

Article

# Artful—An AR Social Self-Guided Tour App for Cultural Learning in Museum Settings

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**Abstract:** The cultural heritage sector has often acted as catalyst in allowing groups to coexist harmonically by investing in intercultural dialogue. Nonetheless, the vast majority of cultural experiences offered by cultural institutions rarely take provisions to make such experiences inclusive for groups with diverse sociocultural characteristics. In this context, this study explores the hypothesis that the adoption of Web 2.0 design patterns could enhance the public's participation and inclusion by making visitors co-creators of the offered cultural experience, and help museums transform into more inclusive spaces by enhancing knowledge sharing and social learning. A self-guided tour tool with augmented reality and social features is proposed to facilitate the creation of an online learning community for museum staff and visitors, and to enable information sharing and interactions. Initially, the paper's theoretical background is presented, focusing on the analysis of social educational theories. Next, a state-of-the-art analysis is conducted. The two aforementioned analyses provide both direction and impetus to the design process and research inquiry. Following this, the key functionalities of the proposed application are presented. A preliminary small-scale experiment conducted in an art exhibition showed that its use could be efficient, as positive feedback was obtained.

**Keywords:** cultural learning; social learning theories; mobile application; Web 2.0; social media tool; augmented reality; museums; cultural institutions; inclusion; participation



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## 1. Introduction

The cultural heritage (CH) sector has always acted as catalyst in allowing groups to coexist harmonically by investing in cultural diversity and intercultural dialogue. However, the vast majority of the cultural experiences offered by cultural institutions are designed to address the mainstream audience and rarely take provisions to make these experiences inclusive for groups with diverse sociocultural characteristics. Inclusiveness and social cohesion may be hindered by a number of factors ranging from poverty and cultural misalignment between visitors and the provided experience to experiences insufficiently targeted to attract diverse audiences. Excluded sociocultural groups are not attracted in cultural institutions per se, because their cultural interests are not sufficiently reflected in or connected to the offered experiences. Making them co-creators of the offered museum cultural experience could increase their interest and foster their cultural inclusion and cohesion with the rest of the society. When people can actively participate in cultural institutions, these places become central to the cultural and community life. Similarly, cultural institutions can reconnect with the public by inviting visitors to actively participate not as passive consumers, but as contributors to the offered experiences.

Nowadays, the Social Web has ushered in a varying set of Web 2.0 tools and design patterns that make public's participation more accessible than ever. Visitors expect the ability to discuss, share, and remix what they consume, becoming more and more accustomed to participatory learning experiences. Specifically, the current information revolution requires the adoption of learning models that cultivate skills such as creative and critical thinking,

reflection, and collaboration. However, the adoption of the Web 2.0 philosophy is understandably not a simple matter to approach for museums, as it requires the establishment of a delicate balance between different priorities. In addition, although learning theories that take into account the social and active nature of learning have gained authority among educators, in most cases, learning in museum settings still largely remains a top-down activity up to this point. Therefore, the adoption of Web 2.0 principles should not be viewed as a kind of panacea in the museum sphere. Instead, museum specialists should pursue a cautious re-examination of current practices in order to carefully redefine their relationship with their audience. In this context, the ongoing research of both successful and unsuccessful cases of Web 2.0 museum practices is of great importance, studying the matter of how visitors can be engaged in cultural learning processes where identity can be shaped, merging both the domains of individuality and collective cohesion.

In this context, in order to increase the democratization of culture and wider participation, while at the same time respecting museums' authority and identity, this paper proposes the design and development of an efficient technology-based solution that could facilitate the creation of an online learning community for curators and museum visitors. Its main aim is to facilitate the sharing and discussing of cultural experiences and information, and many other types of interactions among them. Thus, the ability of these individuals to reflect and connect with the cultural offerings could be restored by engaging in a process of collective learning in a shared domain of cultural endeavor. In more detail, the scope of this research work is to provide a user-friendly tool where curators can offer expert commentaries on artifacts, follow and monitor visitors' activity, and interact with them. On the other hand, the proposed application could also be used by visitors as an interactive self-guided tour tool with augmented reality (AR) features for exploring museum exhibitions, encouraging them at the same time to adopt an active role through interaction with other visitors, content sharing, and feedback provision. Therefore, the AR-enhanced exhibition navigation screen is considered the core of the ARTful mobile application. The sharing of cultural learning episodes aims to enhance awareness, participation, and contribution of new cultural material for visitors, and enable cultural institutions to expose their audience to diverse cultural content, aggregated to through the continuous passing of visitors. Taking into consideration the propositions of modern social learning theories and the state-of-the-art analysis, the main aim of this study is to test the hypothesis that the educational use of such a social media tool could help museums transform into more democratizing, inclusive, and polyphonic spaces by enhancing knowledge sharing, social learning, reflection, and knowledge assessment attitudes.

To evaluate the proposed approach, a preliminary small-scaled experiment was conducted in an AR-enhanced art exhibition to test the educational potential and effectiveness of the developed application. In more detail, in order to assess the perceived quality of the proposed app, a questionnaire was used for evaluating cognitive, emotional, and behavioral elements of the participants' attitudes toward the use of the proposed app as a self-guided tour tool and its potential to enhance further cultural learning and social interactions among the audience. Specifically, the structure of this study is organized as follows:

- Section 2 elaborates on the introduction of educational theories in the field of museum education, focusing mainly on the impact and principles of more radical educational theories, such as social Constructivism, Communities of Practice, and Connectivism, which highlight the social and active nature of learning;
- Section 3 summarizes the current state of the art by reviewing related research works with respect to the creation of inclusive cultural experiences in the CH sector;
- Section 4 presents in detail the functionalities of the proposed tool; that it was designed and developed in the form of a social media mobile application;
- Section 5 presents the methodology adopted for evaluating the proposed application's efficacy and the analysis of the experimental results;
- Section 6 concludes the work and discusses future work.

## 2. Theoretical Framework

The current study focuses on the specialized educational field of museum education that conceives museums as important educational environments with a unique learning potential. In more detail, it studies the development of the educational role of non-formal education spaces and institutions, such as museums, that provide the potential for experimentation by listening and adapting to public's needs, in order to offer richer learning experiences. These learning experiences not only help the process of cognitive information, but also aim to enhance visitors' skills (e.g., critical thinking, self-knowledge, self-regulation, etc.). According to Philip Coombs [1], non-formal education has the potential to satisfy the learning demands of both individuals and collectivities. Unlike formal education, that is rigid with its rules and programs, it is flexible and considers local diversities of culture and society.

In the past, museum education practices and research have been challenged by abstract terms' confusing use and the absence of agreement on the definition of appropriate educational goals and expected outcomes, due to the lack of a coherent approach towards the use of educational theories in the museum space, a key factor in understanding how modern museum's educational strategy and operation are closely interconnected. George Hein's [2] analysis helped the establishment of a theoretical base for museum education that encourages learning of all kinds—changes in an individual's knowledge, skills, attitudes, beliefs, feelings, and concepts. His vision regarding the educational character of museums acted as a trigger for the introduction of new educational theories, which adopt a holistic approach to education. Therefore, George Hein's work on educational theories and their relationship to museum educational practice is still a point of reference today. George Hein's choice analysis also confirmed that there are no strict divisions between educational theories of learning and knowledge, which essentially means that multiple educational approaches can coexist in the museum space and practices.

In this context, this section presents the selected learning theories whose key principles provided both direction and impetus to the following design process and research inquiry. Specifically, Section 2.1 briefly presents the learning theory of Constructivism. Next, Section 2.2 describes Lev Vygotsky's learning theory of social Constructivism, highlighting the effect of social interactions in the enhancement of knowledge acquisition. Following this, in Section 2.3, the key features of the Communities of Practice (CoP) learning theory are defined, as well as their role in the definition of learning as a trajectory into a community process. Section 2.4 studies the connection between Web 2.0 tools and the learning theory of Connectivism, and their impact in learning. Last but not least, Section 2.5 concludes the current section.

### 2.1. Constructivism Learning Theory

George Hein is a strong advocate that Constructivism is the most appropriate choice of a learning theory that would serve best the educational character of a museum. Constructivism's learning approach supports that people actively construct their own knowledge and that reality is determined by learners' prior experiences [3]. Jean Piaget [4], who led the evolution of Constructivism, supported that subjects are motivated by an innate desire to learn. People shape their knowledge through constructing one logical structure after another. Knowledge is constructed, rather than innate, or passively absorbed, and a person's prior knowledge influences what new or modified knowledge they construct from new learning experiences. Furthermore, all knowledge is personal, meaning that learners create their own subjective point of view, based on existing knowledge and values. Therefore, the same stimulus may result in different learning outcomes in each person, as their personal interpretations differ. Constructivism also suggests that conclusions reached by the learner are not validated by some external standard of truth, but only within the experience of the learner. According George Hein's analysis [2], a set of features that a Constructivist museum should include are:

- (i) Ensuring that visitors can establish meaningful connections to the offered cognitive content;
- (ii) Adapting its educational processes to the needs of each visitor;
- (iii) Providing sources of knowledge beyond exhibits;
- (iv) Collaboration with external organizations that make a museum's character more open and offer more learning opportunities for visitors;
- (v) Encouraging social interaction between visitors;
- (vi) Providing demanding intellectual activities that motivate visitors to learn and acquire new meanings and cognitive loads;
- (vii) Developing self-awareness and self-regulation techniques in a museum's workforce, so that all employees can evaluate themselves and the museum's functions;
- (viii) The pursuit of continually improving its effectiveness through visitor studies;
- (ix) The visitors' tour of the museum space should be dynamic, and not linear;
- (x) A one and only truth is not supported, but rather a range of views, a variety of interpretations of a particular theme or an exhibition exhibit;
- (xi) Visitors are invited to reflect, to express their views, and to provide feedback based on their museum experience;
- (xii) Problem-centered and discovery-based learning is encouraged.

Curator Ted Ansbacher [5] offered constructive criticism to George Hein's analysis, mentioning that, despite the invaluable contribution of his work to the museum education field, he failed to address some ambiguities of Constructivism. George Hein accepted the criticism, admitting that he did not manage to cover issues such as the significant differences between social and personal Constructivism. Specifically, he highlighted this issue by stating: "Personal Constructivism is inevitable, but does little to socialize the learner into a larger intellectual community. Social Constructivism—as described so brilliantly by Lev Vygotsky and many since—is what education is about" [5].

## 2.2. Social Constructivism Learning Theory

Constructivism can be currently considered the dominant research perspective in the scientific field of learning. Although different versions of Constructivism share basic core ideas, it comes mainly in two varieties: individualist and social. According to the former, based on the influence of Jean Piaget [4], the individual is the source of everything, whereas according to the second knowledge is constructed within social groups. Social Constructivism was developed by Lev Vygotsky who suggested that "Every function in the child's cultural development appears twice: first, on the social level and, later on, on the individual level; first, between people (interpsychological) and then inside the child (intrapsychological)" [6]. His learning theory emphasized the importance of the social nature of learning, suggesting that the true direction of thinking during activities in a defined social environment does not go from the individual to the social, but from the social to the individual. According to social Constructivism, learning is considered a collaborative process and knowledge is constructed while individuals interact with their culture and society. The individual is enriched by society and society is enriched, in return, by the individual.

