Augmented Reality in Arts Education

AUGMENTED REALITY IN ARTS EDUCATION

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Abstract

This chapter focuses attention on the potential of augmented spatial experience technologies in the pedagogical use of art and how these can significantly enhance the role of art education. The reasons why we feel it is necessary to dedicate deeper analysis to the theme of Augmented Reality in Arts Education are fuelled by the acknowledgement that the theme is developing rapidly but lacks a systematization of the field experiences, coming from different research fields. An assiduous interdisciplinary discussion, with special reference on the one hand by the scholars of the Digital Heritage, forever committed to the documentation and valorisation of the tangible and intangible historical-artistic heritage and, on the other, by the scholars of arts pedagogy and educational technology, seems more than ever necessary in order to contribute to minting the same coin, that is the one

relating to the safeguarding of the value of the arts and the heritage for the development of individual and, therefore, a society capable of evolving starting from the memory of its own expressive capacities.

Keywords: arts education; augmented reality; digital environments; learning augmented; digital competences; language of images; third space; creative expression; digital artefacts

1.Basic concepts

1.1. Augmented reality and arts education: what intersection point?

The reasons why we feel it is necessary to dedicate deeper analysis to the theme of augmented reality in arts education are fuelled by the acknowledgement that the theme is developing rapidly but lacks a systematization of the field experiences, coming from different research fields. An assiduous interdisciplinary discussion, with special reference on the one hand by the scholars of the Digital Heritage, forever committed to the documentation and valorization of the tangible and intangible historical-artistic heritage and, on the other, by the scholars of arts pedagogy and educational technology, seems more than ever necessary in order to contribute to minting the same coin, that is the one relating to the safeguarding of the value of the arts and the heritage for the development of individual and, therefore, a society capable of evolving starting from the memory of its own expressive capacities. In this innovation process, the applied technology acquires a proprietary role. It presents itself as the "mirror" within which scholars reflect, look at each other, observe each other and in some cases "resemble" each other; specifically, it refers to digital technology applied to arts education. In fact, the environments that are described are digital, as are the experiences that a large part of society carries out every day. We obtain

information, build relationships, buy services or products, spend free time, and leave traces of our existence in digital environments, whether they are contained in a mobile device or in the physical space in which we find ourselves.

In this context, where the individual is formed and acts, representation has the primacy, thanks to digital technologies that have increased its possible declinations. We speak through the representation of our voice on the phone, we watch entertainment and on-demand contents through digital devices, we interact via social networks; this list could be extended to include a significant number of daily activities. Ever since the reproducibility of significant artefacts has been extensively investigated, it is clear how the advent of digital processing and communication has transformed artefacts: from simple "faithful copies" of the original to identical originals. In the educational experience of art, both in the school environment and in the exhibition-museum environment, it is now possible to experience all the features of augmented reality that digital technologies have promised for decades: from immersive VR through Head Mounted Display (HMD) stereoscopic viewers to the use of smartphones or tablets for the enjoyment of augmentative content. The most relevant aspect of these technologies is precisely that of expanding the real experience of the acted-out space, both physical and digital, in different contexts. For various reasons, our interest is focused on the potential of augmented spatial experience technologies in the pedagogical use of art and how these can significantly enhance the role of art education.

When Myron Krueger coined the term Artificial Reality (AR) [1], his goal was to define a type of digital experience so immersive as to be perceived as real. He used the concept of AR as a tool to examine human/machine relationships by analyzing their possible exchange interfaces and examining the socio/cultural relationships connected to it. At the early 1990s, the idea of AR was superseded by the concept of the Reality-Virtuality Continuum [2], graphically synthesized in a horizontal segment, where the Real and the Virtual were identified at the two extremes and, in the interval between the two, a type of Mixed Reality, which fades into Augmented Reality or Augmented Virtuality. Milgram used this definition for the construction of a taxonomy of visualization systems for Mixed Reality environments in relation to the degree of immersion required and the immersion device. These intermediate levels therefore belonged to a mixed reality in which the relationship between figure (the user who

experiences reality) and background (the environment in which the user is immersed) determines the point of the Continuum in which one finds oneself.

Therefore, if the user experiences a reality in which structured digital information is added to what really exists around them, the field of Augmented Reality is created, that is the field of computer graphics that studies the possibility of superimposing digital processing on the perceived reality. Conversely, if the user experiences a completely digital artificial reality, in which digital information is structured in such a way as to conform the perceived world, we are in what Jaron Lanier in the early 1980s had called Virtual Reality [3].

Today, virtual reality, augmented reality, mixed reality, haptic feedback and gesture recognition, represent technologies that increasingly tend to be merged together and that can be grouped right under the general term of Artificial Reality, thereby fulfilling Krueger's predictions [1].

In this regard, it is with the launch of Google Cardboard and with the crowdfunding campaign to finance the Oculus Rift project, at the beginning of the 2010s that commercial interest has reawakened in a sector that has only remained of interest for some research centers. Google with its Google Glass (2013) has tried out pioneering ideas in the field of augmented reality, as has Microsoft, which with the expected global launch of HoloLens first of all and then with HoloLens 2, has tried to fulfill the expectations generated, and not fully satisfied, by Google Glass. Finally, the Bridge market was launched, a 3D scanner for small environments which, combined with a mobile headset, allows real-time scanning of the environment in which one finds oneself, allowing for the geometrically coherent integration of 3D models.

