Virtual Reality in Museums: Exploring the Experiences of Museum Professionals

Maria Shehade [1],* and Theopisti Stylianou-Lambert [2]

[1]   Research Centre on Interactive Media, Smart Systems and Emerging Technologies (RISE),
       Nicosia 1066, Cyprus
[2]   Cyprus/Research Centre on Interactive Media Smart Systems and Emerging Technologies (RISE),
       Cyprus University of Technology, Nicosia 1066, Cyprus; theopisti.stylianou@cut.ac.cy
*   Correspondence: m.shehade@rise.org.cy or maria.shehade.09@ucl.ac.uk

Abstract: The past few years have seen an increase in the use of virtual reality (VR) in museum environments in an attempt for museums to embrace technological innovations and adapt to the challenges of the digital era. While there are studies that examine the advantages of VR in museums and visitors' experiences with it, there are no studies examining the experiences of museum professionals who are responsible for a museum's objects and narratives. The aim of this paper is to explore the practices, experiences, and perceptions of museum professionals on the use of VR technology in museums, their perceived advantages and challenges of such technologies, and their vision for the future of technology in museums. The paper provides an in-depth analysis of interviews with museum professionals from a number of countries around the world who worked with particular VR projects in their own institutions. The ultimate aim is to offer a more critical and holistic examination and assessment of the use of VR in museums and provide suggestions for designing and developing VR projects in the future.

Keywords: virtual reality; museums; museum professionals; cultural heritage; advantages; challenges; perceptions; suggestions; VR uses

1. Introduction

Over the last few years, the use of virtual reality (VR) has grown significantly, entering many different aspects of our lives. Consequently, such technologies also entered the museum sector, affecting the way people experience and perceive heritage. In the last few years there has been a considerable increase in the use of VR in museum environments in an attempt by museums to embrace technological innovations and adapt to the challenges of the digital era. Such interventions are seen by many as "vital in the race to 'prove' [museums'] public worth, impact, accountability and relevance" [1] (p. 2). However, for museums, this adaptation to the digital era, created "one of the most important challenges of their modern history" [2] (p. 119) since it created new dynamics in storytelling and content creation.

Undisputedly, technologies, such as VR, have created tremendous opportunities for museums on many levels, offering alternative ways for museums to interact with their visitors [3–5]. VR has been used for reconstructing historical environments [6], for interpretation and experience enhancement both on-side and off-side [7,8], for increased visitor engagement and education [9], and for creating interactive, engaging, and immersive experiences in museum environments [10].

All these applications created new avenues for experimentation with many museums around the world incorporating such technologies in an attempt to democratize and open up their collection to allow multiple interpretations [3]. Indeed, "accessibility, inclusion, and democratization" are

emphasized as some of the most important advantages from the use of VR and other emerging technologies in museums [11] (p. 3).

However, as Dewdney wonders, "how are we to assess this growing trend? Is it a potential moment of radical change in the museum, or is it another fleeting fascination?" [12] (p. 1). This question is critical, since VR and other technologies are starting to profoundly change the way we experience heritage. As Economou notes, "digital technology is not simply an innocent tool in our effort to record and understand the past, for it inevitably affects and shapes drastically how we experience cultural heritage" [3] (p. 225). Thus, it is imperative to critically assess the impact of these technologies on different levels: From the visitor experience to new museological approaches to other organizational issues.

A considerable corpus of literature explores the advantages of VR in museums in terms of alternative content delivery, the customization of museum experiences and visitor participation (see for example [8,13–15]). Although the analysis of VR advantages is undoubtedly useful for exploring new opportunities, many studies tend to overemphasize these advantages, overlooking the challenges or limitations created by the adoption of VR in the museum environment (for an examination of challenges see [16,17]). Furthermore, most studies tend to focus either on the technical aspect of VR development, issues of imaging, digitization, and data management [18] (p. 646) or on the evaluation of the visitors' experience and perceptions on particular projects (see for example [19,20] and [9] for an overview of such studies).

While many aspects of applications and uses are explored in current literature, certain important aspects remain understudied, such as the impact of VR on the social experience of museums [21] and the critical analysis of the overall impact of emerging technologies on museological approaches. Moreover, what is usually left out of the equation is the perceptions, needs, and aspirations of museum professionals who are responsible for the objects and narratives of a museum. Museum professionals are also placed in the unique position of being able to observe the interactions of their visitors with VR technologies and how these technologies might change the flow of an exhibition or the social interactions of visitors. Thus, the emphasis of this study is to explore and understand museum professionals' experiences, perceptions, and practices rather than to provide an overview of technological solutions used or a discussion of technical challenges. Based on the insights gained, the paper concludes with particular suggestions on the development of VR applications in museums that can be used as a guiding roadmap by both museum professionals and VR designers.

2. Methods

2.1. Aim and Research Questions

The main aim of this paper is to explore the perceptions, practices, and experiences of museum professionals on the use of VR, their visions for the future of technology in museums and the possible advantages or limitations of such technologies. To do that and to help us make suggestions for the development of VR applications for museums, this study focused on the following research questions:

1. How do museums currently use VR technologies in their spaces? How do museum professionals perceive the role and uses of VR technologies?
2. Which museum departments are responsible for handling VR and do they have a digital strategy/vision in place that includes emerging technologies?
3. What are the advantages and challenges of VR technologies according to museum professionals?

2.2. Research Design

To explore the experiences and perceptions of museum professionals and to answer the research questions, a qualitative methodology was considered as more appropriate. More specifically, we conducted 16 semi-structured, in-depth interviews, with museum professionals from 15 different museums, asking them about the VR projects they have worked on, the procedures they follow, their experiences so far, and their future aspirations. These museum professionals oversaw or worked

on particular VR projects or have extensive knowledge and experience with technologies in museums. An interview guide with 12 main questions was used for guiding the interviews.

Our aim was to follow a qualitative approach for the analysis of the in-depth interviews. One of the main characteristics of our approach, which is common in many types of qualitative methodologies, is that data collection and analysis are simultaneous, informing each other [22] (p. 428) [23]. In this context, we followed a process of theoretical sampling (instead of statistical sampling), in which the sample is "meaningful theoretically and empirically" [24] (p. 124) and is selected according to the level of insights that each individual is expected to provide [22] (p. 118). Thus, the sample was formed based on particular criteria, that is, the prior or current experience with VR and the level of knowledge and familiarity with VR and other emerging technologies based on the professionals' experiences or the position held within the museum.

In qualitative methodologies, the sample size is determined by the "theoretical saturation of categories rather than by the need for demographic representativeness" [22] (p. 428). Thus, sampling and integrating new data finishes when theoretical saturation is reached and no new data emerge anymore [22,24]. Following this pattern of analysis, we concluded that the number of collected interviews is enough to achieve our aim, since by the end of our data collection no new themes emerged. In such analyses that follow an in-depth qualitative methodology, such numbers are deemed satisfactory, since the aim is not to extract statistical representations of the entire museum community [25,26]. Our aim was to understand the interviewees experiences and identify emerging themes that can be used to guide future endeavors with VR.

2.3. Selection of Participating Museums and Interviewees

Research participants were approached and recruited after an extensive research on current or recent uses of VR in museums, resulting in a list with museums around the world that either have VR installations in their permanent exhibition or have hosted VR technologies sporadically in temporary exhibitions. We comprised a list of 70 museums from the US, Europe, Asia, and Australia, which received invitations to participate in our research. Apart from the museums' details the list also included the names of curators or other museum professionals responsible for new or emerging technologies in the particular museums. When such details were found, invitations were sent out personally to these museum professionals. When such details were not available, we contacted the museum directly, asking to be directed to the appropriate member of the personnel.