The "Zone of Proximal Development" (ZPD), a term developed by Lev Vygotsky, refers to the range of tasks a learner is given in the process of learning. The lower limit is the level of competence the learner has gained by working independently (also referred to as the learner's actual level of development). The upper limit is the level of potential that the learner is capable of conquering with the help of a more capable guide. Specifically, Lev Vygotsky [6] used the ZPD term to explain the relationship between learning and cognitive development. According to individualist Constructivism, development always precedes learning. Therefore, learners first need to reach a certain level of maturity before learning. Lev Vygotsky rejected this position, arguing that learning precedes development. In other words, through the help (i.e., scaffolding) of a more capable person, a learner is capable of learning skills when they exceed their actual level of maturity and development.

He states that each person's cognitive learning potential can be enriched with environmental assistance. Through the mediation of social interactions (of the teacher, parents, peers, etc.), the individual can interactively achieve a higher level of cognition than they possess. When two people collaborate, there is mutual involvement and knowledge-building (i.e., peer-to-peer learning), resulting in the development of new structures that a person would not develop on their own. Spontaneous knowledge (unprocessed) and non-spontaneous (scientific) work together, and are mutually reinforced.

Last but not least, in social Constructivism, a significant element is the acquisition of language. Language is the key mediator for the development of thought and is social in nature. According to Lev Vygotsky [7], language (and especially reason) is fundamental to learners' cognitive development, because language provides purpose, so that behaviors can be better understood. Through the use of discourse, learners are able to communicate and learn from others. Through dialogue, non-systematic, disorganized, and spontaneous thinking is met with more systematic, rational, and correct perceptions. He also suggested that language has a social character, not a self-centered one, that later, in the mature person, will evolve into an internal, silent language. Learners' interactions with others play a dominant role in the development of their perception and sensibility.

### *2.3. Communities of Practice (CoP) Learning Theory*

Etienne Wenger formulated the learning theory of CoP [8]. According to his theory, a CoP can be defined as a group of people sharing one common interest in a field of human activity and is committed to a collaborative learning process that creates links between a community's members [9]. Etienne Wenger also argued that "not every community of people is necessarily a CoP. For example, a neighborhood is often a community, but usually not a CoP" [8]. Members of a CoP should share a common passion for something they know how to do, and regularly interact for the purpose of improving their skill.

Etienne Wenger's work [8] defined the four necessary components of social learning theory: meaning, practice, community, and identity. These four key components are interconnected and mutually defining. Specifically, meaning is a way of talking about a learner's ability to experience their life and the world as meaningful. Practice refers to a way of talking about the shared information that can sustain mutual engagement in action. For example, members of a CoP develop a collective stock together and, over time, resources, or in other words, they form a common practice, and in many cases, members are not even aware of this happening. The mere exercise of the same interest/activity is considered necessary, but not a sufficient condition. In order to form a CoP, interaction is required between its members, as is the development of a sense of belonging. Via their interaction, members have to share practices, experiences, and knowledge. They learn collectively by influencing each other. Identity refers to a way of talking about how learning and participating changes members and their idea of their self, and influences their personality to better fit in the CoP context. According to Etienne Wenger [8], in a CoP, different levels of participation and integration are observed.

Although Etienne Wenger claimed that the concept of CoP was not influenced by previous theories, according to [10], social Constructivism offered a solid foundation for its development, since it was Lev Vygotsky's work [6] that introduced the importance of social context, viewing the learning procedure from a new angle. Indeed, these two learning theories differ from each other from the starting concept of the nature of learning, because Constructivism locates learning at acquisition, while CoPs locate learning at participation. In addition, Constructivism defines knowledge as mind constructions within the learner's mind, while CoPs view knowledge as valuable shared resources. Conversation and discourse appear in both theories as a tool for negotiation and participation; however, learners are motivated by different reasons. As it is understood, Lev Vygotsky [6,7,11] and Etienne Wenger [8,9] attribute the same emphasis to the social context, which people are learning in; however, they do so by adopting different perspectives and assumptions.

Recently, in the literature, there has emerged the notion of virtual CoPs, where members make use of Web 2.0 technologies to communicate and interact [12]. In more detail, online communities create virtual spaces that enrich knowledge sharing beyond narrow geographical boundaries. Consequently, a virtual Community of Practice (VCoP) is a network of people who share an area of interest and communicate about it online. Currently, VCoPs and virtual learning communities are increasingly being disseminated to modern societies, thanks to technological developments that promote interactive communication patterns in conjunction with adequate collaborative pedagogical models.

#### *2.4. Web 2.0 Connection to Connectivism and Its Impact in Learning*

Virtual communities offer the ability to combine modern and asynchronous communication, increasing the number of learner–educator and learner–learner interactions [13–15]. In this study, the Web 2.0 term is used from a learning perspective and not a technological one, and it refers to websites and applications that make use of user-generated content for end users. It reflects the new age of the internet, which puts greater emphasis on social networking, cloud computing, higher participation levels and sharing information between internet users, and collaboration [16]. Web 2.0 technologies allow users to be social producers, rather than just consumers, while their active participation enhances the tools through their use in return.

There is a rather rich body of research reporting that the introduction of Web 2.0 in learning has significant potential to support and enhance learners' overall learning [15,17]. Learners using Web 2.0 technologies are currently able to participate directly in the creation, refinement, and distribution of shared content, in contrast to being merely passive receivers of information [18]. Web 2.0 tools make knowledge decentralized, accessible, and co-constructed by and among a broad base of participants [19]. In addition, they empower the sense of belonging in a learning community [13] and enhance the quality of the collaboration by stimulating new modes of enquiry, knowledge creation, and sharing [13–20]. Studies also suggest that the use of Web 2.0 tools seem to enhance learners' engagement, confidence, autonomy, and motivation [20–22]. Furthermore, Web 2.0 enabled learners to become information evaluators as opposed to passive learners who merely reflect their instructor's knowledge [23]. As evaluators, they are encouraged to think critically about the information and actively engage in its evaluation by providing feedback. Finally, participants tend to develop a sense of ownership [20] that motivates them to produce quality work [24]. This process is closely connected with the shaping of their identity within virtual learning spaces and how fellow members perceive them.

However, it is of special importance that the value of Web 2.0 should not be exaggerated, because the crucial matter is how such practices can be incorporated organically and effectively into the learning process [25]. Therefore, with this new generation of learners, who are using the Internet as part of their daily lives and are growing less and less satisfied with being passive users, pedagogical approaches need to adapt. The learning theory of Connectivism was conceived as an answer to the belief that there was a need for a learning theory that took into account the manner in which society has changed due to rapid digital technology advancement. Connectivism, introduced by George Siemens [26], pulls together the understanding of learning with and into the Web, meaning that the efficient use of Web 2.0 technologies is the key to the Connectivist pedagogical practice. Connectivism argues that learning (defined as actionable knowledge) can reside outside of people (e.g., within an organization or a database), and focuses on connecting specialized information sets. In more detail, learning becomes a process of connecting specialized information sets, and the connections that enable us to learn more are more important than our current state of knowing [26]. The acquisition of new knowledge is established when connections between ideas and perspectives are made, with technology having a key role in facilitating the connections necessary for learning to occur [27]. Such connections enable learners to acquire more knowledge. The ability to draw distinctions between important and unimportant information is also vital. Connectivism's key principles are summarized [26] as below:

- Learning is enhanced by opinion diversity and is a process of connecting specialized nodes or information sources;
- Learning and knowledge may reside in non-human appliances, and currency (accurate, up-to-date knowledge) is the purpose of all Connectivist learning activities;
- Developing and maintaining connections is needed to facilitate continual learning;
- Capacity to know more is more critical than what is currently known;
- Self-regulation and decision making in the learning process is vital. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality.

As it is understood, the fundamental insight offered by Connectivism concerns learners' ability to construct their own chosen social networks that act as personal learning environments, fostering and sustaining the flow of knowledge and information.

### *2.5. Conclusions Regarding the Analysis of the Theoretical Framework*

Currently, a paradigm shift is taking place regarding the composite matter of education and learning, due to the increasing complexity of modern societies, generated by the intersection of diverse fields of study, such as culture, technology, and communication. Therefore, dominant educational models developed in the past century in response to the industrial revolution are rapidly becoming obsolete. The current information revolution requires the adoption of learning models that cultivate skills such as creative and critical thinking, reflection, and collaboration. Against this background, the current section has elaborated on the introduction of educational theories in the field of museum education, and focused mainly on the impact and principles of more radical educational theories, such as social Constructivism, CoPs, and Connectivism. However, it should be remembered that even though social learning theories have gained authority among educators, in most cases, learning in museum settings largely remains a top-down activity. In this context, the main purpose of the analysis of the aforementioned theories' key principles was to help the ARTful mobile app's design process, meaning that its functionalities were influenced by the intention to create a technological solution that serves their main propositions, so that its use could potentially enhance the social character of learning in the museum space.

### **3. Related Literature and Studies**

Museums have long invested in digital forms of presence, as proved by the numerous virtual museums and on-line exhibitions [28]. However, such paradigms are based mostly on top-down practices with very little input sought from visitors. The rise in Web 2.0 and social media tools offers the possibility for the public, on the contrary, to become engaged, to make the museum offer their own, or even to produce and share content, rejecting vertical hierarchical structures. The current section presents a state-of-the-art analysis regarding recent research works that study how and to what degree the integration of Web 2.0 principles from a learning perspective [29] is managed by museums, along with the question of how their practices, their role, and their relationship with their audience is influenced by such a shift in paradigm.

Social learning practices can contribute to the transformation of the museum from a space where there are just exhibits on display to a place of interaction between citizens and society, where meaning and connective knowledge is constructed through a collective and social process [30]. Specifically, cultural institutions are often considered a medium where emerging social issues of various social groups can be discussed. Therefore, their role should not be limited to the conservation of objects; memory must not only be preserved, but also relived through processes that enable its preservation and its process [30]. In this case, cultural institutions have to face the issue of integration not only of the material culture, but also of their oral history into the framework of CH experiences [31]. Material culture and oral history can be related through personal or collective memories and views. Artifacts are related to autobiographies and storytelling because of the meaning and the resonance they hold with a person's memory.

Lois Silverman [32] supported the idea that museum visitors construct deeply personalized (or very detached) meanings from the explicit content of an exhibition. Therefore, the collection of oral history testimonies should not be restricted to specific target groups. On the contrary, a wide range of diverse views can shape a more complete representation of the information plurality concerning a certain artifact. Particularly, views of marginalized groups are often neglected by society due to the problem of “othering”. In more detail, one’s identity constituted the beliefs, values, qualities, and expressions within which they are trained, constructing the sense of self and how they perceive themselves. At the same time, our identity also creates the idea of the constitutive “Other” and how we perceive the other people, according to our similarities and dissimilarities with them. John Powell and Stephen Menendia [33] suggest pluralism and multiculturalism as an answer to the issue of othering, which could provide space for not only acceptance or diversity, but also for the recreation of new inclusive narratives, identities, and structures. Museums and cultural institutions in modern societies can act as agents of cultural understanding by mirroring diversity and tolerance, and by calling to actions that increase social cohesion through the design of cultural experiences that take into account diverse sociocultural groups.