As for the possibility of user interaction within an artificial reality, the enabling technologies are those that derive from the field of *physical computing*, that is the science that studies the creation of physical interactive systems through the integrated use of software, hardware and sensor and actuator systems, capable of “recording” the user's movements, rendering them in the form of a digital signal. Microsoft's Kinect 3D sensor (2010) was the first to enter the video game market on a large scale and, thanks to a moderately “open” policy, offers manipulation actions for real-time tracking of body movements or for home motion capture sessions (2016).

Regarding gesture control, a solution is represented by the devices, developed starting from 2010 by Leap Motion: a sensor that recognizes and tracks the movement of the fingers of the hands translating it into 3D coordinates, which can be used to interact virtually in mixed reality environments. Similarly, the most recent Google Project Soli promises the realization of an electromagnetic sensor capable of interpreting the movements of the fingers as well as some material or morphological characteristics of inorganic objects. Similarly, the MYO, an intelligent bracelet, can read the electrical activity of the forearm muscles to control other associated technologies via arm movements. The most recent developments in mobile devices see the integration of AR technology and, starting from 2020, the use of LiDAR technology, i.e. the possibility of measuring the distance of objects within a radius of a few meters, allowing to contextualise the two-dimensional and three-dimensional graphic elements with extreme accuracy and speed. The reasons that motivate the development of AR applications with respect to VR are different but two are of considerable impact. The first is the possibility to implement many AR applications on mobile devices (hand-held devices) that are particularly easy to use and that do not fully engage the user's visual field, offering a natural perception of the environment in which they is situated. The second is the ease with which digital content can be distributed on paper (using marker activators or even markerless) such as books and magazines, postcards or advertisements

A decisive development for the near future will be the integration of AR technologies with Artificial Intelligence (AI), to allow better and better performance integration between digital content and real environments. The support of neural networks, like GAN (Generative Adversarial Network) and CNN (Convolutional Neural Network), will allow the application to recognize the elements that make up the surrounding environment and the consequent stabilization of the three-dimensional contents and their adaptability to context.

These, and other technologies, which are being released, will contribute to the development of new forms of learning and experiential art teaching. In fact, compared to the overall picture described, it can be observed that the advent of digital and social media offers a new change of perspective, especially in the ways in which we communicate, produce cultural content and “express our identities” [4].

In particular, if communities interact with places of art through research, observation, similar approaches are essential to start a cognitive process with art objects. In this sense, the artistic object becomes an exceptional text capable of combining and narrating extraordinary stories and contexts. In fact, one of the fundamental tasks of art education is that of questioning reality through technologies, when the latter allow us to ask new questions. Among these technologies, the reference is to the new immersive and augmented digital environments that allow not only to access information but also to experiment and create original meanings. It is thus necessary to rethink media in a systemic perspective, in which art and heritage ought to be analyzed as part of a complex context and not just as isolated entities; to do this, an articulated design centred on the procedural nature of the experience is required. The ecosystemic approach to art and heritage leads to an increasingly natural interweaving between physical-virtual spaces and different media, in which the context plays a decisive role to achieve the goals. Many of the technologies today guarantee multiple parties can collaborate and build artefacts in a shared system. With the evolution of products conveyed by one or more media, even the experience is transformed, becoming movement and transit between the various elements of the system itself [5]. Most of our experiences with art and heritage in digital environments, in fact, are configured as a process of actions, facts and behaviours linked together: from initial intentions to research and comparison, to construction and so on. This means that, for example, when the output of an activity is the production of a tangible work, this brings with it a series of visible and invisible connections with other elements of the experience that constitute the actual added value of that product. It is precisely this process that allows the artistic and cultural heritage both to convey information, knowledge, emotions, and to transform over time and re-semantize itself. In this regard, an impressive number of objects are transformed, acquiring different meanings even long after their creation, thus bringing signs of more recent events [6].

It is by now a given that defines heritage education "as a formative activity, formal and informal, which while it educates towards the knowledge and respect of the assets, by means of the adoption of responsible behaviours, makes of the heritage the concrete subject of research and interpretation, adopting the perspective of the recurrent and permanent development of everyone's active and responsible education" [7]. The different learning models,

together with those of didactic mediation, have a key role in defining the concept of enjoyment of the artistic item. This aspect underscores how experience of the heritage also in digital environments cannot coincide solely with one or more active methodologies of knowledge but must be situated within a problematizing pedagogy that is capable of defining the cultural project by developing suitable methods and strategies, in which there is specific attention to the needs of people and society. Jenkins [8] in this regard speaks of "participative cultures" that develop in the open space of the Internet thanks to the Web and social networking instruments with the aim of fostering artistic expression and civic commitment promoting a sense of belonging. Didactics centred increasingly on the relationship between new technologies and forms of learning/entertainment, orienting itself towards an approach between amusement and edutainment, through which it is possible to learning and educate. Techniques of digital mediation, graphic models and three-dimensional models, 360° panoramas, dynamic interfaces, have redefined the spaces and times of leaning. There is indeed no doubt that today digital media are the protagonists of a shift towards renewed models of communication that aim at an expansion, according to ever more rapid and immediate forms, of the didactic and cultural provision. The communicative actions and the new forms of representation aim to facilitate understanding, to clarify aspects of complexity, to present concepts in a clear and synthetic way, to make the information more explicit and accessible guaranteeing at the same time an elevated scientific level of the contents proposed.

In this regard, we cannot end this synthetic review without citing Google once again and in particular the Expeditions project that expands the set of tools to support education in school contexts with particular reference to its virtual educational environment Classroom. Google Expeditions allows teachers and students to undertake immersive "expeditions" by exploring natural environments or museums or art galleries affiliated with the Google Arts & Culture project, virtually redefining the spatial boundaries of classrooms and laboratories.