It is worth noting that we were interested in talking to museum professionals who had a first-hand experience with VR technologies at their workplace and/or that have extensive experiences with a variety of emerging technologies in their museums. In some cases, despite the willingness of some professionals to participate, two factors rendered this impossible. In many cases the VR projects carried out were "one-off" projects as part of an experiment or a temporary exhibition. In these cases, often the person who was involved with the project did not work for the museum any longer, and there was no dedicated department to continue that work. As a result, current museum employees could not answer our questions. In other cases, the VR projects were carried out in collaboration with a company, which managed and developed the VR, with minimal involvement by the museum staff. Thus, again the museum professionals could not answer our questions, directing us instead to the companies that they had collaborated with. The 16 museum professionals who eventually took part in this research come from museums from different countries, providing a wide range of geographical coverage: The US, Australia, Italy, the UK, the Netherlands, and Finland. We also managed to recruit professionals from a wide range of museums: art, archaeological, science, natural history, and art museums. This facilitated a holistic approach in our analysis, irrespective of the museum type. As will be shown, although the use of VR has different aims in each museum type, the advantages, challenges, and limitations faced by museum professionals are common across all museum types.

The 15 participating museums are: National Czech and Slovak Museum and Library, the Pacific Science Centre, the Tate, the San Diego Museum of Art, the Rijksmuseum, the Cleveland Museum of Art,

the Dali Museum, the Natural History Museum of Utah, the Australian National Maritime Museum, the Kennedy Space Center Visitor Complex, the Museo Nazionale della Scienza e della Tecnologia Leonardo da Vinci, the Australian Centre for the Moving Image, the Children's Museum of Indianapolis, the Smithsonian American Art Museum and the National Museum of Finland. All interviewees signed consent forms allowing us to analyze and use their interviews while all data presented in this paper are anonymous.

Regarding the participants' profile, they varied widely in terms of expertise and educational backgrounds, however they were all responsible for managing either information resources, media and technologies in the museum, or exhibition and audience development. They hold a variety of positions, ranging from more traditional museum positions (such as Educators, Heads of Interpretation, Heads of Public Programs) to more technology-oriented positions (such as Chief Digital Information Officer, Chief of Digital Strategies, Interactive Producer, Game Designer, Head of Digital Content).

Although the participants come from many different backgrounds (from mathematics to arts and from history, archaeology or theatre to media communication and information science), the majority hold high-level positions, and they are often managers or heads of their respective departments, overlooking technology projects or other issues relating to the exhibits, digital content and audience engagement.

2.4. Data Collection and Analysis

Interviews were carried out through skype. In cases were a skype interview could not be arranged, usually due to the difference in time zones, questions were answered by the participant in writing. All interviews were recorded in audio files and transcribed to facilitate a qualitative data analysis. Based on the replies received, a process of coding was used [27] to facilitate the comparison between the different data categories. Coding facilitates the development of categories and the exploration of relations between them [22], to identify "structures in the material, like core categories, social processes or story lines" [22] (p. 436). The conducted coding took the form of a comparative study of cases or examples of VR applications. The ultimate aim was to identify emergent or repetitive themes in the data, since by exploring the participants' experiences and views we were able to develop a better understanding of current uses, issues, advantages, challenges, and limitations and gauge how museum professionals envision the future of VR in museums.

The data analysis followed a holistic approach, using both cross-sectional and noncross-sectional analysis [24]. Cross-sectional analysis facilitated data indexing by using particular indexing categories for all the data gathered, while noncross-sectional analysis allowed a more contextual, "case-based" exploration of the data which also took into account the particularities of each project and museum explored. Initially open/initial coding was used to form some initial themes, represented by keywords for each category of issues that we wanted to explore. This was followed by a second round of focused coding, in which "the most significant or frequent initial codes that make the most analytical sense" were identified [23] (p.158). This stage involved a refinement of the identified codes and their interrelations which led to the formulation of the specific categories and themes presented in this paper.

3. VR Uses and Museum Professionals' Perceptions

Although the participants have varied backgrounds and experiences, there were several convergence points, allowing us to identify several common patterns in their responses. In the following quotes we include participant numbers for cross-referencing purposes and have removed all identifying information.

3.1. Uses of VR

In most cases, VR was introduced in the participating museums for the first time in the last 8 or 9 years, with the vast majority being introduced especially after 2015. VR is used by most participants (9 museums) more sporadically in the context of temporary exhibitions, although there are 6 participating museums that incorporated this technology on a permanent basis. Interestingly,

in two cases, the success of the temporary exhibition using VR was such that it invoked the museum to keep it permanently. As further discussed in Sections 4.2 and 5.2, the temporary use of VR can be associated with both a lack of solid strategic framework for introducing such technologies but most importantly with the financial and staffing constrains that VR creates, characterized by participants as "labor intensive and very costly" (Interviewee 16).

In most cases (7 museums), VR was used to allow the visitor to experience a space that is no longer accessible or to time travel. In art museums, this is usually a place depicted in a painting or even the actual studio in which an artist worked to get a sense of his/her ordinary life. VR was also used to immerse the visitor in history and places that cannot be currently experienced. In one example, VR was used to allow visitors to "experience the life on a train car in World War I" (Interviewee 3). Apart from facilitating immersion and education inside the museum, VR was also used as a vehicle for further community engagement, since the aforementioned museum partnered up with high school students to develop the storyline. The use of VR for engaging schoolchildren was evident in another participating museum where a 3D model of the museum was available for schoolchildren to use at school through VR headsets (Interviewee 15). In another example, VR was used to allow the visitor to "time travel" and experience a particular event in history, having a painting depicting a historical event as a starting point. Here the aim is to experience the depicted historical event and to give visitors the "feeling of walking into history" (Interviewee 4).

This category of uses also includes the use of VR to allow visitors to experience places that cannot be accessed easily (such as the bottom of the ocean or Antarctica) and to deepen their understanding on topics relating to climate change, wildlife etc. This is frequently encountered in science and natural history museums, in which we may also encounter a multi-user VR experience, in the form of VR theatre shows. In one case, in order to increase realism, the museum enriched the space in which the VR was offered with real physical components that were also depicted in the VR. As Interviewee 14 explains: "We built these physical walls or baskets that were also represented in the virtual space so that the visitor had that direct visual connection between what they saw in the physical world before they put on the headset".

VR is also used as a tool through which paintings become "alive", allowing the visitor to enter the painting and the world created by the artist (encountered in 3 art museums). This use provides the visitor with an intensified aesthetic experience and enhances art appreciation. Two museums also hosted VR artworks on a temporary basis, shown with the use of head mounted displays (HMDs) in an installation environment. Having said that, artworks that use VR technologies differ dramatically from VR applications created for the purposes of explaining, educating, and interpreting collections or concepts.

In two other cases, the use of VR is strongly connected to the educational aspect of the museum visit. For example, museum 7 offers VR guided tours led by a scientific explainer: "Depending on the type of tour, you are free to explore the virtual environment and to follow the storyline otherwise the explainer guides you during the exploration commenting what you are watching in real time" (Interviewee 7). An interesting finding is that 3 participants coming from art museums mentioned that they prefer to use VR less in the actual museum space and use it instead as part of their online tools available to visitors. For example, in the case of museum 16, 360-degree films were available to view online while in the case of museum n.8, a series of downloadable VR experiences were created for online users. Perhaps one of the reasons for this, is the often-common belief that VR might be disruptive to the overall aesthetic experience if used inside art museums. As Interviewee 15 argues:

> *"The reason that we have not really adopted this form of technology is also because we believe it's not really a technology that—as an art museum—is interesting to have inside your museum as it closes you off from the environment. You're already in an immersive environment once you're in an old art museum. You don't want to close people off from that experience. So, we don't really see it happening in the museum. But outside the museum, yes".*

Moreover, in two cases, the museums turned to AR because of the limitations they found with VR (discussed in Section 5.2) and because they believed that AR would provide a higher engagement on both a personal and an emotional level compared to VR, and offer to the visitor a stronger interaction level. For example, in the case of museum 11, AR was chosen to bring a painting to life: Through AR the figures of the painting start moving and talking to share their personal story with the visitor who can also ask questions to the figure. As interviewee 11 explained, they believed that through this technology an educational element can also be emphasized, apart from just a simple experience enhancement.