Nowadays, IT developers and museum specialists have in their disposal a wide selection and variety of Web 2.0 tools (blogs, Wikis, etc.) that can be used in a variety of educational scenarios, as well as a plethora of creative digital tools with a higher degree of specialization, such as Storybird (Storybird Web 2.0 tool <http://storybird.com>) for creative writing short stories alongside illustrations, PowToon (Powtoon video maker Web 2.0 tool <http://powtoon.com>) for creating videos, or MakeBeliefsComix (Make beliefs Comix Web 2.0 tool <http://makebeliefscomix.com>) for creating comics. Another instance is PicBreeder (Pibreeder Web 2.0 tool <http://picbreeder.org/>), a collaborative art application based on the idea of evolutionary art that stores images created through interactive evolution in a public gallery, where users can edit each other’s creations. Recent research works that stand out include cultural awareness games developed by the CrossCult project, where a badge system rewards users that explore how to combine paintings on a virtual gallery wall [34], while exploring the city and contributing their stories. In this way, interactive narratives that maximize situational curiosity and learning are enabled. Furthermore, the PLUGGY project provides a social platform where audiences act as storytellers. Specifically, participants can create personalized stories and share them on social networks. The shared material is both crowd-sourced and retrieved from digital collections, allowing users to establish connections between seemingly unrelated facts, events, people, and digitized collections [35]. Moreover, the GIFT project, designed and developed in partnership with leading museums, called the GIFT Box [36], is a set of free, open-source tools that enables visitors to compose their own museum tours as digital “mixtapes” and share their creations with close contacts.

Such innovative approaches place interaction at the heart of the museum strategy and are considered by researchers as emblematic cases of Web 2.0 practices that enhance visitors’ skills and redefine their relationship with the museum. However, these initiatives can be considered the exception and not the rule. Paul Capriotti et al. [37] conclude that museums currently pursue a low level of interactivity regarding the presentation of information, relying mostly on traditional forms of reporting, and practice a medium level of interactivity with regard to the interaction resources.

Nevertheless, it should be highlighted that such paradigms of shift are, as expected, followed by consequences for the visitor–museum relationship. Yet, the possible challenges and limitations of such efforts are rarely addressed and discussed in the literature, which is unfortunate since the addition and analysis of unsuccessful cases could also contribute to an improvement in current Web 2.0 practices [38]. Paradoxical tensions may be induced that challenge museums’ authority and legitimacy and disenchant the public’s visit experience [39]. Nina Simon [40] further argues that visitors’ ability to produce quality content should not be exaggerated, as often happens in Web 2.0 practices, and a balance must be maintained between visitor input and curator expertise to ensure the quality and

coherence of museum content and exhibition interpretation. She also reports several tension triggers such as:

- Museums shape clearly defined spaces, while Web 2.0 tools define blurred boundaries allowing users to outline their own space;
- Museum exhibitions are usually fixed without many alterations after their completion, whereas Web 2.0 content is constantly updated;
- Museum specialists own authority in museums, but Web 2.0 practices hand power and control to users.

However, despite the challenges, experimentation with Web 2.0 practices, besides promoting greater educational opportunities for the audience and society, also offers other more straightforward benefits for cultural institutions' operation. For example, such practices can grant access to a wide range of observable visitor data in a fast and cost-efficient way. Valuable data can be translated into a stream of continuous visitor feedback, offering insight into how audiences perceive their museum experience or even information on their thoughts regarding exhibits. Such invaluable input can contribute to cultural institutions' practices improvement, social empowerment, and economic growth.

Specifically, the information collection around artifacts is a widely known methodology in cultural institutions [41]. Currently, several sources of information about autobiographies, artifacts, and intangible CH can be found from DBpedia (DBpedia <https://wiki.dbpedia.org/>), Europeana (Europeana <https://www.europeana.eu/en>), and other sources. At the core of figuring out the ways people perceive a given cultural item to serve large-scale research initiatives, there is the need to describe in a computer-understandable manner how they interact with it. Specifically, computer–audience interaction is needed for precise user modeling and content analysis in order to provide successful user experiences and generated content metadata. With the rapid rise in social networks and media in recent years, many research approaches focus on social interactions in order to design a general understanding of people's behaviors and their cultural background [42]. On top of this, social media and networking sites are the virtual space where subjects publicly interact and exchange views on several emerging issues. In particular, large-scale information on what people believe about any given topic remains present online in the form of social network activities.

Another part of research in this direction focuses on online experiences such as behaviors, tendencies, and preferences related to a user's activity. General user modeling techniques can be classified based on how much information they need from users and how they extract such information from their behavior. In particular, such techniques can either directly ask the user their personal information (explicit feedback) or simply extract it from specified user activities (implicit feedback) [43]. Directly asking information can be considered invasive; therefore, studies are focused mainly on the latter case, where users do not provide personal info and the modeling is based on how they behave in certain times, such as the recording and analysis of users' clicks in web page navigation [44].

To conclude, cultural institutions in collaboration with computer science experts can envision and construct adequate virtual and shared spaces to encourage visitors to create their own personal narratives within the museum space that best reflect their goals and needs. However, the degree of integration of Web 2.0 practices by museums surely depends on their readiness to redefine their relationship with their audience, and each case should be studied on its own. The adoption of Web 2.0 philosophy is understandably not a simple matter to approach and requires the creation of a completely new vision, one many museums are not familiar with. Although many already speak of a new digital and participatory revolution [45], this evolving process in the relationship between museums and their visitors is actually part of a movement that started many years back, with many unresolved difficulties [39]. As aforesaid, the matter of maintaining a certain degree of control over published content and reconciling the quality of information with users' freedom of participation is of great importance for a museum's authority and reputation [30,40]. This is an issue that surely requires the establishment of a delicate balance between different priorities.

Therefore, the ongoing talk about Web 2.0 tools viewed as a kind of panacea in the museum sphere calls for a cautious re-examination of current practices [39]. As [30] suggests, there is a lack of awareness of the potential of Web 2.0 for creating virtual communities around cultural institutions.

Instead of simply identifying technology tools, museum specialists should define specific goals before selecting appropriate technology solutions [39]. On the other hand, the adoption of Web 2.0 practices, even if they are well designed, unfortunately, does not guarantee the creation of a virtual meeting point in museum settings [30]. Usually, pre-existing active communities create successful museum virtual communities, while social media tools are used to enhance communication among its members [30]. Museums use web tools differently depending on their philosophy of communication and their identity [46]. However, it remains of great importance to continue the further research on both successful and unsuccessful cases of Web 2.0 museum practices that experiment with the concept of how visitors can be engaged in cultural learning processes, where identity can be shaped, merging the domains of individuality and collective cohesion.

#### 4. Design and Development of the Proposed Tool

Taking into careful consideration the sections of the social learning theories and the state-of-the-art analysis, the scope of this research work is to design, to develop, and to provide an efficient and creative technology-based solution that could facilitate the creation of a virtual learning community for curators and museum visitors, aiming to motivate participants to practice in discussing art and enable many types of interactions among them. In order to introduce an adequate Web 2.0 technology to museums that are typically less open to innovation, the proposed tool should facilitate such outcomes in an affordable and technically minimally demanding way for museums and its staff and visitors; a user-friendly tool where curators can offer expert commentaries on highlighted artifacts in the museum exhibition, follow and monitor visitors' activity, and interact with them. On the other hand, the proposed tool could also be used by visitors as a self-guided tour tool for exploring exhibitions. However, the audience should not be expected to remain passive, but on the contrary, should be encouraged to adopt an active role by offering input, expressing feelings, accessing each other's generated content, and providing each other with feedback. Therefore, the upper goal is to foster such a museum network activity that encourages a collective discussion with audiences by enabling visitors to relate to the exhibits by interacting with fellow museum visitors, learning from each other, and questioning their own understanding, while being exposed to a range of different perspectives concerning the same matter.

In more detail, for the creation of an efficient and easy-to-use mobile app, the 10 heuristic usability rules proposed by Jakob Nielsen [47] were followed and a heuristic evaluation was performed by having a number of individual evaluators inspect the interface by themselves. Prior to the implementation of the application, early usage scenarios were created (storyboards), which showcased a detailed description of the key features of the application using images and comments, and acted as guiding resources for its development (see Figure 1). The produced outcome of the design and development process was named 'ARtful'. Figure 2 depicts screenshots of its intro video. The font's shapes cross over and its colors are blended, representing the forming of an open, participatory and fluid community.

Next, in Section 4.1, the technological framework of the ARtful mobile app is briefly explained, as is how the application can be downloaded and installed. Section 4.2 presents the registration and login phase a user has to go through to use the app. Furthermore, Section 4.3 describes the components of the user interface (UI) of the application and the bottom menu for navigating through the screens hosted inside the app. Section 4.4 presents the addition of certain gamification features that aim to acquire, engage, and retain users. Finally, Section 4.5 provides some brief conclusions regarding the design and development process.

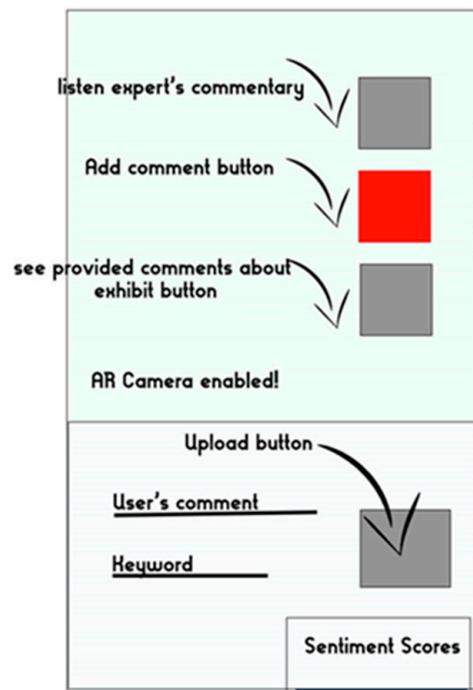


Figure 1. George Hein’s diagram classifying learning and knowledge theories ([2], p. 25).



Figure 2. ARTful’s logo presented in the app’s intro video.

#### 4.1. ARTful’s Mobile App Technological Framework

Figure 3 presents the ARTful mobile app’s technological framework. The proposed social tool was developed using Unity 3D (Unity Real-Time Development Platform <https://unity.com/>), a commercially available multiplatform game engine used for the production of 2D and 3D video games, as well as non-game interactive simulations and visualizations, along with the C# scripting language. ARTful was also built as an AR app using Unity’s Vuforia (Vuforia Developer Portal <https://developer.vuforia.com/>) SDK, which features computer vision functionality to recognize images and objects and enable people to interact with virtual and real-life objects overlaid in the physical environment, made digitally visible. In addition, Firebase’s (Firebase <https://firebase.google.com/>) real-time database was selected as a cloud-hosted database for data storage and retrieval, where the application’s data are stored in JSON format and synchronized in real-time for all ARTful mobile app’s users.

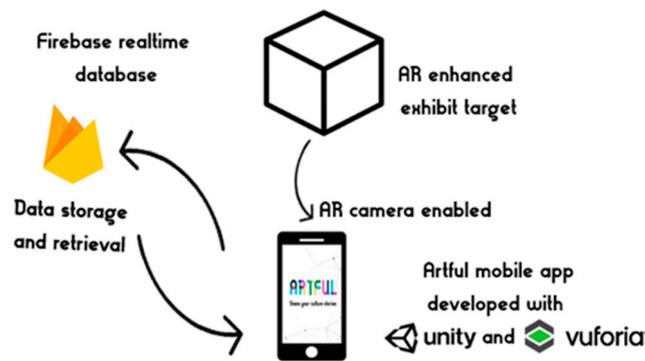


Figure 3. ARtful mobile app’s technological framework.