1.2. Arts education strategies in the 21st century

Growing globalization is posing significant problems to the world of education with particular reference to migration and multiculturalism, on the one hand, and technological advances and the development of the knowledge

economy, on the other. The educational system can contribute in a decisive way to prepare young people for the different roles they are called to play in contemporary society. In particular, schools have the task of helping young people to develop self-confidence, as individuals and members of community groups, supporting them in the acquisition of a wide range of skills and interests, as well as identifying and expanding their creative potential. These elements also pose several challenges for art and digital education. In fact, the growing interest shown by international organizations has led, in recent years, to a fundamental awareness on the subject and to the proposal of research on artistic and cultural education in formal and non-formal contexts in Europe, also through the contribution of digital.

The specific reference is to the actions proposed by UNESCO regarding the development of initiatives that promote art education, emphasizing its role in everyone's education of. In this regard, the first World Conference on Arts Education: Building. Creative Capacities for the 21st Century, held in Lisbon in 2006, affirmed the need to define and increase the importance of art education in all societies, through the carrying out research aimed at establishing guidelines for the enhancement of artistic education. "Art education is a universal human right and the arts play a key role allowing the full development of the individual".

In the decade 2003-2012, UNESCO specifically published three strategic documents for culture, art and art education: the UNESCO Convention for the Protection of the Intangible Cultural Heritage (ICH-UNESCO, 2003), the Road Map for Arts Education (UNESCO, 2006), Seoul Agenda for the Arts Education (UNESCO, 2011). These three documents intersect with the broader conventions and policies of the United Nations, seeking to promote humanism, cultural pluralism and equality and therefore represent guidelines at the basis of regional and national cultural policies. In particular, the Intangible Cultural Heritage recognizes performing arts practices as forms of immaterial cultural knowledge and emphasizes the rights of minorities to support these practices by withstanding the hegenomous culture. Ratified in 2003, ICH extends UNESCO's previous political directives on human rights (UN, 1948), economic, social and cultural rights (UN, 1966a), civil and political rights (UN, 1966b), cultural and natural heritage (UNESCO, 1972), traditional culture and folklore (UNESCO, 1989) and cultural diversity (UNESCO, 2001). ICH has been widely applied within formal education [9] and supports the

values of programmes dedicated to research, higher education, and the practice of intangible cultural heritage. Specifically, the convention promotes:

1. Educational programs, of awareness and information, aimed at a general public, particularly young people;
2. Specific educational and training programmes within communities and interest groups.

These two points represent an indispensable social track especially for those who are not aware of the value of intangible culture and who, therefore, need an education in the continuous practices of immaterial culture. These two objectives also raise questions for art educators who work within dynamic and multicultural communities, in particular in urban schools and places of informal education [10, 11, 12]. Teachers who implement the ICH objectives within the curriculum have to deal with uncertain paths, to integrate the cultural performances of minorities, without trying to represent them in rigidly or statically.

In fact, the Road Map for Arts Education (UNESCO, 2006) focuses on role of art educators by emphasizing the importance of cultural pluralism as essential for equality, with reference to the United Nations Convention on Human Rights (1948) and the United Nations Convention on the Rights of the Child (ONU, 1989). Indeed, this document does not promote artistic education as an end unto itself but identifies the function of the arts in the development of every individual's potential. Based on the theoretical assumptions of arts education [13, 14, 15], the Road Map recognizes how the arts can enhance young people's creativity (not just a small elite considered "talented") and support learning in interdisciplinary areas within formal education by emphasizing the relationship between art education and the economies of creative knowledge of the 21st century [16].

Emphasizing the importance of artistic education in formal curricula, the Road Map seems to assume that arts education around the world takes place predominantly within institutional contexts but neglects the complex diversity of global arts pedagogies that resist institutionalization.

The Seoul Agenda for Arts Education, adopted in 2011 (UNESCO, 2011), sought to extend the Road Map, through specific objectives, to be achieved at national and regional level [17]. The importance of informal education, of the involvement of students of different age groups and with different learning styles, in order to achieve personal and social well-being is highlighted. In fact, the third objective of the Seoul Agenda refers to

the application of principles and practices of art education to help solve the social problems and cultural challenges that today's world must face (UNESCO, 2011). The Seoul Agenda can thus be seen aligned with university education and specifically with degree courses that emphasize arts educators' social responsibility.

The European Council has also proposed significant reflections and actions towards the development of artistic education at school. Already in 1995, the Council of Europe launched a project called Culture, Creativity and Youth, aimed at dealing with art education in the schools of the Member States, involving professional artists and creating collaborations for the implementation of extracurricular activities.

Ten years later, in 2005, a Council of Europe Framework Convention on the value of cultural heritage for society was defined, underlining the need for European countries to preserve their cultural resources, to promote the cultural identity, to respect diversity and encourage intercultural dialogue. In particular, the Article 13 of the Framework Convention recognized the important role of cultural heritage in the field of art education but also recommended developing links between the disciplines taught in different fields of study. In 2006, an international conference was organized on the theme Promoting Cultural Education on Europe, preceded by a meeting of the European network of officials working in the field of artistic and cultural education. During this conference, the idea of a glossary was launched to lay the common foundations for the definition of cultural education and other related terms. The 2007 Council resolution also introduced a new Open Method of Coordination in the field of culture. Within the framework of the OMC, a working group on synergies between culture and education has been set up to promote key competence for "cultural sensitivity and expression". The task of this work group was to validate the best practices and formulate recommendations for initiatives aimed at promoting cooperation between culture and education, including arts education. In May 2007, the European Commission adopted a communication on A European Agenda for Culture in a World undergoing Globalization. In November of the same year, this communication was transformed into a Council Resolution on a European Agenda for Culture that recommended "encouraging arts education and participation in cultural activities in order to develop creativity and innovation." This resolution was in turn followed by a 2008-2010 Work Plan that recognized the importance of culture and creativity. 2008 is thus designated as the European Year of Intercultural Dialogue and 2009 as the

Year of Creativity and Innovation. In fact, in 2008 the Council of Europe published a White Paper on intercultural dialogue proposing an intercultural approach to manage the diversity of cultures. This document highlighted how educational institutions, including museums, heritage sites and schools of all types and levels must be able to support intercultural exchanges, study and dialogue through arts and cultural activities.