3.2. Museum Professionals' Perceptions about the Role and Uses of VR

Apart from current uses, our aim was to also explore the interviewees' perceptions on the ideal use and role of VR in museums. Current literature tends to emphasize the role of VR in attracting new audiences and enhancing the experience offered (see for example [28]). However, for museum professionals, technology has a broader and multifaceted role to play in a museum context. For most interviewees (8 out of 16), VR can offer new ways of interpretation, allowing for personal involvement of the visitor in interpretation processes. It can promote new ways of understanding art, objects, and concepts, and can allow visitors to explore their ideas on these concepts. Thus, the role of such technologies is not to offer something innovative but to serve the audience's actual needs. As interviewee 16 emphasizes, "it doesn't really matter to us if the technology is innovative or not. It's whether or not it serves audiences and whether or not it gives them something new that they will enjoy and that will enrich their visit".

Moreover, it is essential to understand the reason why we incorporate VR in a museum in the first place. According to interviewee 16, VR should not be used to replace the gallery experience but to allow the visitor to experience something he/she would never have access to in any other way and to incorporate this meaningfully in the overall museum experience. As interviewee 16 notes:

"I think where it gets challenging is when you try to use VR to replace the gallery experience or to provide a gallery experience in a virtual environment. That's not what it's good for. It's good for offering a different kind of experience. So, use VR to create experiences that people can't get anywhere else. People can walk into museums and galleries all over the world. So, don't try and make a virtual museum or a gallery, make something else, a studio, a scene, a location, or send them to the moon. But don't try and create a gallery in there".

If this experience enhancement is achieved in a meaningful way, then these technologies can also contribute to attracting new audiences. However, as stressed by interviewee 3: "Understanding from the beginning the goal of using these technologies is the key", otherwise the entire offering is compromised. In fact, a common challenge faced is how to best find the right balance to offer a truly meaningful experience without turning the museum into a meaningless theme park.

Many museums use technology to "remain relevant" and align the offered experience to people's everyday lives. Thus, they consider technology as a tool to stay up-to-date, while at the same time, seeking for interactions that do not diminish the content. As interviewee 6 explains:

"The expectation today of people and technology is high. A lot of people try and interact with screens that are not interactive. I don't think this is always because people want to know more about what they are watching but rather they are used to interacting. I think it's important to be up-to-date with emerging technologies to remain relevant in the public eye but also do this in a respectful way, not to diminish the reason the technology is there [that is] the content".

While struggling to stay relevant, museums are also seeking ways to offer new social experiences with technology that allow social interaction and can transform learning. According to three interviewees, for VR to have an effective role in a museum, it should be connected to a basic human need, such as communicating and sharing with other people. Thus, new technologies have a role to play in allowing visitors to share their experience and interact with others. These technologies

can also offer experiences that cannot be offered at home. Thus, museums do not need another experience that can be also found at home through an application, but rather an experience that provides the missing context in conjunction with the aura of the original, which can be offered only inside the museum.

As stressed by some participants, VR also has a role to play in empathy building practices. For example, VR can be used for immersive first-person narratives or for "body swapping VR experiences", through which you can virtually experience someone else's point of view or get into his shoes. If used in such ways, emerging technologies can support a wider social good and create empathy for a variety of topics such as homelessness, migration, or other issues of social importance. As interviewee 12 notes, "there are a growing number of these types of persistent social experiences that can lend themselves to empathy building practices [. . .] These are experiences that make you feel, and in some cases they will make you act". Indeed, VR can be a powerful tool to convey emotions, which is also recognized in relevant literature [29,30]. Through such uses, museums will be able to "create a more informed and engaged public" (Interviewee 12).

Thus, VR has multiple roles to serve in a museum, but, as interviewee 16 emphasizes, in order to be meaningful, these roles should be well thought and designed beforehand:

> *"It might not be one experience that does all of those things, but you might have multiple different experiences that serve different aims. Some of them will be about presenting the museum to audiences who either have never heard of us or who just don't think we're there for them and to help them feel excited and engaged and that there is something here that is relevant to them. Sometimes it might be about surprising people with something that they didn't think the museum would do. Some of these experiences are to offer those wow moments that just get people coming in and queuing to try out an experience. And then some of them are about offering really deep learning, meditative, thoughtful experiences. It depends what you want to achieve and who you want to achieve it with and for".*

Therefore, understanding the roles of such technologies and the needs that they address is a key to the creation of effective VR projects.

4. Departments/Teams Handling VR in Museums and Digital Strategies

One of our research questions was to explore the museum departments responsible for handling VR and whether they have a digital strategy/vision in place including emerging technologies. This allowed us to analyze the organizational and operational challenges that VR may impose on museums and what reforms are required for incorporating VR more effectively.

4.1. Departments and Teams

The application of VR in museums is a challenging task, requiring a variety of expertise and an interdisciplinary team dedicated to the development of such applications. This proved a challenge for museum professionals, since most museums either do not have a specialized department as such or have departments with a variety of responsibilities that lay in the digital sphere. The variety of managerial approaches regarding the application of new technologies and VR is also evident in the practices followed by the museums participating in this research.

In 13 cases, a single department handles VR and other technology-enhanced projects. For example, museum 1 has a "Digital Innovation and Technology Services Department" that "works on strategy, concept, design, and implementation of interactive experiences". In another example (museum 5), the "Interpretation and Design" department, which includes a Public Engagement Technologies officer, oversees such initiatives, illustrating an interconnection between the use of new technologies and new audiences engagement. In the case of museum 8, the "External Affairs and Digital Strategies" is the responsible department, while museum 4 has an "Information Management Unit" focusing on digital collection management and 3D modelling. In some cases, these departments have varied

responsibilities and the creation of technology-enhanced exhibits falls under the wider umbrella of digital experiences (also including social media and online presence) or even marketing.

In four cases the introduction of VR is the result of collaborations and synergies between different departments and teams. For example, in museum 2, several departments are collaborating for the implementation of emerging technologies across the institution: The Technology, Exhibitions, Collections, and Information and Communications Technology (ICT) teams. Thus, what professionals strongly emphasize is the imperative need for collaboration across different teams for developing such projects:

> *"I think the immersive technologies sits with the digital department as a sort of natural extension of what we do online. But it also sits with our interpretation colleagues as a natural extension of what they do in the galleries. So, this is about two departments having to work closely together to deliver something using this new technology"*. (Interviewee 16)

Despite these intra-departmental synergies, many museums are struggling to cope with the needs arising, due to the lack of personnel and the necessary funds to expand their personnel, emphasizing that "the need for a dedicated team is growing" (Interviewee 12). Due to these increased needs, in the last years two of the participating museums started to form dedicated labs experimenting with the abilities of VR and other emerging technologies.

All the above illustrate that a new setting is beginning to emerge in the museum sector due to the rapid advancement of VR and other emerging technologies: dedicated departments or labs are formed, new managerial structures are needed to support the collaboration of different teams in each museum, and additional personnel is needed with new skill sets. As Dewdney notes, "embracing networked culture would require a very different outlook and skill set for museum professionals, where the current organization still defines the break between curatorial knowledge holders and technical media skills, the future museum needs to be of the network itself" [12] (p. 9).

4.2. Digital Strategies

Most participating museums have an overall digital strategy (10 out of 16), either in the form of a roadmap or in the form of particular goals for introducing emerging technologies. Despite the existence of such strategies, they are usually quite broad and cover many aspects of digital experiences, from social media, to virtual tours to VR, and usually do not include specific guidelines on VR. As interviewee 16 mentions: "At the moment, we have an organizational digital strategy, but that touches everything. That includes from the website and our online ticketing and our online shop all the way to immersive or non-immersive digital experiences in the galleries".