The commercially free ARtful mobile app has been added to the Google Play Store (ARtful mobile app on Google Play Store <https://play.google.com/store/apps/details?id=com.agramma.artful>) after extensive testing and bug fixing. Potential users can easily install it on their Android smartphone or tablet device by choosing to download and install the offered APK after visiting the aforementioned link. The ARtful mobile app requires an internet connection, since the app uses cloud computing for data storage and analytics.

4.2. Login and Registration

The first time the application is launched, if the device that the application runs on has Android version 6.0 or higher, a popup message shows up, requesting permissions for the app to access the phone camera and storage space for its proper functionality. Right after the permissions are granted, an intro video follows, greeting the user and informing them about the purpose of the app (see Figure 2). Figure 4 presents ARtful’s mobile app registration form. It consists of a number of input fields, reserved for the user’s email, name, surname, occupation, gender, age, and password, data that shape each user’s profile structure. In the future, such insightful contextual information can be used to enhance the application’s self-adaptation to diverse user profiles. Figure 5 presents an example of a JSON structure created after a user’s registration, stored in the Firebase real-time database. After user registration is complete, users can login by inserting their email and password (see Figure 4).

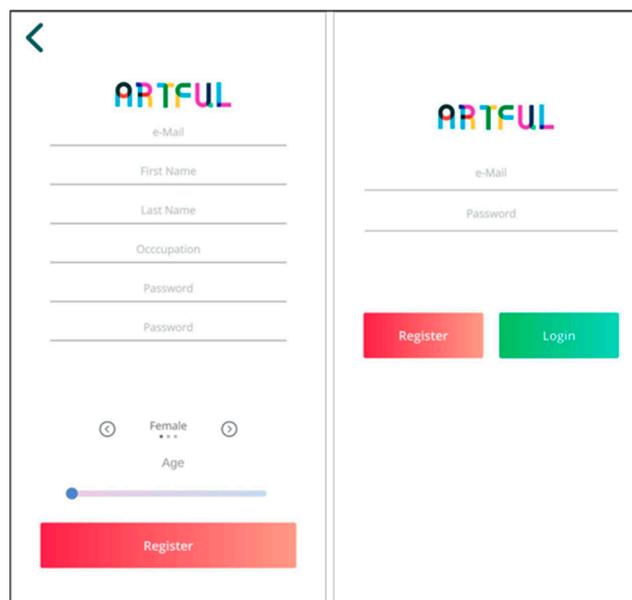


Figure 4. ARtful’s mobile app registration form.



**Figure 5.** ARtful mobile app’s user profile data structure example stored in JSON format.

According to Wenger’s theory, Ref. [8] within a CoP, different levels of participation and integration are defined. In this context, regarding the ARtful app, two types of user roles are possible at the moment, visitors and museum experts. Visitors’ accounts can be created by users themselves through ARtful’s registration form, while museum expert accounts can be created and authorized by the app developer. As we will see in Section 4.3, the ARtful mobile app has certain functionalities common to both groups of users and others that are user-specific.

#### 4.3. ARtful’s User Interface (UI), Navigation, and Available Functionalities

ARtful’s UI color palette was selected with the purpose of producing an impression of unity and harmony between its logo and its interface design, resulting in an appropriate and corresponding branding concept targeting to satisfy users’ visual perception sense. In addition, it was designed considering that users may have access to prior knowledge regarding Web 2.0 tools and social media, and can draw upon similarities between common usage patterns of familiar Web 2.0 tools and the ARtful mobile app. Therefore, the design of its functionalities and UI elements was influenced by popular Web 2.0 tools and social networks, such as Facebook and Twitter.

Specifically, users can navigate inside the app using the bottom menu (see Figure 6). Its menu icons correspond to the following available options:

- The **user’s profile screen**, where a user can edit their profile and personal timeline;
- The **news feed screen**, where a user can view the stream of all available posts;
- The **AR exhibition navigation screen**, where a user can experience an interactive and participative exhibition audio guide;
- The **user’s friend list screen**, where a user can manage their selection of friends;
- The **messaging system screen**, where a user can view their message history and message their friends;
- The **settings screen**, where a user can exit the app and edit their settings.



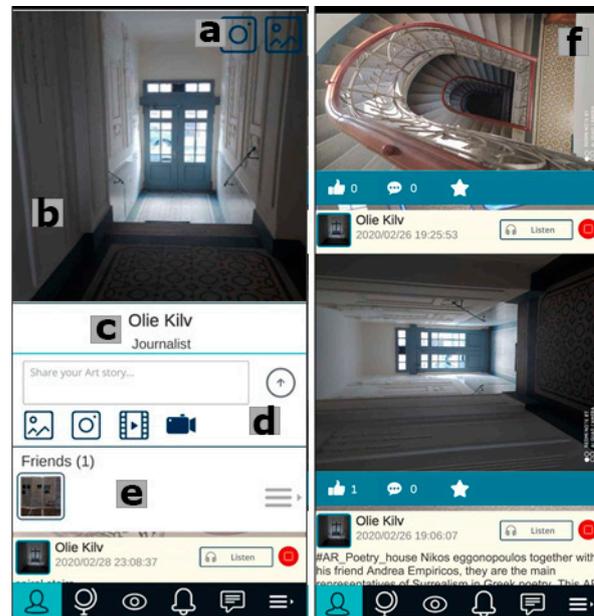
**Figure 6.** ARtful mobile app’s navigation bottom menu.

The most important features, along with the functionalities they provide, are described in detail in the following subsections.

##### 4.3.1. User’s Personalized Profile and App’s Main Functionalities

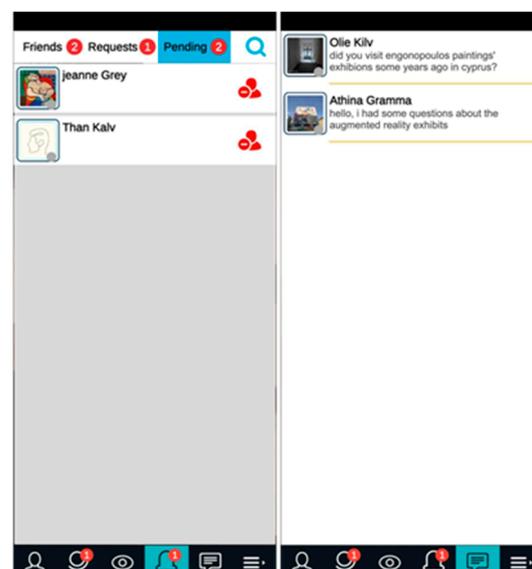
Web 2.0 tools should provide users with interactive services and control over their own content [48]. As mentioned in Section 2.2, users’ identity and its social formation within a virtual learning community is a central point to the CoP learning theory. Therefore, the ARtful mobile app enables users to differentiate themselves from other users by personalizing their profile. Figure 7 presents an example of a created user profile along with

the elements it contains. Users can upload a profile picture (see Figure 7b) and post feeds (see Figure 7d) that can contain video, text, and images, providing in-depth multimodal information about subjects that interest them.



**Figure 7.** Example screens of a visitor's user profile and timeline containing the following elements: (a) the user's profile image upload buttons, (b) the user's uploaded profile image, (c) the user's personal info, (d) the user's post input field and selection of its modality buttons, (e) the user's friends list, and (f) the user's post timeline.

Specifically, the users' timeline (see Figure 7f) acts as a digital log of their activity in reverse-chronological order, containing their updates. The functionality of creating, updating, and retaining their profile's content aims to help users develop a sense of ownership for their contributions [20,24], a feeling that can motivate users to try to share posts of higher quality [20]. Figure 7e presents a user's friends list feature. Users can visit their friends list (see Figure 8) screen and manage their connections by searching, inviting, removing, and adding other users. After two users become friends, they can further interact with each other through the messaging system (see Figure 8).



**Figure 8.** Two example screens of ARTful's messaging system and friends list section.

#### 4.3.2. ARTful's News Feed Screen

Learning cannot be constrained to formal educational environments, since it often is occasioned, not caused or premeditated. Thus, art concepts are infused into all aspects of daily life, and temporal and spatial boundaries between learning, leisure, and work are blurred. Art learning and discussion may derive from any related activity, such as reading a book, visiting an exhibition, or creating an artifact. By exposing cultural experiences in social media, the democratization of culture and wider participation are enhanced. Therefore, the ARTful mobile app aims to encourage users to share their cultural stories. Specifically, its news feed (see Figure 9), where users can view the posts of all users (or only their friends'), can serve as a discourse medium by providing learners with opportunities to socialize, express feelings, access each other's content, and offer each other feedback by commenting on or liking a post. In addition, the new knowledge construction and reflection is further supported by making knowledge and information such as fellow visitors' cultural learning episodes available to visitors, which otherwise would either be inaccessible or time-consuming for them to trace on their own. However, it should be taken into consideration that the access to unlimited user-generated content along with filtering options serves as an adequate feature if the proposed app is meant to be used for a certain exhibition or by a certain amount of users; otherwise, the audience might feel overwhelmed with too much information.



**Figure 9.** An example screen of a user's news feed screen.

#### 4.3.3. AR Enhanced Exhibition Navigation

ARTful can be used as a social media tool for sharing glimpses of art, but also as a user-friendly tool for creating interactive AR exhibition audio guides, where visitors can read/listen to expert commentaries and other visitors' comments concerning exhibits, share their own pieces of information, offer and receive feedback, and interact with them. Therefore, the AR-enhanced exhibition navigation screen is considered the core of the ARTful mobile application.

Specifically, museum experts' accounts have the right to create and publish posts regarding chosen exhibits, consisting of an image of the artifact, a unique hashtag, and their expert commentaries about it. Figure 10 presents an example of such a post. This type of expert post constitutes the main content of ARTful's interactive AR exhibition audio guides. In more detail, when a visitor navigates the exhibition space, they can visit the

AR-enhanced exhibition navigation screen by enabling the AR camera of the app. Then, each time they target an exhibit that has been added to the AR exhibition audio guide, the menu presented in Figure 11 appears. It consists of the following options:

- **Listen to the expert’s commentary about the targeted exhibit:** By pushing the headphones button (see Figure 11a), the visitor can listen to the expert’s commentary concerning the exhibit, which was published in the corresponding post. The feature of audio narration was considered important, so as not to interrupt visitors’ viewing experience of the exhibit;
- **Read/listen to other visitors’ shared content about the targeted exhibit:** By clicking the messages button (see Figure 11b), the visitor can view posts shared by other visitors and choose to listen to them by pushing the listen button. Filtering options are also offered that can help visitors more easily locate the comments most interesting to them. Specifically, they can search for posts containing a specific word or sentence (see Figure 12b), and they can also order comments by their popularity (see Figure 12c). Then, they can listen to all or only to the filtered posts by pushing the ‘listen to all’ button (see Figure 12a). They can also offer feedback by commenting on a post or by liking it;
- **Share their own content regarding the targeted exhibit:** By pushing the plus button (see Figure 11c), an input form appears to the visitor, where they can insert and upload their own personal comment about the targeted exhibit;
- **View keywords of most popular visitors’ shared comments about the exhibit:** By pushing the lock toggle button (see Figure 11d), the visitor can either enable or disable the appearance of floating words above the targeted exhibits (see Figure 13). The content of the words are the keywords of the five most popular visitors’ posts for that specific moment. By clicking on the ones that seem most interesting to them, visitors choose to listen to their content. Hence, visitors can find posts that seem interesting to them in a more immediate way, without interrupting their viewing experience by navigating through the comments screen.