In March 2009, the European Parliament passed a Resolution on Art Studies in the European Union, which included the following recommendations:

• artistic and intercultural teaching must be compulsory at all levels of education;

• the teaching of the arts must use the latest information and communication technologies;

• the teaching of art history must include meetings with artists and visits to places of culture;

• to make progress in these areas, the resolution calls for better supervision and coordination of artistic teaching at European level, with monitoring of the impact of artistic teaching on the skills of students in the European Union.

In addition to these main developments, linked above all to international and European cooperation, various conferences and initiatives have been held, some of which have led to changes in the policy of the various countries in the field of artistic and cultural education. At the same time, three international organisations representing educators in the artistic field - dramatic arts /theatre, plastic arts and music - came together to form a global alliance (International Society for Art Education 2006-2017) inviting UNESCO to place art education on the global agenda for human development and sustainable social transformation. Creative Europe is the most recent framework programme of the European Commission dedicated to culture and the creative sectors for the period 2014-2020 which aims to operate beyond national borders by actively promoting cultural and linguistic diversity.

1.3. Augmented reality in art teaching at a European level: what developments?

Comparisons among the various initiatives, organized at European level over the last twenty years, have led to the identification of relevant questions for the areas of art education, particularly important in the field of school teaching. The studies confirm the existence of a hierarchy of school programs, in which the skills related to

reading, writing, and learning logical-mathematical skills are favoured to the detriment of arts teaching. In addition, among the arts, some forms of expression such as the visual and musical arts tend to be favoured over others such as drama and dance. By way of confirmation of this different recognition of the arts in the educational system, the survey on Culture, Creativity and Youth, carried out by the European Council, highlights the importance of the cultural dimension in educational policies and the need to nurture the artistic and creative attitudes of young people within a system of educational provision.

The arts in formal educational contexts not only have little recognition compared to other disciplines but in some European countries there are attempts to reduce the arts supply in the curricula in favour of subjects considered more relevant in terms of economic or academic success. In most national systems, the teaching of visual arts is compulsory both in primary education and in lower secondary school and only in some courses of upper secondary school. By analyzing the importance attributed to the arts in official documents, two main approaches were identified: art as a discipline and art learned through other disciplines. In particular, drama and dance are often integrated into other disciplines such as dance within physical education. In this context, it is difficult to promote the expressive qualities of dance in a discipline focused on physical exercise and sport. In the case of the arts as an autonomous discipline, Taggart and others [18] observed that the plastic arts and music are studied as compulsory courses in all twenty-one countries involved in the survey. The minor status recognized to artistic disciplines is reflected in the lack of interest in the evaluation and monitoring of standards in art teaching. The research has also highlighted the problems related to the fact that the time officially dedicated to teaching arts and the time actually made available within schools is insufficient to offer a broad and balanced program. Lack of time, space and resources are thus identified as key factors limiting the success of arts teaching. We expect more and more that artistic teaching will fulfil a series of objectives, besides offering knowledge relating to this field. If the education systems increasingly recognize the importance of developing children's creativity and of acting in favour of their cultural education, it is not clear in what way the arts can contribute to each student's educational curriculum. Taggart and others [18] also observed that almost all countries have similar purposes, summarized as follows: the development of artistic skills, the knowledge and understanding of different artistic forms, the

perception of cultural realities, the sharing of artistic experiences, as well as the possibility of becoming enjoyers of art and attentive users in this area. Furthermore, in most countries, arts education is also aimed at ensuring personal and socio-cultural outcomes, such as self-esteem and self-confidence, individual expression, team spirit, understanding and intercultural participation. Among the purposes of artistic teaching, particular attention to creativity emerges, also in relation to the importance attributed to innovation. As Bamford [19] remarks, many education systems rely on generalist teachers for arts disciplines, particularly in preschools and primary schools. Teaching the arts at a high level is not easy and that is why teachers do not feel confident with in this task. We can thus deduce that it would be necessary to envisage the initial preparation of the teachers for the artistic subjects via measures of continuous professional development that allow for their knowledge to be brought up to date and their competencies improved. The research has dedicated little attention to the modalities of evaluation of the quality of artistic teaching, even if concerns often emerge regarding the variability in the standards and the need to offer a high-level learning experience inside the schools. In particular, Robinson [15] highlighted a structural problem that hinders the development of art in schools. Most of the time the governmental responsibilities in the field of art, cultural heritage and education are shared between two or more Ministries, such as those of education and culture, and sometimes of youth and sport. This can be a source of difficulty in the common understanding of needs and priorities. A unification of the Ministries can therefore produce benefits in terms of better understanding and greater effectiveness and efficiency.