Nevertheless, it appears that the existence of a digital strategy, even a more general one, is one of the factors facilitating VR's permanent inclusion in the museum. Quite interestingly, in most cases the museums that had a permanent VR installation also had a digital strategy in place, while the museums that did not have such a strategy only used VR technology sporadically in the context of temporary exhibitions.

What was evident in the conducted interviews is that four museums are uncertain regarding the possibilities that emerging technologies can offer, which may partly explain the fact that such technologies are still not included in a wider policy or strategy, with most museums still being at the phase of trial-and-error in an attempt to discover if these technologies actually serve their needs:

> *"We do not have a written down strategy regarding emerging technologies. Basically, we just want to deliver content in the most effective way possible. If it turns out that it's an emerging technology that we think would provide the best experience or the most effective way to deliver content for visitors, then we would go with that"*. (Interviewee 14)

Finally, in two cases the introduction of VR is connected to branding issues and is used as a marketing tool to promote the museum as a space of "immersive experiences" (Interviewee 5). This is

illustrative of an often-encountered connection between the use of technology and the overall marketing and promotion of the museum [28].

Another important aspect of a digital strategy is whether or not evaluation of new technologies is required. Out of 15 museums, only 3 cases did not have any type of evaluation procedure in place, while in one case the evaluation is currently limited, since they are "working on creating more robust measurements" (interviewee 13). The evaluation procedures mentioned by most participants include observation, visitor interviews, questionnaires, and user testing combined with visitor feedback. In many cases these tools are used in conjunction with other data collected in the museum space or online (such as visitor statistics on attendance, earned income, usage data, visitors' most favored aspect of an exhibition, or the number of downloads of related material). However, despite the attempts of many museums to incorporate rigorous evaluation procedures, this proves challenging due to the different evaluation needs associated with different types of technology and the lack of funds to carry out such procedures. The challenge also lies in the fact that an evaluation should not only measure the effectiveness of an individual technology but rather the "experience as a whole" and how this experience is affected (Interviewee 1), which is often neglected by many evaluation studies. The challenges relating to evaluation procedures have also been acknowledged in relevant literature, which emphasizes that the impact of such technologies is difficult to measure in the absence of specific objectives set out in digital strategies [31].

5. Perceived Advantages and Challenges of Using VR Technologies

5.1. Perceived Advantages

In order to better understand the use of VR in the targeted museums, an exploration of the perceived advantages gained from its use by museum professionals was also necessary. Overall, seven categories of advantages were identified based on the participants' replies, relating to engagement with collections, visitor attraction, accessibility, education, immersion, customized experiences, and technology reliability (see Figure 1).
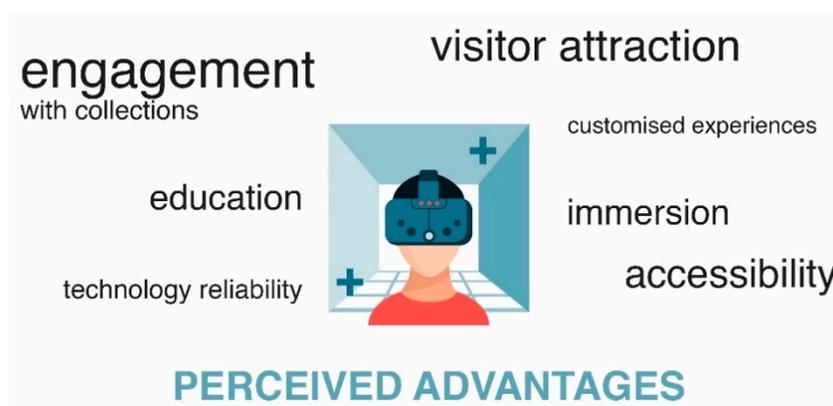
Figure 1. Reported advantages of virtual reality (VR) as perceived by the interviewees.

The first advantage identified by seven interviewees is the enhancement of visitors' engagement with the museum collection and the ability of VR to offer powerful experiences through immersive storytelling or to transport the visitors to inaccessible places or to particular points in time and history. This enhanced engagement seems to be more "internal" and emotional, moving away from a simple interpretation of a collection through text. As interviewee 16 put it:

> *"If they can step into a virtual environment, there is another way of connecting through emotion, through being immersed in an artist's world. You can feel a connection that is more visceral, that you can't access necessarily or not everyone can access through reading a wall text".*

This type of engagement can allow for the creation of playful interactions and memorable experiences that can be so intense that remain unforgettable for many years, or even engage people that initially may not be so interested in the museum. Quite characteristically, interviewee 15 described this effect that VR had on him as a child:

"I can remember when I was young back in the '90s, I was seven. Me and my dad went to an aviation museum describing how the Americans parachuted out of the planes and fought the Germans in the Second World War. They had this harness where you would get into and they had the VR headset and you would jump with the soldiers out of the plane. This was one of the most intense and cool experiences I've ever had in a museum. And this was because of the VR and because I had this whole visualization of a story that was being told which didn't really have an impact on me until I used this VR headset. And it had a very lasting effect on me".

Most interviewees agreed that VR can be an added value for museums to enrich their content and engage the audience in these stories in a powerful way.

One of VR's undisputable advantages according to museum professionals (mentioned by 5 interviewees) is its power as a marketing tool to attract new visitors and engage younger audiences, who "will stand in line for a long time to try it out" (Interviewee 8). VR also has an effect on regular museum visitors, who "changed how they saw us" (Interviewee 3) and on the overall image and perception of the museum by its visitors, shifting the perceptions from old-fashioned to exciting: "It shifted perspective on what a museum presents. It can be exciting and engaging, even for those who have low expectations of what a museum can offer" (Interviewee 11).

Accessibility was also emphasized as an important advantage by four interviewees, for different reasons. First, VR may offer advantages for people with disabilities by enabling them to access places that would otherwise be inaccessible. For example, in one case, VR was used to virtually access a ship (Interviewee 5). Second, although VR technology has been around for a long time, in many cases these museums offered the chance to their visitors to experience VR for the first time in their lives. As Interviewee 6 mentions:

"I think the largest advantage of having VR in our museum is the exposure and opportunities our visitors get. I often take for granted the access I have to this technology and I am always surprised at the numbers of people that still haven't had the chance to experience VR".

Finally, VR provides increased accessibility for online visitors who want to have museum experiences at home and allows a museum to reach thousands of people, by offering "an immediate translation of their building and the collection to the digital world" (Interviewee 15).

The fourth advantage emphasized by three interviewees, is VR's contribution to the overall education aims of each museum and the ability to teach or introduce concepts and themes more effectively. As stressed by interviewee 1, the technology used in their galleries, "provides a new way of teaching art concepts, equipping visitors with tools to deepen their understanding of art". Indeed, "VR presents a number of innovative elements that provide rich opportunities for the medium to be an effective learning tool" [32] (p. 453), which was also reaffirmed through the evaluation process of some participating museums. For example, the evaluation of a temporary exhibition using VR dedicated to a particular artist, illustrated that VR offered an additional knowledge layer to some visitors:

"Some of the feedback we had was that until then, they haven't thought about the artist as a man who really lived. It was just the name associated with these pictures on the wall. So even though the artist himself didn't figure in the VR at all, but because we were looking at his living environment, it has brought him to life with a sense that he had really existed, which again, gave them a sense of a greater emotional resonance with the artworks". (Interviewee 16)

The fifth advantage, reported by 3 interviewees, is the ability of VR to offer immersive experiences, impacting both the engagement level and learning. Although immersion is emphasized in relevant

literature on VR in museums as an important element offered by this technology, only three interviewees mentioned immersion as a strong advantage of VR for their museums, indicating a discrepancy in the way VR is perceived by computer scientists compared to the perceptions of museum professionals. In fact, some participants consider that this immersive capability may have multiple drawbacks in the museum environment (see Section 5.2).