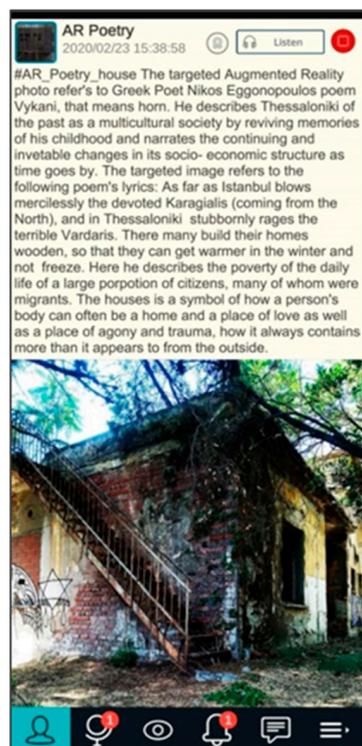
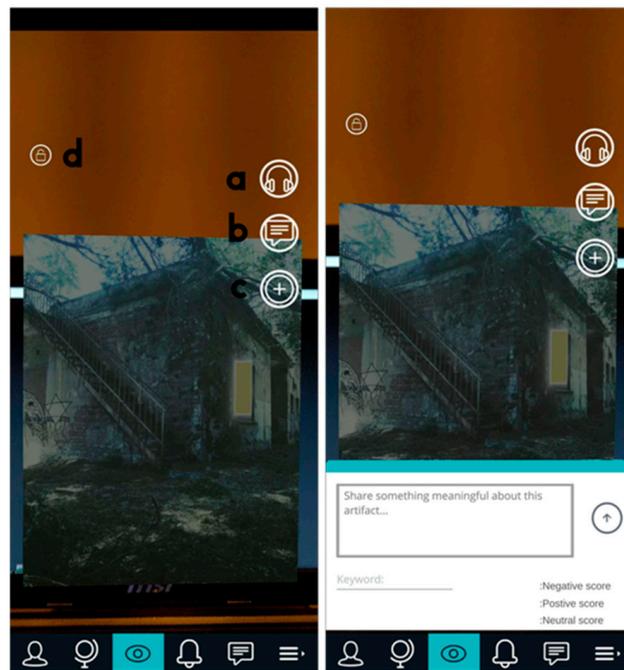
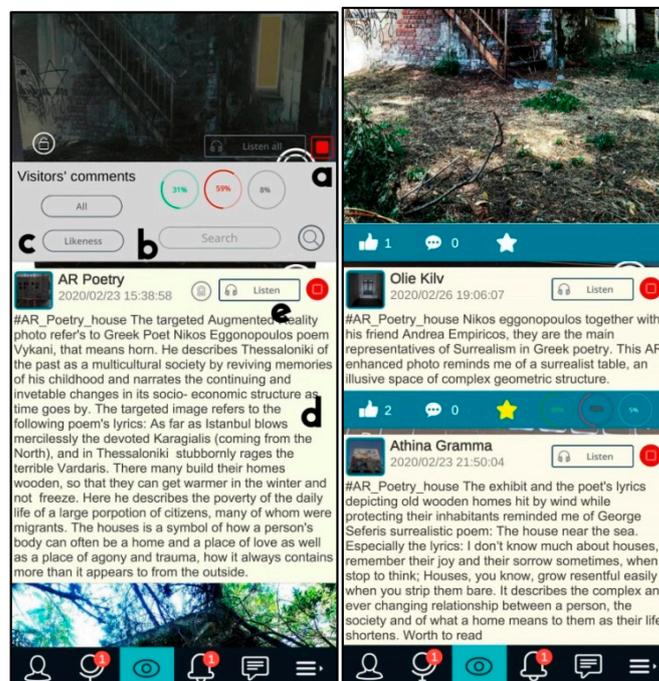


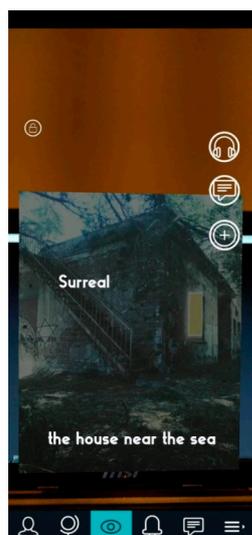
Figure 10. Example of a museum expert post regarding an exhibit.



**Figure 11.** The left picture presents the AR menu appearing when an exhibit is targeted by the device's camera. It includes the following options: (a) the headphones button for listening to the expert's commentary, (b) the messages button for reading/listening to and interacting with other visitors' posts, (c) the addition button in case a user would like to offer their own comment about the exhibit completing the form presented in the right picture, and (d) the keywords button for selecting keywords of most popular visitors' posts regarding that exhibit.



**Figure 12.** Read/listen to other visitors' shared content about the targeted exhibit screen. Its key features are: (a) the 'listen to all' button, which narrates the text content of the shared posts, (b) the search input field, where a visitor can filter posts by keywords, (c) the likeness button, which orders posts by their popularity, (d) uploaded posts, and (e) 'listen to a specific post' button.



**Figure 13.** Enabled view of floating keywords surrounding the targeted exhibit behaving as buttons that narrate the corresponding visitor's comment once it is clicked.

As aforementioned, the ultimate purpose of the functionalities of the AR-enhanced exhibition navigation screen is to provide many types of interactions, constructing a virtual meeting point for the audience. According to the learning theory of social Constructivism (see Section 2.1), the educator should offer scaffolds to learners adequate to their ZPD [6]. Web 2.0 tools, such as the ARtful social media app, not only allow more interaction between museum experts and visitors, but also enable the interaction with other visitors. In this way, visitors can learn from each other, reflect, and question their own understanding, while being exposed to a range of different perspectives and information concerning the same matter [49]. Hence, ARtful, as a Web 2.0 tool, has the potential to create a new time-space for communication [25], providing opportunities for more interaction between not only a visitor and a museum expert, but also between visitors themselves, even if they do not coexist in the exhibition space at the same time. Users may provide relevant material, discuss, comment, and share content. Therefore, the learning dialogue could last more and be enriched with even more perspectives.

However, the adoption of such Web 2.0 techniques by museums, apart from redefining their relationship with their audience by reinforcing the relationship with the public via the democratization of collections, may also introduce tensions by challenging their authority and the legitimacy and identity of these institutions [39]. Therefore, in order to pacify the potential worries of museum experts and curators, certain capabilities were added for museum experts' accounts to help them obtain more control over the visitors' generated content. Specifically, when a museum expert approves a visitor's post, they endorse it by enhancing its visibility. In more detail, when a post is liked by a museum expert account, the star icon (see Figure 13) is highlighted and, in addition, the endorsed posts appear before all the others when the visitors' 'shared comments' view is loaded on the screen. Moreover, a language and profanity filter has been integrated to ARtful to provide a variety of text filters, such as bad words and profanities filters that can be edited and extended, in order to prevent users from uploading inadequate and inappropriate content.

#### 4.4. Gamification Features for Enhancing Engagement

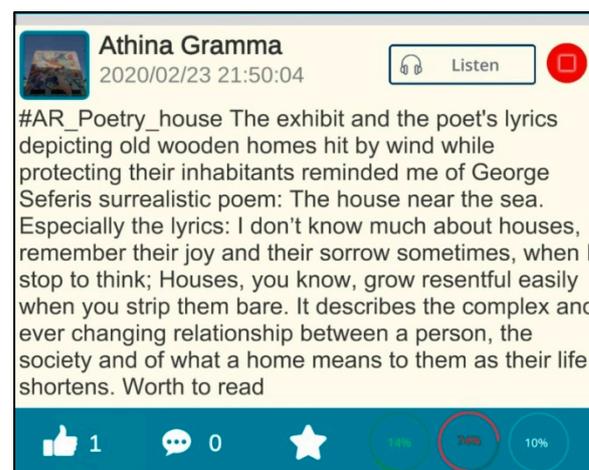
Web 2.0 tools adopt social engagement techniques to motivate users in participating and learning by enabling them to interact with each other and be involved in the making of educational content. Apart from Web 2.0 techniques, another method for enhancing users' engagement in using a learning application is gamification, which also uses social functions and involves implementing game mechanism elements in non-game applications [50]. Kapp Karl [51] defines two types of gamification: structural gamification and content

gamification. Structural gamification focuses on developing a gamified environment, while content gamification focuses on the content. The main ARtful mobile app's functionalities that can be considered its most prominent gaming elements are presented below:

- **Badges:** Gamification badges usually consist of simple virtual symbols that are considered structural gamification elements that symbolize rewards given to learners for their achievements, making them stand out in a virtual community. The ARtful mobile app supports two types of assigned badges (see Figure 14): one for participation, awarded to users with an intense post sharing activity, and one for popularity, assigned to users whose posts tend to receive a high number of likes and replies. The badges' icons are placed next to a user's profile picture and are visible to the whole community;
- **AR elements:** VR and AR technologies are reshaping users' experience, where physical and virtual objects are integrated at different levels. Unlike VR, which creates a totally artificial environment, AR users experience a real-world environment with generated perceptual information overlaid on top of it. Their brain is rewired in response to the experienced stimuli and new connections are built [52]. Therefore, AR technology has grown popular in educational processes for improving user engagement and performance. The ARtful mobile app uses AR elements such as pop-up keyword buttons (see Figures 11 and 13) and navigation menus to enhance users' touring experience with a fun element of unpredictability.
- **Post sentiment analysis:** Sentiment analysis is the process of computationally detecting if a specific body of text has a positive, negative, or neutral tone. ARtful uses the Unity 3D asset of sentiment analysis as a content gamification element to encourage users to focus on posts' content in a playful way by helping them identify the writer's sentiment towards a subject, and at the same time nudges them to contemplate if the computational analysis agrees with their own by reflecting further on the meanings presented in a post text (see Figure 15).



**Figure 14.** ARtful's gamification badges awarded to users for intense participating activity and popularity.



**Figure 15.** Example of a post text sentiment analysis computational result. The three loading bars at the bottom right of the picture along with their corresponding percentages estimate the positive, negative, and neutral feeling derived from the content of the post.

#### 4.5. Design and Development Phase Conclusions

This section has described the ARtful mobile app’s main functionalities. However, ARtful cannot be considered a traditional Web 2.0 app as far it concerns its technological development, since it was employed as a mobile app that does not utilize popular web technologies (e.g., HTML, CSS, AJAX, JavaScript). However, since it serves as a social media app, it supports Web 2.0 principles from a learning perspective (see Section 2.4). Future work may concern its development as a purely Progressive Web App (PWA), a browser-based application that has become an alternative to a native mobile app. As aforementioned, the aim of its design was the provision of an easy-to-use social media tool for both visitors and museum specialists that could facilitate the interconnection of visitors’ virtual experiences, by connecting individual interactions of users, as happens in popular social networks. The creation of a social network of posts, ratings, and comments aims to enable visitors to connect with others who have interacted with similar content, cultivating relationships and motivating them to practice art discussion. The design and development was influenced by the principles of the social learning theories of social Constructivism, CoP, and Connectivism, presented in Section 1. Specifically, Tables 1–3 provide a detailed analysis related to how closely the ARtful mobile app’s features correspond to the aforementioned learning theories’ key principles.

**Table 1.** Description of how the ARtful mobile app’s design and development were influenced by the key principles of the Constructivism and Social Constructivism learning theories.