While it is essential to monitor pupils' progress throughout the course of all studies, for artistic disciplines assessment this is even harder. A recent international study, carried out by Bamford [19] on the evaluation of arts and culture teaching in a European context, states that the main purpose of evaluation in arts teaching should be to clarify and make more concrete the objectives that students must achieve in the arts program. Assessment can be used formally (during learning) and summative (at the end of one or more learning sequences) to establish the pupils' results. Challenges for evaluation in this sector include the trend towards more integrated approaches to arts and cultural teaching and the fact that the evaluation responsibility is often divided between different subjects that have to collaborate and carry out planning jointly. Bamford [19] also states that the evaluation itself must be

a creative act, arguing that the evaluation methods must capture the different types of learning of the student, be they actor, critical observer, or creator. The previous research has shown that, where requested, the evaluation of the artistic subjects is generally entrusted to teachers who, depending on the cases, may or may not have benefited from training and an orientation suited to that purpose. Furthermore, Taggart and others [18] have discovered that the main methods of evaluation used by the teachers consist in the request for a representation and/or work by the student on the given theme and in the awarding of a mark for the work done. Hence, three main approaches have been distinguished. The first one requires that the teachers should formulate an individual professional judgement as a function of the objectives and the contents of the syllabus. The second requires that the teacher should evaluate the students' performance on the grounds of a common standard expected of a given age-group/level of studies. Lastly, the third sees the teacher attribute a level of progress to each student on the grounds of a graduated scale, irrespective of the age or the level of study. Most countries use the first two approaches for the evaluation. These systems allow to identify which students are making important progress and which ones are instead unsatisfactory, but the questions concerning the validity, the reliability and the consequences of the different teaching systems, besides the methods of arts learning, have not been examined in great depth. The involvement of professional artists in art teaching has been recommended in different studies. This should allow for an improvement in the quality of the teaching and the art learning to favour, generally speaking, a greater creativity and more specifically to develop competencies and confidence in the teachers, giving access to a greater range of cultural resources. Bamford [19] has observed the existence of a significant link between the quality of artistic teaching and the involvement of professional artists as "quality art teaching tends to be characterized by a strong partnership between schools and artistic organizations inside the community. In this sense, museums can also play a significant role in projects in which the museum becomes an experimental didactic room on the territory in connection with the school spaces; or in projects that see the museum enter the schools with its professional figures of reference to enrich the teaching activities.

Several studies have underlined that the art education programme of the 21st century will have to include in an ever clearer way the study of the new media (cinema, photography and digital arts) allowing some students to

use the technologies within the scope of the creative process. Also highlighted is a tendency towards greater transcurricular activities, which involve integrations between artistic subjects and other fields relating to the creative and/or cultural themes. these developments pose new demands on the teachers and the schools, besides the need for a strong sense of responsibility and support at the political level.

From the research into artistic education in Europe it has emerged that the objectives relating to this type of education are very similar between all the European countries involved. The programmes indicate, among their main objectives, "competence, knowledge and understanding tied to the arts," "critical evaluation", "cultural heritage", "cultural diversity", "development of personal expression" and "creativity." However, the goal concerning the development of "a permanent interest in the arts", which definitely represents one of the most important goals of art education, is recalled only in a few curricula. Also, if on the one hand many art education programmes identify as general aims the "development of social competencies and those of communication" and as a specific objective that of "encouraging the connections between the artistic subjects and the other disciplines," on the other hand, in some countries, the acquisition of cultural and artistic competencies remains a generic aim of compulsory education. The conception of the programme of artistic education is very heterogeneous among the European countries: in around half of these, the artistic subjects are proposed as individual courses in the school curriculum (e.g., musical education or visual arts) while for the other half of the countries involved artistic education is conceived as a field of integrated studies (e.g., under the heading 'Arts'). The range of the artistic fields varies greatly, even if the programmes analyzed comprise Music and the Visual Arts in all the countries and nearly everywhere also Theatre, Dance and Crafts; the Communication Arts are offered by twelve countries; Architecture is part of the compulsory artistic programme in just five countries. At the primary level, artistic education is compulsory for all the pupils. The same is true for nearly all the countries at the level of lower secondary school education. At this educational level, when the artistic subjects are not compulsory, they are offered as optional subjects. The minimum compulsory number of hours of teaching to dedicate each year to artistic education at the primary level is between fifty and one hundred hours in half of the countries. This number is slightly lower to the secondary level, where the programmes of around half of the countries recommend

dedicating to this subject between twenty-five and seventy-five hours a year. However, almost all of the countries encourage the schools to offer extracurricular activities in the artistic field. Even if the forms of art proposed in this field are multiple, music is well represented [20].

In Europe there are numerous scholastic experiments to reinforce the encounter of the pupils with the world of the Arts and Culture. Thus, in almost every country, visits are organized to places of art and cultural interest, as well as the creation of partnerships with artists. We can also cite some examples of art festivals, celebrations, and competitions which the pupils of schools are encouraged to take part in. In some countries this effort to develop the arts, culture and education has been institutionalized with the creation of bodies and networks addressed to promoting artistic and cultural education. In many countries reforms of the curricula are in progress and, in many cases, the planned changes also concern artistic education. The criteria for the evaluation of the pupils in the artistic subjects are usually defined at the school level by the teachers themselves. These criteria, which are established on the grounds of the learning objectives defined in the syllabus or by the guidelines provided by the further education authorities, allow the teachers to identify the pupils' various levels of achievement. Only in a small number of countries (seven) are the evaluation criteria defined by the central educational authorities. Most of the countries recommend using one or more types of evaluation scale, mainly at the secondary level, where the numerical scales are the most diffuse. At the primary level, the most frequent situation, cited in around twelve countries, is the use of synthetic grades, especially in the early years of schooling. In most of the countries, a final mark of unsatisfactory in artistic subjects is not taken into account for class changes and does not have a direct consequence on the pupils' education. In nearly all the countries, artistic education is entrusted to unspecialized teachers at the primary level, that is to teachers qualified to teach all or most of the curricular subjects. In most of the cases, these teachers have received a general training in one or more artistic subjects and a targeted pedagogical training. The subjects in question are often Music and Visual Arts, which are part of the compulsory subjects in the study syllabus. Instead at the secondary level specialized teachers are responsible for the artistic education. before starting teacher training, they usually need to have acquired skills in one or more artistic subject.