The next advantage, mentioned by two interviewees, is the ability to personalize a visit through the use of VR and offer customized experiences (especially if VR is combined with other types of technology such as beacons, AR scanning, connectivity with personal devices or motion sensors). Finally, reliability is emphasized by two interviewees as an advantage of VR compared to other types of emerging technologies. As interviewee 5 characteristically notes, VR "is pretty robust now as it has been out in the market for a while". The actual need of trustworthiness and reliability of the technology used was stressed by 5 interviewees, who emphasize they do not necessarily need something that is extremely innovative but something that is "tried and tested" and thus, reliable both in terms of the experience provided and in terms of the maintenance cost.

Figure 1 summarizes the advantages of VR technologies as perceived and reported by the participants of this study.

5.2. Perceived Challenges and Limitations

Apart from VR advantages, our aim was to also explore the challenges and limitations that museum professionals faced with VR technologies in their museum spaces, as these were perceived by the interviewees. Overall, 9 categories of challenges and limitations were identified based on the participants' replies, relating to the lack of social interaction, staffing and training needs, cost, accessibility, practical and technical issues, graphics quality, exhibition flow, distraction, and technology acceptance (see Figure 2).

Figure 2. Reported challenges/limitations of VR as perceived by the interviewees.

One of the most strongly emphasized limitations relates to the social aspect of the museum visit (mentioned by 11 interviewees). Since most VR is designed for a single user, participants consider VR as "too isolating", cutting the visitor off the rest of the environment and not allowing any social interaction. Since most people visit a museum as part of a pair or a group, social interaction is an essential component of every museum visit which is hindered by VR headsets, creating an "antisocial experience" (Interviewee 8). Although immersion was also highlighted as an advantage of VR, this same feature is also considered a limitation if seen from a different standpoint. This is especially so for museums focusing on families and groups, which feel that VR cannot help them to fulfil their mission. This social isolation was one of the reasons why some museums did not repeat a VR project or do not have plans to design a new one. Interviewee 14 argues: "We are an institution that's very

focused on family learning and family members being able to have a shared experience. That's a bit of a challenge with VR where it's a much more individual experience".

In an attempt to overcome this, some museums tried to apply alternative ways of using VR to make it more social. However, all such attempts created new issues. For example, interviewee 5 reflects on other problems that arose when trying to provide a more social VR experience: "When we tried to use more than 50 headsets in the gallery there was a lot of interference and issues with Bluetooth and Wi-Fi—they took a lot of time to set up". Interviewee 12 also mentioned that "mass use is hard on the hardware and then there are the other issues like hygiene".

The second most emphasized challenge relates to staffing and training needs. In many cases visitors are not familiar enough with VR and usually need assistance, meaning that "extra staff should be hired just to manage the VR stations" (Interviewee 8). Thus, the extra staffing needs and the added responsibilities (mentioned by 11 interviewees) pose operational challenges for museums both from a financial and an organizational point of view, since new operational procedures had to be developed (Interviewee 14). Even if new people are hired, with an additional operational cost, they must also be trained since for many museums their staff is part of the offered experience, which is something often neglected by VR developers who focus only on what happens when the headset is on. Interviewee 16 warns:

> *"The thing we must never forget is the [visitor's] experience around the technology. It's not just what happens when they put the headset on, it's who did they speak to in order to be able to do this? Was that person able to make them feel comfortable? Is the equipment clean? Is everything working when they press the button? It's all the attention to detail of the experience for the person who's coming into it before they even put the headset on. And then also, what happened when they took the headset off? Was there somebody there to greet them, to point them which way to go now? That's what makes the experience great. And that's how you can make it feel authentic and not just like something that's stuck in a corner that you can have a go at if you like, but nobody really cares".*

Another challenge is the required expertise needed to implement VR projects (mentioned by 5 interviewees). As stressed by some interviewees, many museum professionals do not have the expertise on developing such projects and special training is needed on how to handle or troubleshoot the equipment. Such training may be extensive since the VR used should be integrated in the overall curatorial approach of the museum, its promotional activities and be designed with the guidance of curators. Interviewee 7 explains this challenge: "The real challenge has been the inclusion of the activities inside the cultural offer of the museum: The involvement of the curators, the training of scientific explainers, the design of the promotional activities, and the commercial offer".

This also relates to the issue of finances and the overall cost of VR, which is one of the most pressing problems faced by 8 interviewees. In many cases the overall cost is prohibitive, while others find it very hard to adopt VR on a permanent basis due to the budget limitations they have. The issue of cost includes the initial equipment required, the extra staffing needs for developing and handling the VR, and the costs of repair and maintenance. Especially the operational burden created by the extra staffing needs is a big challenge in many cases. Thus, in most cases, VR is used for temporary exhibitions since the cost of maintaining VR on a permanent basis is prohibitive.

In order to overcome this challenge, many museums collaborated with companies and developers that provided the equipment. In seven cases, temporary exhibitions including VR were developed after the museum was approached by a company who wanted to test the equipment in a museum environment. This also explains why VR is mostly used on a temporary basis, since many museums rely on external collaborations with technology companies that can provide the hardware due to the high cost. Nevertheless, as discussed in Section 6.2 some of these museums found many creative, innovative ways to overcome some of these challenges and incorporate VR.

Although various aspects of accessibility were amongst the identified advantages, some other aspects of accessibility pose serious limitations for museums (emphasized by five interviewees).

As noted by interviewee 8, VR is not friendly to users with disabilities such as blind or deaf users. Thus, people with disabilities may end up having an impoverished experience, especially if the VR replaces other means of interpretation. Furthermore, four participants stressed the difficulties they face due to the age restrictions on the use of VR by children, since "there has been some debate about the age that a person has to be to use the equipment, with differing advice" (Interviewee 5), which causes confusion to many museum professionals. In most cases, the common recommendation of some manufacturers is for VR not to be used by children under 12 [32]. However, as interviewee 16 puts it, this means "that if you are a museum that is encouraging families to visit, you are potentially excluding a large proportion of your audience". These age restrictions may cause frustration in small children for not being able to use a headset that is available to the rest of the visitors. As interviewee 16 explains, "you have to manage their expectations, because if a 12-year-old sees that there is a headset in the gallery and they want to have a go and they are told that they can't—that's not a brilliant experience for them".

Museum professionals also often face other more practical but equally important issues when using VR (stressed by 5 interviewees). The issue of hygiene came up very often in the interviews, since all necessary equipment requires regular cleaning due to the large number of users per day. This category of limitations also includes medical limitations, such as dizziness caused by the VR, which in turn limits the time of usage (mentioned by 3 interviewees).

Limitations were also identified regarding specific technical issues, which may also affect the quality of experience or the sense of immersion (indicated by 4 interviewees). For example, interviewee 6 argues:

> "I find a lack of industry standard a challenge when receiving content or feeding into the creation of new VR content. The greatest limitation I find is the video resolution available at this stage. Battery life and overheating for portable devices and cable tethering for larger systems also limit the experience".

The overall aesthetics and the graphics quality of the VR experience were also raised by three interviewees. Apart from high resolution 3D photography, many participants noted that the graphics used, especially for creating immersive worlds in paintings are still "pretty unconvincing" (Interviewee 4) which may also affect the immersion and engagement level. Indeed, it has also been acknowledged in relevant literature that the level of realism of graphics can affect the level of virtual presence felt by the user [33]. This proved a major drawback especially for art museums that place a great emphasis on aesthetics. Interviewee 15 explains:

> "You can use Rembrandt, for example, as an inspiration. But once you start to add onto his paintings and create these 3D worlds, you are never going to be as good as the artist himself. And the technology isn't there yet and the graphics are not there yet. So, this was one of the first problems that I came across".

Exhibition flow issues were also raised as a challenge by three participants, who reported that they needed extra staff resources to manage the queues formed. Although some solved this through a booking system with time slots, the most difficult problem to the exhibition flow was created when the VR malfunctioned and "took down" the entire experience. Especially if the VR is a central component of the exhibition and interpretation, this can ruin the visitor experience.