Principles of (Social) Constructivism	ARtful Mobile App’s Related Features
<b>Establishment of meaningful connections to the offered cognitive content.</b>	Users are offered the possibility to contemplate the offered content and provide their own feedback, which is the result of a cognitive process influenced by both their personal knowledge structures and the shared information.
<b>Adaptation of educational processes to the needs of each visitor.</b>	Currently, users are offered certain, although limited, features of adaption (e.g., filtering and selection of certain users’ posts to process).
<b>Providing sources of knowledge beyond exhibits.</b>	Besides experts’ commentaries, users can read or listen to other users’ feedback and input.
<b>Collaboration with external organizations.</b>	The ARtful mobile app’s current system architecture can support the development of numerous cultural institutions’ profiles, which can all coexist; a feature that could perhaps encourage a cultural dialogue and interconnection among them.
<b>Encouraging social interaction between visitors and museum staff.</b>	The ARtful mobile app offers many features of interaction between its users (e.g., message system, likes, comments, etc.).
<b>Providing demanding intellectual activities for visitors.</b>	The ARtful mobile app’s exhibition tour guide can be considered a more demanding intellectual activity than a traditional audio guide tour, since users are exposed to a different range of opinions and are encouraged to share their own input and feedback.
<b>Developing self-awareness and self-regulation techniques.</b>	The ARtful mobile app’s features (comments, likes, and posts’ sentiment analysis) offer cognitive triggers to users, encouraging them to evaluate other users’ perspectives and reconsider their own.
<b>Museum’s pursuit to continually improve its effectiveness through visitor studies.</b>	Currently, this feature is not supported, but in the future as the collection of user data increases, certain machine leaning techniques can be used for user behavioral modeling processes.
<b>Dynamic and not linear presentation of exhibition objects.</b>	The ARtful mobile app does offer a dynamic presentation of exhibits, since users can view artifacts’ related content in any order they wish.
<b>A variety of interpretations of a particular theme should be supported.</b>	The ARtful mobile app allows interaction not only between museum experts and visitors, but also between visitors, making it possible for them to construct their personal meanings while being influenced by a range of different perspectives.
<b>Reflection and provision of feedback is encouraged.</b>	Users are encouraged to reflect and provide feedback by liking or commenting on selected posts. Furthermore, the posts’ sentiment analysis scores further invite them to contemplate a post’s content and meaning.
<b>Problem-centered and discovery-based learning is encouraged.</b>	Problem-centered learning and discovery-based learning are not currently supported.
<b>The acquisition of language and use of discourse is encouraged.</b>	Discourse is a core element of ARtful mobile app since many channels of communication and types of interaction are offered (e.g., message system, comments, posts, etc.).
<b>Provision of scaffoldings that can expand visitors’ ZPD.</b>	Users can search, select, and view certain content that appeals to them as interesting or/and familiar (e.g., keywords search functionality).

**Table 2.** Description of how the ARTful mobile app’s design and development was influenced by the key principles of the learning theory CoP.

Principles of CoP Learning Theory	ARTful Mobile App’s Related Features
<b>The definition of the meaning component of a CoP.</b>	Users are encouraged to interact with the offered cognitive content and share their own input, a process that helps them establish more meaningful connections to exhibits. In addition, they can interact with other visitors that otherwise they would not have the chance to.
<b>The definition of the practice component of a CoP.</b>	Users are invited to process cultural content and are offered the possibility to cultivate the skill of art discussion in a public context. The ARTful mobile app enables the construction of a social network within museum settings, offering a variety of communication and interaction features that can be considered fundamental for the creation of an online community.
<b>The definition of the community component of a CoP.</b>	Users can create, personalize, and maintain their profile, which is visible to the community; a feature that enables them to construct and adjust their online identity.
<b>The definition of the identity component of a CoP.</b>	Two levels of group users are defined at the moment: visitors and museum experts.
<b>Different levels of participation.</b>	

**Table 3.** Description of how the ARTful mobile app’s design and development was influenced by the key principles of the Connectivism learning theory.

Principles of Connectivism Learning Theory	ARTful Mobile App’s Related Features
<b>Learning is enhanced by the diversity of opinions and is a process of connecting nodes of information.</b>	Users could potentially be exposed to a different range of perspectives. Such influence could encourage them to reconstruct their personal view by combining a number of inputs.
<b>Learning and knowledge may reside in non-human appliances.</b>	All user- and interaction-generated data are stored in a real-time cloud-hosted database hosted by Firebase. In the future, adequate machine learning techniques can be applied to the aggregated data and metadata to reveal hidden insights and trends related to users’ behavioral patterns.
<b>Development and maintenance of connections to facilitate continual learning.</b>	Users can befriend each other, if they wish to maintain a connection with other visitors or museum experts.
<b>Capacity to know more is more critical than what is currently known.</b>	Users are enabled to review and contemplate, as well as experts’ commentaries, other visitors’ content, and to combine the offered information by establishing more complex connections to exhibits. Users are enabled to choose which content they want to view and process. In addition, through the passing of time, the content size is expected to increase and not remain static, as in traditional exhibition experiences.
<b>Self-regulation and decision making in the learning process is vital. Choosing what to learn and the meaning of incoming information is seen through the lens of a shifting reality.</b>	In more detail, emerging sociopolitical and cultural events may influence users’ shared input from time to time. The collection of data related to exhibits that is labeled by timestamps could offer significant insights on how visitors can provide diverse meaningful connections to artifacts, while being influenced by diverse and shifting perceptions of reality.

However, although the proposed tool’s functionalities can theoretically support the key points of the aforementioned social learning theories, it should also be highlighted that the creation of an online functioning learning community should under any circumstances be considered self-evident. On the contrary, visitors’ attitudes, along with the proactive and the reactive stance of museum staff towards the adoption of such social learning practices is, of course, also of critical importance to the development and maintenance of an efficient virtual community. Unfortunately, it is also unpredictable and may vary from case to use. Last but not least, nowadays, mobile applications pass through many design, development, and release cycles. This section presented in detail the initial design and development phase of the ARTful mobile app. Mentioned notions regarding future work along with feedback gained from how users and museum staff interact with the proposed app in experimental settings will further define the required improvements, additions, and fixes of future releases.

## 5. Evaluation Methodology and Experimental Results

In order to assess the perceived quality of the proposed app, a limited user experiment was conducted using content from the AR art exhibition *Poetry meets AR* (Poetry meets AR Workshop homepage <https://www.labattoir.org/poetry-meets-ar.html>). The exhibition was the result of a creative workshop that sought from its participants to study what can AR in conjunction with photography offers in the representation of poetry. During the workshop, participants photographed the area of the old municipal slaughterhouse neighborhood in west Thessaloniki, drawing inspiration from selected poems, which all had the city of Thessaloniki as a common point of reference. For each poem, three photos were selected, which were then used as image targets. Once the images were recognized, users were able to see the associated AR content (videos, sounds, 3D animations and objects, etc.) that was co-designed along with the workshop's participants.

As a first step of this evaluation study, a museum expert account was created (see Figure 16) in the ARtful social network, where the curator's commentaries were posted along with the corresponding exhibit photos (see Figure 10) regarding one of the four available poems, namely *Vykani*, written by the late Greek poet Nikos Engonopoulos. During the preliminary small-scaled experiment, participants were asked to download the ARtful mobile app, register, and view the content of the AR exhibition regarding the selected photos. They were also encouraged to use the social features of the proposed app to interact with the curator of the exhibition and other visitors by sharing content and by providing feedback. In total, participants shared ten posts (see Figure 17) concerning the selected photo exhibits. Some of them offered chunks of scaffolding information about the poet Nikos Engonopoulos (see Figure 17a,c) that could help other users discover more about his work. Other participants shared posts commenting about the exhibits by choosing a sociopolitical (see Figure 17b) or a sentimental approach (see Figure 17d). In addition, users also published a number of other posts to their timeline wanting either to comment further on the exhibits or to share their own personal art glimpses (see Figure 18). Last but not least, they also interacted with other users' content, mostly by liking their content. Some incidents in discourse also occurred (see Figure 18); however, they can be characterized as scarce and of limited quantity.



**Figure 16.** Created profile for the Poetry meets AR exhibition that was assigned the museum expert role.



Figure 17. Examples of users’ posts shared regarding the selected AR photo exhibits.

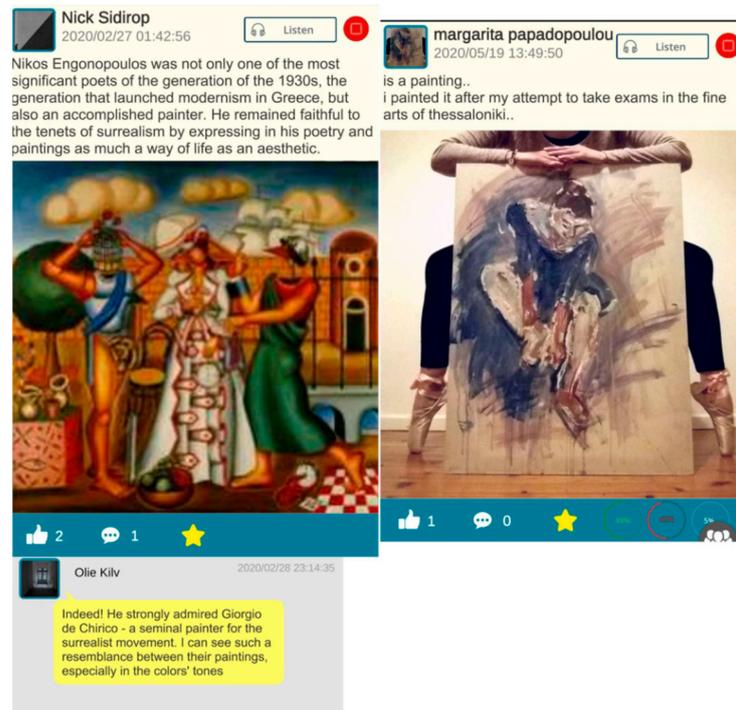


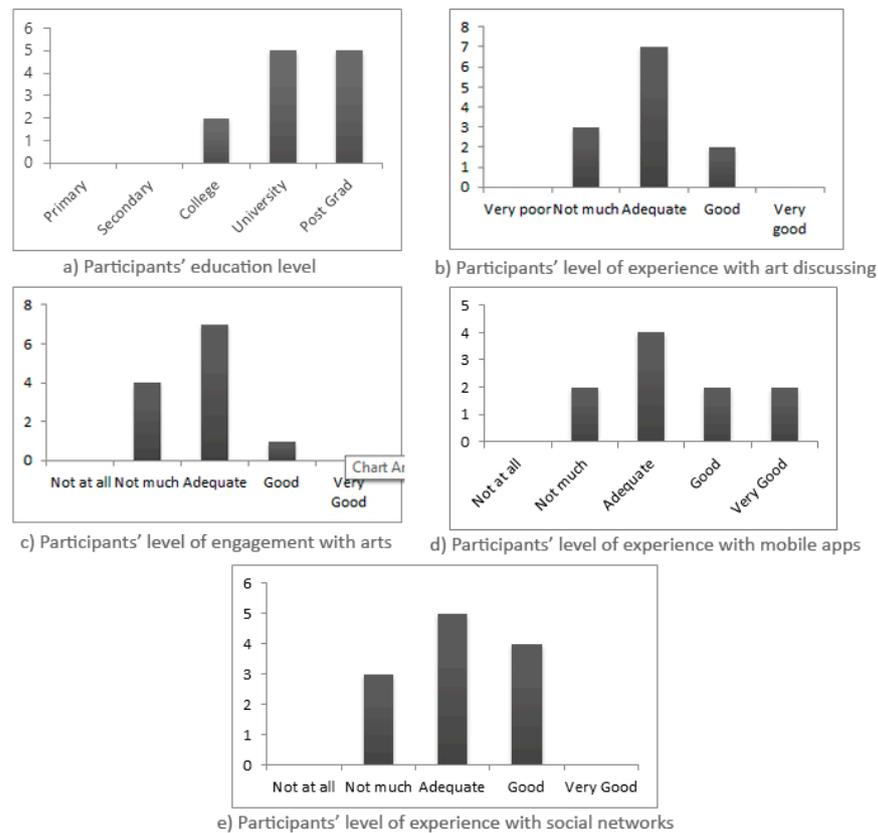
Figure 18. Examples of users’ posts shared to their timelines.