The professional artists are seldom involved in art teaching in the schools is they do not have adequate qualifications. If they are authorized, this generally occurs for short periods. Furthermore, the participation of artists in the initial and continuing education of the teachers is seldom encouraged in the State projects. The realization of collaborative project between the different actors in the artistic field at school, also by means of political agreements and understandings, is a strategic choice that can valorise artistic education. At the political level, in some countries, collaborations have already been defined between the different ministries that support the projects or the creation of networks and bodies for the promotion of artistic education. However, it is recognized how artistic education in schools can draw greater benefits from the experience of professionals and institutions specialized in this sector, to ensure that art does not just represent a subject of study but, above all, a real-life experience [20]. The use of information and communication technologies is explicitly cited in the programme of artistic education in many European countries where specific initiatives are organized to encourage the use of technologies. This is a priority goal for the future development prospects, and thus also in the perspective of augmented reality.

The new technological augmented reality instruments can indeed offer concrete potential if they are put at the service of critical models of didactic mediation and developed within a precise educational project, relevant and coherent. In this sense, the most recent developments of the augmented reality technologies pave the way to unexpected scenarios for learning in formal and informal educational contexts, in particular in schools and museums. Indeed, the applicability and the application of augmented reality to the fields of didactics represents an innovative research field, whose growing experimentations provide significant elements for a pedagogical reflection. The efficacy of the educational pathways realized through augmented reality represents one of the most interesting themes in the current debate, especially as concerns the design, implementation and evaluation of an enhanced didactics to be traced back to within an adequate theoretical-methodological framework [21, 22, 23].

Several studies have evidenced the educational potential of the digital environments (virtual, augmented and hybrid), in which each student can try out concrete learning models of a cognitive and socio-relational nature [21, 24, 25, 26, 27], with particular reference to education to the arts and to the cultural heritage. In this sense,

the design and the construction of augmented reality digital environments for education to the heritage falls within the actions of the NOP – National Operative Programme "For school, competencies and environments for learning 2014-2020" that support the need to sensitize the students to the cultural, artistic and landscape heritage to construct a full citizenship. In this perspective, the schools are trying out new experiences, oriented to the spread of a digital culture, for the knowledge and valorisation of the cultural heritage through forms of digital artistic creation (performing arts) and digital communication (digital media, e-learning).

Hence, the design and realization of didactic experience through augmented reality represents one of the continuously evolving innovative themes [28, 29, 30, 31, 32]. The application of augmented reality to the fields of didactics relates in particular to mobile learning, literally understood as learning that avails itself of mobile devices [31, 32]. This form of learning draws on the affordances proper to the mobile devices: portability and flexibility, multifunctionality, ubiquity and ease of access, multimediality, multitouch and personal possession [25, 33]. These characteristics determine the development of "educational experiences based on learning systems hinged upon mixed and/or augmented learning systems in the light of the construction of meanings by the student, allowing them to take part in a rich media milieu, distinguished by the combination of real and virtual objects, by the use of sensorial inputs and by the possibility to place virtual learning objects in the real world and to interact virtually with a hybridized world" [34, p. 134]. We are thus witnessing the "transition from Mobile Learning to Augmented Reality Mobile Learning" [35], where upon "Augmented Reality Learning is a further development and extension of Mobile Learning" [35]. The use of augmented reality is part of the most recent developments in Learning with Technology that looks at new technological devices as a means that can facilitate the learning process [36]. In fact, augmented reality is a dynamic and interactive teaching tool that helps transform spaces, times and ways of learning, thanks also to the fact that laboratories and classrooms are beginning to be widely equipped with suitable technological infrastructures. The Wi-Fi networks, for example, allow for the connection of the devices managed directly by the students for research and work activities done in class, according to the "Bring Your Own Device" philosophy (BYOD) [37]. The way of managing the classroom changes as a consequence and new didactic methodologies and strategies are tested such as simulations,

gamification, augmented reality, virtual reality and immersive learning, wearable devices, mobile learning, shifting the attention to the new emerging models of learning (immersive learning, via simulation, learning in mixed realities...). In addition, the potential of augmented reality is significantly manifested also in the context of situated learning: “in a broader context of education, augmented reality is appealing because it aligns with situated learning. Students find connections between their lives and their education through the addition of a contextual layer” [38]. In fact, augmented reality, as a new frontier of digital communication based on the combination of augmented content and geo-referencing, allows just-in-time and just- in-place access to digital content with respect to the real perceptual experience. Digital objects and real objects coexist in another space that does not replace the physical world but overlaps it through a process of digital addition, in synchronicity and interactively, in order to provide an experience to high content that involves all our senses and reaches gradually rising levels of concreteness. In fact, the total 'transparency' of the devices (from the monitor to the display, from the helmet to the glasses) moves in the direction of the immediacy of the experience on a perceptual, sensory and motor level. By offering the possibility of experimenting in real time new and creative ways of interaction, contextual to the experience, augmented reality is an active technology that offers opportunities for 'immersion' and involvement, also on a cognitive, emotional and relational level. Therefore, augmented reality is significantly inserted in the relationship between technologies and didactic mediation [24]. Its applications are placed within that category of mediators, analogues, based on simulation and which Damiano [39] places between iconic and symbolic mediators. With reference to the model of education architecture proposed by Clark [40] and subsequently integrated [41], learning centered on the use of augmented reality is placed in simulation architecture and recognizes precisely in the symbolic simulation the its main didactic strategy that “is based on reproducing, in a protected and controllable context, experiences similar to those of the real world, to provide students with the possibility to act and learn from the consequences of their actions (...) through a both intellectual and emotional involvement [34, p. 68], leading “to reconceptualize teaching in a more participatory and interactive form [34, p. 133].