Despite the many advantages offered by VR, in two cases museum professionals noted that visitors can be distracted by VR technologies, resulting in the technology overshadowing museum objects and pre-designed narratives. As interviewee 3 explains:

> "The technology itself made more of an impact than the story the VR was supposed to connect to. Many visitors walked away with their first experience using VR, while positive, did not connect with the content to the degree we had hoped".

Finally, two interviewees also noted that not all visitors are excited with the use of emerging technologies in museums. While most visitors—usually younger ones—are eager to try them out,

some visitors are more skeptical about their use in museum spaces. This presents a challenge for museum professionals who are called to find a balance between the needs of their different visitors.

Figure 2 summarizes the challenges/limitations of VR technologies as perceived and reported by the participants of this study.

6. Future Directions: What Does the Future Hold for VR in Museums?

6.1. Suggestions for Incorporating VR Applications in Museums

The previous sections outlined the current uses of VR applications in museums, which departments are responsible for new technologies and digital strategies, and highlighted the perceived advantages and challenges of VR technologies. All the aforementioned needs and perceptions should be taken into account and guide the design of VR in museums. The perceptions and experiences of the participating professionals, some of which are also confirmed by the available literature, lead us to particular suggestions (see Figure 3) that could be considered when designing and incorporating VR applications in museums.

- Integration into museum mission and strategies

- Seamless, well blended, not an individual offering

- Match each technology with a particular need

- Augment the original instead of distracting or replacing

- Fair balance between use and overuse

- Match VR with other sensory stimuli and social stimuli

- Use scientific and ethical criteria

Figure 3. Summary of proposed suggestions for designing and developing VR experiences in museums.

First, any integration of technology should be designed within the overall museum mission and strategies and not as an isolated individual offering, fulfilling the criteria set out in business plans and "the guiding principles of institutions" (Interviewee 2). The importance of integrating the adoption of interactive technologies into an overall strategy and a consistent museological approach has also been stressed by many scholars, who emphasize that if the adopted technology is not integrated within an overall strategy, it will not be able to contribute to the museums' mission [34–36]. The technology used should be seamless, well blended and integrated with the overall experience of the museum and not be used just for the sake of using something innovative. As interviewee 11 puts it:

> *"It has to be organic. We can't force technology on a museum. It must interact with it, just like the construction and flow of an exhibition directed by a curator. It must interact with the narrative you want to tell as well as the experience the visitor wants to have".*

Furthermore, since a variety of different types of emerging technologies is available, a museum should adapt every technology based on a particular need and on how it can be better used, considering the advantages and limitations of each technology. It is worth quoting interviewee 8 at length here:

"Technologies are just a set of tools to be put in service of a greater goal. A hammer is only as good as what you want to build with it. Similarly, technology in museums must be in service of providing the best, most engaging experience with the actual content. Any good technology project must be visitor-centered, accessible to people of all abilities, and in service of that higher goal: To educate, to inspire, or to motivate people to take action. Technology for technology's sake is not a worthy aspiration for museums. We should not be distracted by what is new and shiny, but really think about people, about our mission, and what we can do to serve audiences in the best possible way".

VR is not always the solution to everything and there are cases where, due to its limitations, it may prove a wrong choice for a museum. Here the question is not about which technology is more effective, but which technology fulfils specific needs and achieves specific aims in the best way possible.

It is also imperative to understand what VR has to offer in a museum setting. The ultimate aim of any VR project should be to increase the visitors' level of engagement with the original objects on display and not distract them from their actual purpose of their visit. The relationship with the physical objects is of great importance to museum professionals since if this connection remains intact, VR can also become more effective. Indeed, this distraction from the physical object has been also acknowledged in relevant literature [37–39]. As interviewee 1 argues: "We find that [. . .] these technologies, they are most effective when positioned strategically to the art objects, allowing the visitors to carry over knowledge gained from technology to their direct relationship with the physical object". Therefore, VR can be used to create the missing context, while having the object at the center of attention. For example, as shown in Section 3.1 many art museums use VR to allow the visitor to enter the world of a painting. However, interviewee 15 advises:

"My advice would be not to dive into paintings, but maybe create the world around it, create the context around it. So, for example, you could dive into the 17th century on the Dutch canals where Rembrandt painted the Night Watch. You can build the context, build the world around it, but don't go in it".

As emphasized by interviewee 15, VR could be more effective if it was used to re-create the world around the painting, since the original and its aura can never be replaced by VR. On the other hand, the use of VR should not overload the visitor or cut him off from the experience of the museum visit, and thus a fair balance should be found between use and overuse. Especially in the case of VR, which tends to create an isolation of the user from the environment, it is important to match the experience with "other sensory stimulus" (Interviewee 10) to make it more effective. Such stimulus could include other senses, such as touch or smell but can also include other social stimuli by incorporating a social element in the VR and ways for people to share their experience and communicate. In this way, VR will seamlessly blend with the museum experience which in itself is inherently social and a "360 completely immersive experience", as noted by interviewee 15. The issue of social stimuli and the importance of offering collaborative activities through such technology has been recognized by some scholars, however, VR technology has still not reached a point of offering truly social experiences [37,40,41].

Finally, any VR experience that re-creates a holistic reality or a time in history should abide to specific standards of scientific accuracy and ethics criteria. This also relates to concerns raised in many cases by museum professionals regarding the authenticity of the experience offered [42,43]. In many cases the amount of information needed to create a VR is very large and not always available. Thus, curators and other scientists will have to make interpretive choices which, if not made carefully and based on specific criteria, may result in a VR which is only meant to recreate and not merely enlighten, educate or even immerse the visitor.

6.2. Envisioning the Future of Emerging Technologies in Museums

This section asks: What does the future hold for VR and other emerging technologies in museums and how do museum professionals envision the future?

Most participants agree that there will be an increased necessity for museums to adapt and incorporate new technologies, since especially the new generation of visitors will seek digital experiences and expect museums to be "digitally literate" (Interviewee 16). This poses challenges, as already explained, on an organizational and strategic level and requires an investment in partnerships and capacity building to develop the necessary expertise amongst museum professionals, in a "process of creative learning at a sector level" (Interviewee 16). For this to be achieved, museums will need to have a clear vision for the incorporation of emerging technologies and invest on both sound strategies and evaluation procedures, and on the appropriate technological infrastructure and personnel training. As evident through the conducted interviews, the digital literacy of museum professionals is also a problem that needs to be addressed, but which proves problematic due to the lack of necessary funds for the required training [44,45]. Given the challenge of securing the necessary funds for such developments, many participants stress the need for the formation of strong partnerships, to allow them to experiment and overcome the funding difficulties.

Some participants have already used VR in new creative ways and have achieved high levels of engagement and innovative partnerships, highlighting a new avenue for the future on VR uses. For example, in the case of museum 6, the museum organizes VR workshops and talks, including workshops for developers interested in VR, so that developers can come together and show their work on museum related activities. In the case of museum 7, the museum organized VR festivals dedicated to VR, which included "experts in the development of VR software and psychologists to explain how the brain works when we're experiencing VR" (Interviewee 7). Such festivals, together with special weekends offering VR itineraries linked to the museum's themes, were used by the museum to create new ways of engagement with its audience. In another example, a museum organizes 3-day events in which external researchers act as "visiting educators" engaging visitors around various topics using VR to convey their research (Interviewee 12). The same museum issued "an open invitation to the VR community to reach out when they need user testing" (Interviewee 12). In this way the museum builds bridges with developing companies, also diversifying what is on offer to its visitors. The particular museum also developed a new model for creating partnerships, by having in residence start-ups dealing with VR and which can test their products and receive feedback by the visitors. These examples of other types of partnerships that can be achieved, illustrate a possible way forward not only for adopting VR in new creative ways but also for creating fruitful partnerships and overcoming budget constraints.