### 5.1. Survey Instrument and Sample

Subsequently, a questionnaire was used for evaluating cognitive, emotional, and behavioral elements of the participants’ attitudes toward the use of the ARtful mobile app as a self-guided tour tool for exploring the Poetry meets AR exhibition, and its potential to enhance further cultural learning and social interactions among the visitors of an art exhibition. Specifically, the survey instrument was a structured questionnaire that has two substantial parts. The first one is related to the demographic characteristics of the

respondents, and its analysis is presented in Section 4.2. The second one included closed-ended questions that used the five-point Likert scale (from 1 to 5): (1) strongly disagree, (2) disagree, (3) neither agree nor disagree, (4) agree, and (5) strongly agree. Specifically, the subjects were asked to answer six groups of questions that concerned the setup of the mobile app, its visual aesthetics, its usability, the offered learning experience, its potential to create a virtual learning community, and its perceived overall performance. Attention was also paid to the alternation in positive and negative statements' formulation, in order to check whether the users responded randomly without reading the questions.

The sample of the evaluation study consisted of twelve people (four female, eight male), all of which were adults (average age 34.1, SD 6.0) that had completed at least secondary school education (see Figure 19a). The majority of participants declared that they were adequately experienced with art engagement (see Figure 19c) and art discussion (see Figure 19b). Furthermore, the majority of them also stated that they were experienced users of mobile applications (see Figure 19d) and social networks (see Figure 19e). Such a group of participants was considered adequate for the purpose of this evaluation study, as they seem to belong to the mainstream audience that could show interest in using a Web 2.0 tool such as the ARTful mobile app in museum settings in the future.



**Figure 19.** Statistical data regarding characteristics of the participants related to their (a) education level, (b) experience with art discussion, (c) level of engagement with art, (d) experience with mobile apps, and (e) experience with social networks.

### 5.2. Experimental Results

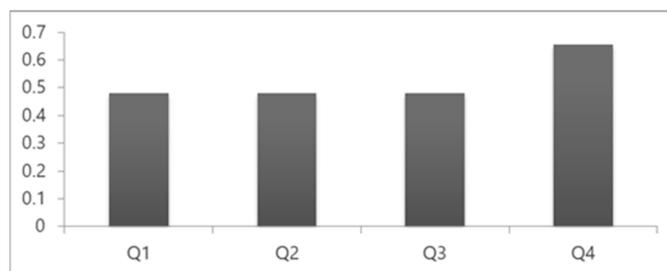
This subsection presents the key outcomes derived from the analysis of the data obtained through the participants' questionnaires. The results for each aforementioned group of questions are presented below.

### 5.2.1. Application Setup

The first set of questions concerned the attitude of the participants toward the setup and use of the proposed app. This group consisted of four questions, shown in Table 4. The average ratings are displayed in Figure 20, and the average value of users' ratings is 4.40 (SD 0.52). Therefore, it can be assumed that participants shared a positive attitude toward the use and the process of the setup of the ARtful mobile app, since they stated that it would not be a challenge for them to use it on their own in the future (Q4).

**Table 4.** Questions and average ratings of participants' attitude concerning the setup of the ARtful mobile app.

#Q	Questions	Avg.	SD
Q1	I easily understood how I should install the ARtful mobile application.	4.58	0.48
Q2	It was comfortable and easy to use and navigate the ARtful mobile application.	4.33	0.48
Q3	The profile setup did not cause any disturbance to me.	4.25	0.48
Q4	It will be easy for me to use the ARtful mobile application by my own as an educational social media tool for art exhibitions.	4.42	0.66
	Average	4.40	0.52



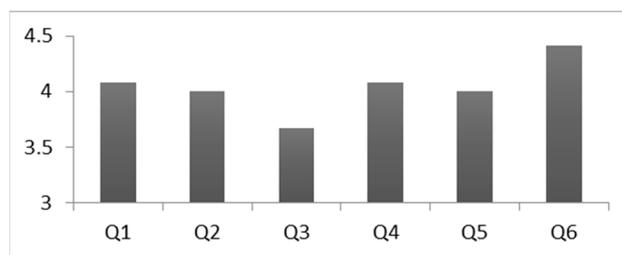
**Figure 20.** Average ratings of participants' attitude regarding the setup and the use of the proposed app.

### 5.2.2. Visualization

The second set of questions consisted of six questions, presented in Table 5, regarding the evaluation of the visual elements and graphics of the proposed app. The average ratings obtained are displayed in Figure 21. The results show that, in general, participants found the visual elements of the ARtful mobile app pleasant, satisfactory, and helpful. However, they seem to have doubts about the accuracy of the depicted sentiment analysis scores for posts (Q3).

**Table 5.** Questions and average ratings of participants' attitude concerning the visual appeal of the ARtful mobile app's UI design.

#Q	Questions	Avg.	SD
Q1	I found pleasant the ARtful mobile app in terms of design and aesthetics.	4.08	0.51
Q2	I found satisfactory the appearance of design of its interface.	4.00	0.43
Q3	I found accurate the depicted sentiment analysis scores offered for each shared post.	3.67	0.48
Q4	I found helpful to watch sentiment analysis of the posts offered by the ARtful application and to analyze how they correspond to the character of the post content.	4.08	0.74
Q5	How comfortable do you think it is to listen or read the offered posts' cognitive content while visiting an exhibition?	4.00	0.67
Q6	The AR features offered by the app made the experience more fun and entertaining.	4.42	0.77
	Average	4.04	0.60



**Figure 21.** Average ratings of participants’ attitude regarding the UI’s visual aesthetic elements of the proposed app.

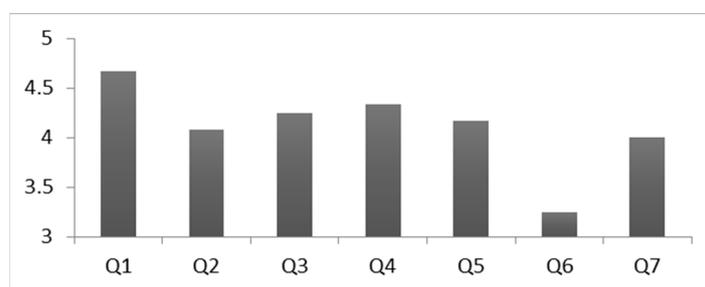
Nevertheless, even their neutral responses can be considered a positive outcome, since it can be concluded that participants paid attention to the analysis of the sentiment analysis asset and contemplated if the result was consistent with their own perception regarding the tone of the posts’ content.

### 5.2.3. Usability

The next set of questions (see Table 6) included seven questions regarding the usability of the proposed app. The average ratings are displayed in Figure 22. Their average value was 4.11 (SD 0.67). Although results show that participants found the ARtful mobile app easy to learn, navigate, and use, participants also stated that the existence of several buttons on the screen sometimes caused some confusion (Q6), suggesting that there is space for improvement in the navigation usability.

**Table 6.** Questions and average ratings of participants’ attitude concerning the usability of the ARtful mobile app.

#Q	Questions	Avg.	SD
Q1	The process of creating posts with cognitive content about exhibits was easy and understandable.	4.67	0.48
Q2	The process of creating posts with cognitive content about exhibits was easy and fun.	4.08	0.60
Q3	Following exhibitions and visitors’ activity in the ARtful mobile application was easy.	4.25	0.64
Q4	In the future it will be easy for you to use the ARtful tool by yourself?	4.33	0.66
Q5	In the future you would like to use the ARtful mobile application to view and create educational content for exhibition purposes?	4.17	0.57
Q6	I found the existence of several buttons in the screen not to be confusing and annoying.	3.25	1.21
Q7	I found the general feedback provided by the application satisfactory.	4.00	0.51
	Average	4.11	0.67



**Figure 22.** Average ratings of participants’ attitude concerning the usability of the ARtful mobile app.

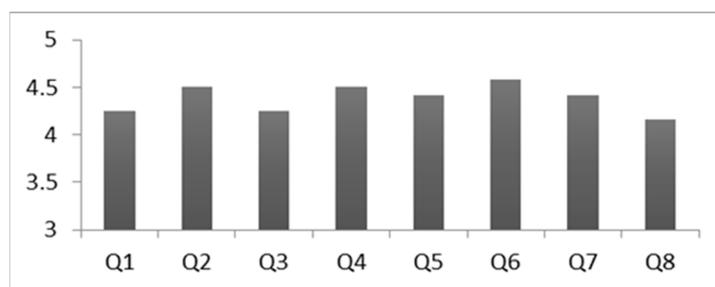
### 5.2.4. The Learning Experience

Participants were also asked about the educational effectiveness of the proposed app. This group consisted of eight questions, presented in Table 7. The average ratings are displayed in Figure 23. Taking into account their average value (4.39, SD 0.67), it can be assumed that participants expressed a positive attitude toward the educational character of the proposed app, declaring that cultural learning and art discussing experience would

be easier with the use of such an app, compared to more traditional exhibition techniques (Q1). They also stated that they found its use fun (Q5) and not stressful (Q4). Moreover, participants expressed a positive attitude toward the idea of using a similar app in museum settings (Q7), and its potential to create a virtual meeting point for visitors and museum specialists enhancing interaction among them (Q2, Q3).

**Table 7.** Questions and average ratings of participants’ attitude concerning the learning experience offered by the proposed app.

#Q	Questions	Avg.	SD
Q1	I think that this application makes art learning and discussing experience easier compared to traditional exhibition techniques (exhibition texts, acoustic guides).	4.25	0.72
Q2	I think that this application would help the creation of more interactive and participatory exhibitions.	4.50	0.66
Q3	I would recommend the use of a similar app for the creation of virtual learning communities where visitors and curators can interact and practice art discussing.	4.25	0.72
Q4	I did not find the application stressful in any way.	4.50	0.50
Q5	I had fun using the application.	4.42	0.64
Q6	I think that the application respects the exhibits’ value, for which visitors can discuss and share opinions and information.	4.58	0.66
Q7	I would like to see such an application or similar technologies included in the educational process of other museums/art institutions.	4.42	0.88
Q8	Other visitors’ posts offered me valuable cognitive information, that otherwise would be hard to grasp.	4.17	0.57
	Average	4.39	0.67



**Figure 23.** Average ratings of participants’ attitude concerning the learning experience offered by the ARTful mobile app.