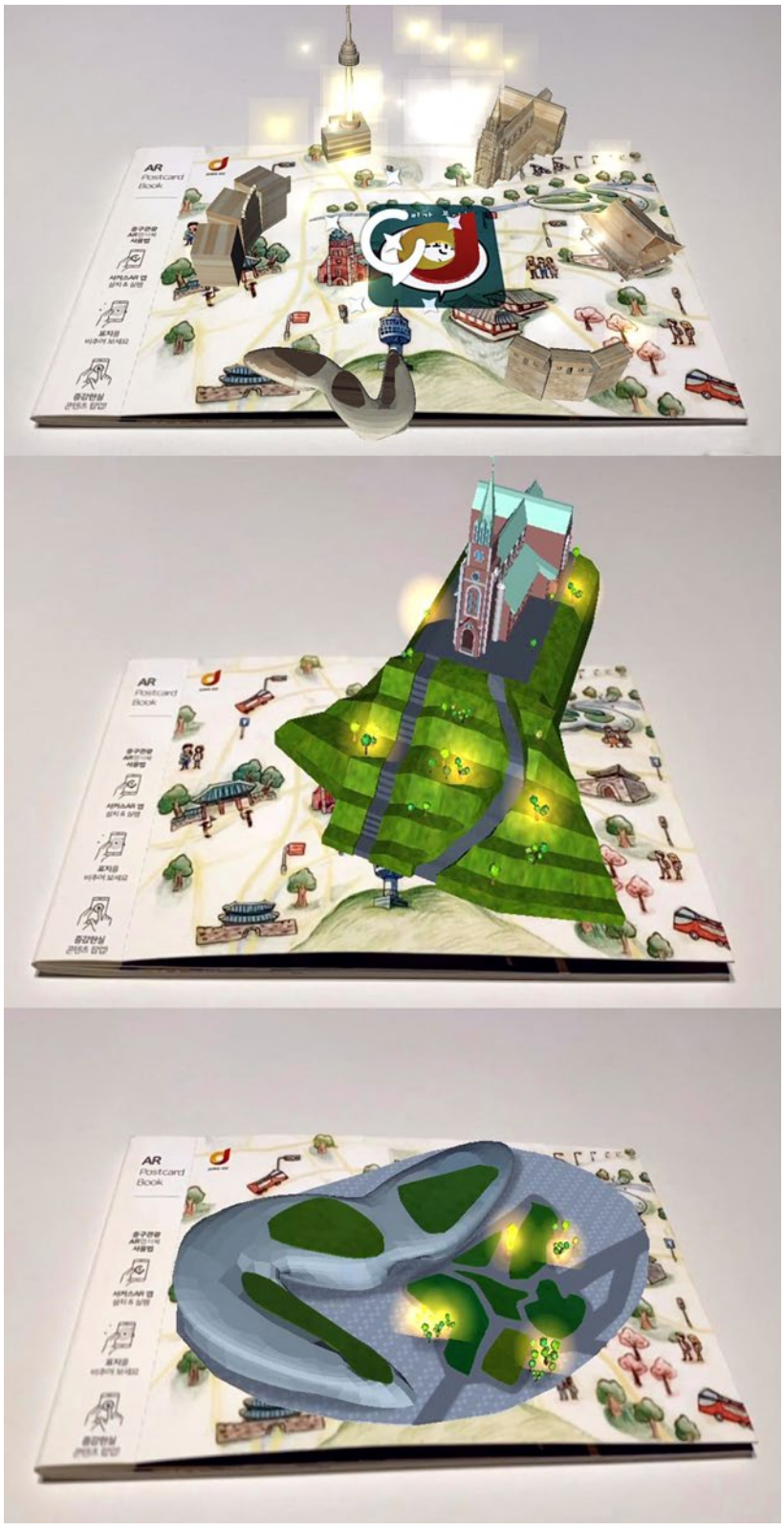

Fig. 1. Screenshot of AR application of interactive postcards, committed by Seoul Metropolitan Government in 2017.