Furthermore, a few participants expect that in the future many current challenges in terms of cost and equipment will be solved, since museums will rely more on the personal devices of their visitors, which will become even more sophisticated in the future, and thus museums will only invest on software development. Indeed, the role of the visitors' personal devices has been also stressed by some scholars as an easier and cost-effective option [37,46]. However, some others appear skeptical about the consequences this may have for the quality of the experience. For example, Interviewee 16 mentions: "You don't get the full immersive world in AR/VR through a phone. You lose something there, but you gain a much bigger market, much bigger potential audience, and also the costs go down. It's a win–lose situation". Constant updating was also identified as a characteristic of the future of new technologies in museums. As explained by some participants this will be necessary to keep up with technological advancements, provide new experiences and most importantly "update our approach as we learn what works best for visitor engagement" (Interviewee 1).

Interestingly, apart from VR, many participants are starting to turn their attention to the potential of AR, mainly to overcome the problem of isolation and to create more social experiences. As interviewee 16 claims: "I think there are enormous opportunities particularly around AR much more than VR, for young people and families to engage with artworks and having playful experiences that they can enjoy as couples or as a group". Finally, some participants noted that they envision digital experiences

in museums that are not intruding on other people's visits and that can be used without disturbing the experience flow of the rest of the visitors.

7. Conclusions

Undisputedly, VR and other emerging technologies created a fundamental shift, necessitating in some cases a reinvention of traditional concepts on what the museum experience entails. Thus, a holistic understanding of the impact of VR is more critical than ever, since this will affect both the design of VR and its perception and acceptance by museum professionals.

However, we argue that such a holistic approach should take into account all stakeholders involved with and affected by VR technology. That is, the museum visitors, the VR developers and the museum professionals. Although a considerable corpus of literature is either devoted to the visitors and their experiences, or the developers and the technical issues that preoccupy them, what is usually neglected is the examination of the needs and perceptions of museum professionals who are usually the mediators between the VR developers and visitors. Therefore, the aim of this research was to fill this gap and understand the experiences and perceptions of museum professionals regarding the use of VR technologies in museums and critically discuss the future of these technologies.

When it comes to the use of VR in museums, the data analysis revealed seven categories of perceived advantages and nine categories of perceived challenges and limitations. Despite the interviewees' consent on the main advantages of VR, immersive installations are still not frequently encountered in museums and when found, they are usually included on a temporary basis. This can be explained by the many challenges faced by museum professionals. According to the interviewees, the most important challenge that VR developers need to overcome seems to be the inability of VR to provide engaging social experiences. This points towards a necessary direction for further research: Interactive and social VR applications. Furthermore, the increased staffing and training needs identified, point towards the need to create dedicated interdisciplinary teams in museums that will deal with technology and the need for further training both for current museum professionals but most importantly, for university students who will become the future museum professionals, and who usually do not have topics relating to technology in museums incorporated into their studies.

In general, there is a lack of adequate research on the impact of VR on different levels, some of which are often neglected: From the visitor experience, to museological approaches, to organizational issues. The insights of museum professionals presented here indicate that there are many issues we tend to forget when exploring the potential of these technologies, which are nevertheless extremely important for museum professionals and the museum sector.

Through this research, we attempted to achieve two aims. On the one hand, it is important to understand where we currently stand regarding the use of VR in cultural institutions and it is important to do so from the museum professionals' perspective. This will allow a more comprehensive analysis, since "it remains unclear where we are in terms of how well the research community and cultural institutions are doing with the technology" [47] (p. iv). Based on the presented findings, researchers and developers can direct their research towards current needs. This will allow us to align and bring together the worlds of museum professionals and VR developers. On the other hand, it is important to explore how we can use VR in the future "for increasing value, for both cultural heritage and our users" [47] (p. iv). Thus, through the experiences of these professionals we presented specific suggestions on how to best develop and use VR in museums. Our aim is not to propose solutions to technical issues, but rather to direct future research on how VR can be better incorporated in museums. These proposals can act as a roadmap, setting the stage for the future and allowing people from both worlds to understand each other's needs and communicate more effectively.

So, what does the future hold for VR? Although each participant has its own vision for the future, it is evident that a multidisciplinary approach, collaboration, and knowledge exchange is imperative for designing VR for museums. This will allow the incorporation in the design process of issues relating to cost, usability, sociality, etc. This design should be based on the actual needs of museums and their

audiences, taking into account all their concerns to provide not necessarily the most innovative, but the most meaningful, truly engaging, and memorable museum experience.

References

1. Kidd, J. *Museums in the New Mediascape*; Routledge: London, UK; New York, NY, USA, 2014.
2. Kargas, A.; Karitsioti, N.; Loumos, G. Reinventing Museums in 21st Century: Implementing Augmented Reality and Virtual Reality Technologies Alongside Social Media's Logics. In *Virtual and Augmented Reality in Education, Art, and Museums*; Guazzaroni, G., Pillai, A., Eds.; IGI Global: Hershey PA, USA, 2020; pp. 117–138.
3. Economou, M. Heritage in the digital age. In *A Companion to Heritage Studies*; Logan, W., Craith, M., Kockel, U., Eds.; Wiley & Sons: Sussex, UK, 2016; pp. 215–228.
4. Carrozzino, M.; Bergamasco, M. Beyond virtual museums: Experiencing immersive virtual reality in real museums. *J. Cult. Herit.* **2010**, *11*, 452–458. [CrossRef]
5. Bekele, M.K.; Pierdicca, R.; Frontoni, E.; Malinverni, E.; Gain, J. A Survey of Augmented, Virtual, and Mixed Reality for Cultural Heritage. *J. Comput. Cult. Herit.* **2018**, *11*, 7. [CrossRef]
6. Bruno, F.; Bruno, S.; De Sensi, G.; Luchi, M.L.; Mancuso, S.; Muzzupappa, M. From 3D reconstruction to virtual reality: A complete methodology for digital archaeological exhibition. *J. Cult. Herit.* **2010**, *11*, 42–49. [CrossRef]
7. Gonizzi Barsanti, S.; Caruso, G.; Micoli, L.L.; Covarrubias Rodriguez, M.; Guidi, G. 3D visualization of cultural heritage artefacts with virtual reality devices. *Int. Arch. Photogram. Remote Sens. Spat. Inf. Sci.* **2015**, *40*, 165–172.
8. Shah, N.; Ghazali, M. A Systematic Review on Digital Technology for Enhancing User Experience in Museums. In *User Science and Engineering*; Abdullah, N., Wan Adnan, W., Foth, M., Eds.; Springer: Gateway East, Singapore, 2018; pp. 35–46.
9. Kang, Y.; Yang, K. Employing Digital Reality Technologies in Art Exhibitions and Museums: A Global Survey of Best Practices and Implications. In *Virtual and Augmented Reality in Education, Art, and Museums*; Guazzaroni, G., Pillai, A., Eds.; IGI Global: Hershey, PA, USA, 2020; pp. 139–161.
10. Pantile, D.; Frasca, R.; Mazzeo, A.; Ventralla, M.; Verreschi, G. New technologies and tools for immersive and engaging visitor experiences in museums. In Proceedings of the 12th International Conference on Signal-Image Technology & Internet-Based Systems, Naples, Italy, 28 November–1 December 2016; pp. 463–467.
11. Mac Devitt, A. Editorial. *Mus. Int.* **2018**, *70*, 3–4. [CrossRef]
12. Dewdney, A. What Is the Current Fascination with VR on the Part of Museums and Art Galleries? In Contemporary Art Society Annual Conference: The Virtual in Museums: Hot Medium? Available online: https://openresearch.lsbu.ac.uk/item/86qyq (accessed on 20 March 2020).
13. Auffret, S. VR Opportunities, White Paper, Arts Management and Technology Laboratory. 2017. Available online: https://static1.squarespace.com/static/51d98be2e4b05a25fc200cbc/t/59760593d482e9419b20a5c7/1500906901804/VR++Opportunities.pdf (accessed on 5 March 2020).
14. Loumos, G.; Kargas, A.; Varoutas, D. Augmented and virtual reality technologies in cultural sector: Exploring their usefulness and the perceived ease of use. *JMC* **2018**, *4*, 307–322.