### 5.2.5. Creating a Virtual Learning Community Potential

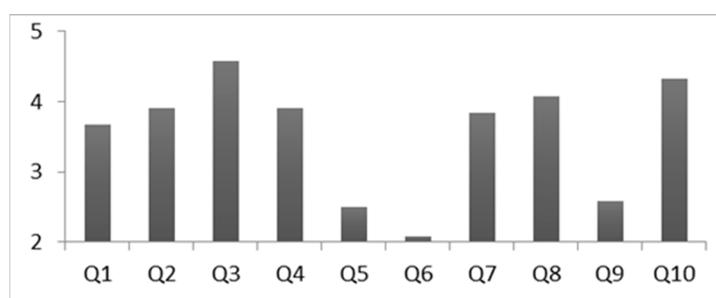
The next set of questions concerned the potential of the proposed app to create a virtual learning community in cultural settings. This group consisted of ten questions, presented in Table 8. The average ratings are displayed in Figure 24. Their calculated average value is 3.59 (SD 0.75). Participants stated that they enjoyed reading other visitors’ shared content (Q3), and that using the proposed app made them feel more connected to other users, even though they never met them in person (Q7).

**Table 8.** Questions and average ratings of participants’ attitude concerning the potential of the ARTful mobile app to create a virtual learning community in cultural settings.

#Q	Questions	Avg.	SD
Q1	I was trying to share piece of knowledge that would be useful or interesting to both myself and other visitors.	3.67	0.96
Q2	I tried to develop a critical look on my own, personal way about appreciating and discussing art.	3.92	0.64
Q3	I especially enjoyed reading the other visitors’ perspective in their posts. It was also useful for me.	4.58	0.49
Q4	I liked the informal style of other visitors’ posts.	3.92	0.76

**Table 8.** *Cont.*

#Q	Questions	Avg.	SD
Q5	The social part of the activity (knowledge sharing) was of no particular value to my personal understanding of the exhibition.	2.41 (2.49)	1.18
Q6	Everyone has their own perspective on art appreciation, and so most of the time I was not interested in the knowledge shared by other visitors.	2.08 (2.92)	0.76
Q7	Using the app made me feel more connected to other visitors, even though I did not meet them in person.	3.33	0.75
Q8	Compared to other art exhibitions, interaction with other visitors due to application usage increased.	4.08	0.76
Q9	I was worried about what other visitors would think about the information I shared.	2.58	1.11
Q10	I think that the use of such an application enhances the feeling of Participating and Belonging while visiting an art exhibition.	4.33	0.47
	Average	3.59	0.75



**Figure 24.** Average ratings of participants' attitude concerning the potential of the ARtful mobile app to create a virtual learning community in cultural settings.

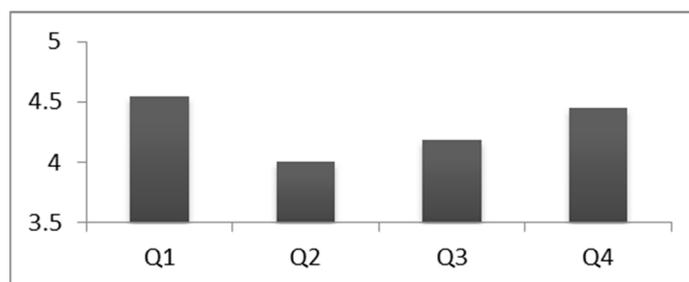
They also stated that that the use of such an application-enhanced social interactions (Q8) and the feeling of participating and belonging during their exhibition experience (Q10). Therefore, they sought to share meaningful content (Q1) for other users too, although they did not seem to be rather worried about how other users would perceive the information they shared (Q9). In general, it can be concluded that subjects showed a rather positive attitude toward the use of such a tool for the creation of a virtual meeting point in museum settings that seeks to enhance the interconnection of visitors' virtual experiences by connecting the individual interactions of users.

#### 5.2.6. Perceived Performance

The last set of questions (Table 9) consisted of four questions regarding the general perceived performance of the ARtful mobile app by the subjects, i.e., to what extent visitors considered the proposed app to be effective, efficient, satisfactory, and innovative. The average ratings are shown in Figure 25. The average outcome of the questions was 4.30 (SD 0.68), showing that participants shared a quite positive attitude toward it.

**Table 9.** Questions concerning the perceived performance of the ARtful mobile app.

#Q	Questions	Avg.	SD
Q1	The application is effective (if the app meets its objectives).	4.55	0.67
Q2	The application is efficient (if the app responds satisfactorily and in a short time).	4.00	0.63
Q3	The application provides satisfaction (if the app provides satisfaction to the user).	4.18	0.75
Q4	The application is innovative (if the app offers novel tools/techniques in CH management).	4.45	0.66
	Average	4.30	0.68



**Figure 25.** Average ratings of participants for the sixth set of questions concerning the perceived performance of the proposed app.

### 5.3. An Example of Behavioral Data Use

The acceptance of visitor observation has been considered a valid and reliable method of understanding and measuring the success of an exhibition [53]. New technologies have certainly facilitated and automated such data collection processes, identifying trends and patterns in visitor behavior that can inform the design of future exhibitions. When it comes to Web 2.0 tools in particular, the great advantage they offer is the aggregation of large-scale information on what people believe about specific topics, information that otherwise would remain invisible and abstract. Unfortunately, the presented limited control study did not provide adequate data for exploring user classification/modeling capabilities. However, a simple example of data exploration would be the presentation of data collected through the sentiment analysis module that identifies visitors' prevailing emotional opinion within their posts' text, to determine their expressed attitude as positive (associated with green color), negative (associated with red color), or neutral (associated with blue color). Nevertheless, it should be noted that the appearance of negative expressed sentiments does not necessarily mean that visitors shaped a negative attitude toward an exhibit or an exhibition, but that the derived feelings were characterized by a negative (e.g., sad, melancholic, angry, etc.) tone. Such experimentations could enable museum specialists not only to obtain audiences' sentimental reactions toward exhibits, but also to observe their evolution, gaining significant insights on how visitors, who are being influenced by events of the ever-changing reality, can provide diverse, meaningful connections with artifacts from time to time. For example, Figure 26 shows a graphic representation of the overall sentiment scores generated by participants shared content at a certain point of time. Such a graphic illustration could even be animated, showcasing its evolution through the duration of an exhibition, or other modalities could be used to express such a flow of data (e.g., an exhibition's sound landscape installation of the memory of visitors' sentimental reactions).



**Figure 26.** A virtual illustration of the overall sentiment scores generated by participants' shared content about the selected exhibits at a certain point of time.

In more detail, a network of otherwise invisible information of this type could make possible the shaping of a sentimental aura in the museum space, aiming to function as a means of activating the relationship between the museum and its visitors and their engagement in actions that result from it or aim at it. By adopting such technological approaches to represent cultural sources through virtual illustrations and augmented modeling, cultural institutions could contribute to the development of social networking monuments, cultivating a new image for museums, where their spaces are not seen as static, but as interactive living environments that could foster multi-collection systems of past, present, and future cultural stimuli.

## 6. Conclusions

The degree of integration of Web 2.0 practices by museums depends on their readiness to redefine their relationship with their audience, although it is understandably not a simple matter to approach and requires the creation of a completely new vision, one with which many museums are not yet familiar. In this context, based on the analyses of modern social learning theories and state-of-the-art technologies, this study proposed the implementation of a novel social media tool that can be used as a self-guided tour tool with AR features by visitors. Its use may facilitate the creation of a virtual learning community of museum curators and visitors that will enable art discussions, information sharing, and other interactions in a cost-effective and less technically demanding way. The proposed tool's scope is to connect the individual interactions of users, creating a virtual meeting point and a space for publishing content, as happens in popular social networks. Hence, visitors become co-creators of the offered museum cultural experience and are exposed to different perspectives and opinions, thus strengthening social cohesion and inclusion. In addition, taking into account potential worries of museum experts, certain capabilities were added to their accounts to allow them to have more control over the visitors' generated content.

Evaluation results, derived from a small-scaled experiment in cultural settings with potential users, have shown the positive potential of the ARtful mobile app. In more detail, participants considered the proposed app satisfactory and efficient, its visual elements pleasant and helpful, and its setup easy to do. Furthermore, they positively evaluated its educational character, stating that the art discussion experience would be easier with the use of such an app in exhibition spaces. They also expressed a positive attitude toward the idea of using such an app in museum settings to enhance their interactions with other visitors and museum specialists, since they claimed that they enjoyed reading other visitors' generated content. In general, they perceived the proposed app as an efficient, satisfactory new tool to be used in the cultural sector. Furthermore, participants showed a rather positive attitude toward its potential to create an online community in museum settings, since participants stated that its use enhanced their feeling of participating and belonging during their exhibition experience, an incident that motivated them to share more meaningful content. However, although the majority of them shared relevant information regarding the exhibits, their interactions remained on a superficial level, since incidents of discourse among them were of limited quantity. Therefore, it is important to mention that the creation of a functioning online learning community cannot be the result of merely using a social media tool, even a well-designed one. On the contrary, it is usually a museum staff's task to develop the community and improve discussions and debates [30]. Their stance, along with the audience's attitude toward the adoption of such Web 2.0 practices, plays a principal role in the development and maintenance of an efficient virtual community, but, unfortunately, such parameters are also unpredictable and tend to vary from case to case.

The findings of this study highlight several directions for future research. First, from a technological point of view, future work will focus on improvements derived from feedback gained from how users interacted with the proposed app during the assessment process, so its use can become more efficient. Specifically, future refinements may concern the improve-

ment in user experience through refining and redefining the app's information architecture for ease of navigation and usability. Furthermore, future work may include ARtful's development as a PWA application, so its technology framework will become lighter and better support short loading times, good performance in poor network conditions, and instant updates.

Second, from a research point of view, it should be further studied how the addition of such an information stream could influence the audience's overall museum experience, since there are already exhibitions which rely too heavily on text. John Falk and Lynn Dierking in [54] highlight the need to find the right balance of text in museums, making sure that objects are supported by concise and effective interpretive text. In more detail, they note that inexperienced visitors face a higher risk of being overwhelmed in comparison to experienced visitors that are able to group, filter, and classify the shared information. In this case, a potential research question of great interest could be the effect of the ARtful mobile app to the Interactive Experience Model [54], which suggests that a museum visit takes place within three contexts: the personal, the social, and the physical. Specifically, elaborating on the use of such a tool in museum settings and examining whether its addition enhances or deteriorates visitors' experience could yield useful information concerning both the proposed tool's functionalities and diverse audiences' behavioral patterns.

Next, further research should be conducted and, in particular, more large-scale controlled experiments should be organized in close cooperation with museum staff and diverse audiences to study how such a tool can adapt to different museum settings and improve visitors' experience under varying circumstances. For example, since results showed that the use of the proposed app can enhance a museum's network activity, such a tool can be used, for instance, by memorial museums on the work concerning transitional justice in domestic tourism [55]. By enabling visitors to relate to the exhibits by interacting with fellow visitors and museum experts, while being exposed to a range of different perspectives concerning the same matter, the relationship between individual experiences in memorial museums and wider societal process of coming to terms with traumatic past histories can be further studied. Last but not least, the proposed tools' impact can be studied in the context of both rural and urban tourism development, researching its use and adequacy for the participatory creation of interactive digital cultural experiences (e.g., AR enhanced self-guided tours for open-air museums). Such an application can allow the engagement and interaction of multiple stakeholders, a process of underlying importance according to [56].

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