15. Wang, B.; Liu, Y. The Research on Application of Virtual Reality Technology in Museums. *J. Phys.* **2019**, *1302*, 042049. [CrossRef]

16. Marques, D.; Costello, R. Concerns and Challenges Developing Mobile Augmented Reality Experiences for Museum Exhibitions. *Curator* **2018**, *61*, 541–558. [CrossRef]

17. Shehade, M.; Stylianou-Lambert, T. The Future of Technology in Museums. In Proceedings of the Future of Tradition in Museology: Materials for a Discussion, Papers from the ICOFOM 42nd Symposium, Kyoto, Japan, 1–7 September 2019; pp. 153–158.

18. Li, Y.; Liew, A.; Su, W. The digital museum: Challenges and solution. In Proceedings of the 8th International Conference on Information Science and Digital Content Technology (ICIDT2012), Jeju, Korea, 26–28 June 2012; pp. 646–649.

19. Jarrier, E.; Bourgeon-Renault, D. Impact of mediation devices on the museum visit experience and on visitors' behavioural intentions. *Int. J. Arts Manag.* **2012**, *15*, 18–29.

20. Kang, Y.W. The applications of digital reality in creative and oceanic cultural industries: The case of Taiwan. In *Cases on Immersive Virtual Reality Techniques*; Yang, K.C., Ed.; IGI Global: Hershey, PA, USA, 2019; pp. 269–296.

21. Parker, E.; Saker, M. Art museums and the incorporation of virtual reality: Examining the impact of VR on spatial and social norms. *Convergence* **2020**, 1–15. [CrossRef]

22. Flick, U. *An Introduction to Qualitative Research*, 4th ed.; SAGE Publications: London, UK, 2009.

23. Thornberg, R.; Charmaz, K. Grounded Theory and Theoretical Coding. In *The Sage Handbook of Qualitative Data Analysis*; Flick, U., Ed.; Sage Publications: London, UK, 2014; pp. 153–169.

24. Mason, J. *Qualitative Researching*, 2nd ed.; SAGE Publications: London, UK, 2002.

25. Crouch, M.; McKenzie, H. The logic of small samples in interview-based qualitative research. *Soc. Sci. Inf.* **2006**, *45*, 483–499. [CrossRef]

26. Corbin, J.; Strauss, A. Grounded theory research: Procedures, canons, and evaluative criteria. *Qual. Sociol.* **1990**, *13*, 3–21. [CrossRef]

27. Corbin, J.; Strauss, A. *Basics of Qualitative Research: Techniques and Procedures for Developing Grounded Theory*, 4th ed.; SAGE Publications: Thousand Oaks, CA, USA, 2014.

28. Pop, I.; Borza, A. Technological innovations in museums as a source of competitive advantage. In Proceedings of the 2nd International Scientific Conference SAMRO, Sibiu, Romania, 14–16 October 2016; Volume 1, pp. 398–405.

29. Guazzaroni, G. Role of Emotions in Interactive Museums: How Art and Virtual Reality Affect Emotions. In *Virtual and Augmented Reality in Education, Art, and Museums*; Guazzaroni, G., Pillai, A., Eds.; IGI Global: Hershey PA, USA, 2020; pp. 174–193.

30. Milk, C. How Virtual Reality Can Create the Ultimate Empathy Machine. TED 2015. Available online: https://scholar.google.com/scholar?q=milk+2015+virtual+reality+empathy&btnG=&hl=en&as_sdt=0%2C48 (accessed on 5 April 2020).

31. Freeman, A.; Adams Becker, S.; Cummins, M.; McKelroy, E.; Giesinger, C.; Yuhnke, B. *NMC Horizon Report: 2016 Museum Edition*; The New Media Consortium: Austin, TX, USA, 2016.

32. Castaneda, L.; Bindman, S.; Cechony, A.; Sidhu, M. The Disconnect between Real and Virtually Real Worlds: The Challenges of Using VR with Adolescents. *Presence* **2018**, *26*, 453–464. [CrossRef]

33. He, Z.; Wu, L.; Li, X. When art meets tech: The role of augmented reality in enhancing museum experiences and purchase intentions. *Tour. Manag.* **2018**, *68*, 127–139. [CrossRef]

34. Dodge, R. Technology—Are Museums keeping pace? *MUSE* **2016**, *35*, 40–45.

35. Bearman, D.; Geber, K. Transforming Cultural Heritage Institutions through New Media. *Mus. Manag. Curatorship* **2008**, *23*, 385–399. [CrossRef]

36. Hunt, J. Museums of the Future. In *Re-Thinking Technology in Museums: Towards a New Understanding of People's Experience in Museums, Proceedings of the International Workshop: "Re-Thinking Technology in Museums", Interaction Design Centre, Limerick, Ireland, 29–30 June 2005*; Ciolfi, L., Cooke, M., Hall, T., Bannon, L., Oliva, S., Eds.; University of Limerick: Limerick, Ireland, 2005; pp. 6–8.

37. Mayr, E.; Wessel, D. Potentials and challenges of mobile media in museums. *Int. J. Interact. Mob. Technol.* **2007**, *1*, 1–30.

38. Damala, A.; Van der Vaart, M.; Clarke, L.; Hornrcker, E.; Avram, G.; Kockelkorn, H.; Ruthven, I. Evaluating Tangible and Multisensory Museum Visiting Experiences: Lessons Learned from the meSch Project. MW2016:

Museums and the Web 2016. Available online: https://mw2016.museumsandtheweb.com/paper/evaluating-tangible-and-multisensory-museum-visiting-experiences-lessons-learned-from-the-mesch-project/ (accessed on 20 May 2020).

39. Ciolfi, L.; Cooke, M.; Hall, T.; Bannon, L.; Oliva, S. (Eds.) Re-Thinking Technology in Museums: Towards a new understanding of people's experience in museums. In Proceedings of the International Workshop: "Re-Thinking Technology in Museums: Towards a New Understanding of People's Experience in Museums", Limerick, Ireland, 29–30 June 2005.

40. Chan, S.; Cope, A. Strategies against Architecture: Interactive Media and Transformative Technology at Cooper Hewitt, MW2015: Museums and the Web 2015. Available online: http://mw2015.museumsandtheweb.com/paper/strategies-against-architecture-interactive-media-and-transformative-technology-at-cooper-hewitt/ (accessed on 20 May 2020).

41. Meecham, P. Social Work: Museums. Technology and material culture. In *Museums Communication and Social Media*; Drotner, K., Schrøder, K., Eds.; Routledge: New York, NY, USA, 2013; pp. 59–87.

42. Dueholm, J.; Smed, K. Heritage authenticities—A case study of authenticity perceptions at a Danish heritage site. *J. Herit. Tour.* **2014**, *9*, 285–298. [CrossRef]

43. Shehade, M.; Stylianou-Lambert, T. Revisiting authenticity in the age of the digital transformation of cultural tourism. In *Cultural and Tourism Innovation in the Digital Era*; Katsoni, V., Spyriadis, T., Eds.; Springer: Cham, Switzerland, 2020; pp. 3–16.

44. Trant, J. Emerging convergence? Thoughts on museums, archives, libraries, and professional training. *Mus. Manag. Curatorship* **2009**, *24*, 369–387. [CrossRef]

45. Marty, P. Finding the skills for tomorrow: Information literacy and museum information professionals. *Mus. Manag. Curatorship* **2006**, *21*, 317–335. [CrossRef]

46. Medic, S.; Pavlovic, N. Mobile technologies in museum exhibitions. *Turiz. J.* **2014**, *18*, 166–174. [CrossRef]

47. Ch'ng, E.; Cai, Y.; Thwaites, H. Special Issue on VR for Culture and Heritage: The Experience of Cultural Heritage with Virtual Reality: Guest Editors' Introduction. *Presence* **2018**, *26*, iii–vi.