2. Augmented reality for meeting and making art

The latest developments in augmented reality technologies offer unexpected opportunities for learning in formal and non-formal educational contexts. In particular, the international scientific literature focuses on the relationship between augmented reality and arts education and on its potential [42, 44, 45, 46]. In particular, the use of augmented reality in educational contexts refers to the acquisition of the key competence recommended by the European Council for lifelong learning: the 'cultural awareness and expression'. The main feature of the this competence is to be found in the 'awareness of the importance of the creative expression of ideas, experiences and emotions in a range of media, including music, performing arts, literature and the visual arts" and includes "an awareness of local national and European cultural heritage and its place in the world (...) and a basic knowledge of major cultural works, including popular contemporary culture" [47]. Such competence refers to skills related to "the appreciation and enjoyment of works of art and performances as well as self-expression through a variety of media" [47]. In this sense, access, exploration, knowledge and enhancement of the artistic heritage through technological experiments that orient towards "a new cultural approach that requires a rethinking of the identity construction of the self, the vision of urban spaces and the ways of using cultural and artistic products" [48]. Specifically, the use of augmented reality in the field of art education can be declined via two different modalities: augmented reality for the knowledge of art, at different levels, through the ability to access personalized and customizable paths; reality increases to support creative expression, promoting forms of participation and re-elaboration. The first modality refers to the field of reception/use of the artistic heritage. The second modality is positioned within the scope of production. In both cases, AR can offer involving, creative and participative forms of learning [49].

2.1. Augmented reality for knowledge of arts

Augmented reality technologies transform objects and places of art into digitally enriched environments through the preparation and preparation of paths that provide information that is not immediately usable. In fact,

augmented use renews the methods of mediation of art and the related forms of learning. In this sense, augmented reality is an environment in which the acquisition of basic knowledge (didactic information) takes place, as well as the possibility of further study (contextualization, logical connections, ...) [45].

The use of augmented reality is in fact correlated with an increase in the accessibility of information able to offer the subject who learns an experience of a predominantly visual nature, based on the possibility of exploring the object on the surface, through zooming later, but also from the inside, showing the invisible, thus improving and facilitating understanding also through a more realistic and engaging approach. The subject can query the works exhibited within a museum exhibition space and explore them without actually needing to touch them, giving rise to an enriched visit at the perceptive-sensorial level that extends the range of possibilities tied to the user experience. Indeed, the superimposing of layers of data of a contextual nature upon the artistic object impacts the process of acquisition and the deepening of the knowledge. Augmented knowledge is provided in a stratified way to allow progressively for the search of further meanings relating to the provenance of an object, to the historical and economic context of production, to the technique of manufacture, to the curiosities connected to it. The languages and the media used are multiple: short textual contents, images, graphical representations, video re-constructions, audio contents. Some augmented reality experiences are based on the rendering of a digital version of the artistic object in high reproduction, in which the elements of virtual reconstruction are superimposed upon the real ones, in an immersive experience that renders the impressions of finding oneself before a unique object (painting, monument, sculpture, etc.). This aspect turns out to be particularly importance where it is necessary to show what the monuments were like in the past comparing them with the present. In these cases, the mobile device works like a real GPS navigator that accompanies the visitor along the thematic routes. Specifically, there are three aspects that the AR technologies have in common: 1. motion tracking, to identify the subject's position; 2. environmental understanding, to understand the surrounding space; light estimation, to make the illumination of the virtual objects and the light sources of the scene coherent with one another. Specifically in regard to the artistic assets, the augmented reality technologies can be used in a dual modality [50]: indoors, with particular reference to the pathways developed inside the museums and the galleries; outdoors, in relation to the external

pathways realized both in the place of art present diffusely in the urban territory, and in the archaeological parks and the contemporary art parks [51, 52, 53].

Augmented reality-based art learning in museums

Historically the museums as places of conservation and exhibition valorise the materiality of the objects and stimulate the visitor to have a direct experience to reflect on the singularities of the craft objects. Indeed, the museums and more in general the cultural goods are recognised as large dataspaces [54] places of transmission of knowledge in which the memory of a people is collected [53].

Each object conserved in a museum is not a simple datum, but it inscribed inside it a story that the technologies and in particular the augmented reality devices succeed in telling. Augmented reality indeed allows us to represent a cultural object without isolating it from the context it belongs to. Its nature as a datum in this way is enriched and becomes a story in itself. The museum experience is thus transformed into performative terms and the museum becomes a sensible organism that finds in the interaction between artwork and visitor its most evident rationale [55, 56]. When the spectator is in a position to articulate their relationship with the work, they are predisposed to a better knowledge of it and cooperates creatively to its evolution. Thus, the digital technologies start to make practicable far more radical forms of interactivity that can enrich the visitor's experience [57]. Hereafter we present AR pathways realised in some museum contexts both in regard to their own permanent collections, and in regard to temporary exhibition events, according to an explorative approach that allow the invisible to be seen. Since 2017, the Detroit Institute of Arts has offered its visitors, via systems of augmented reality activated on mobile devices, the chance, after having framed one of the mummies conserved in the exhibition spaces, to know the ancient burial rituals, to discover what is not visible and it hidden beneath the bandages. The visualisation of the relics through the AR system shows another layer of reality, otherwise invisible to the naked eye (the skeleton of the mummy, the mummification process and the way in which the curators have taken care of the object; the Ishtar Gate in scale, the figurative scenes inside the Mesopotamian seals,…), as well as the

possibility to access a musical layer that renders sounds and noises correlated to the object or to the scene of reference, conducting the subject to other contexts, beyond the physical walls of the museum.

The director of the DIA Salvador Salort-Pons has praised these educational values, stating that “augmented reality allows the user to see the invisible, to imagine art in its original situation and to understand how the objects have been used and experiences by people in their everyday lives” [58].

With reference to this type of use of AR, *GO! Muse* is also used. GO! Muse is the application for AR experiences developed for the MUSE-Museum of Sciences of Trento (Italy). It offers the visitor the opportunity to see how the prehistoric animals housed in the museum looked and moved, whose physiognomy has been reconstructed thanks to the collaboration between the museum's researchers and the paleoartists Davide Bonadonna and Fabio Manucci. The application allows to virtually place virtual 3D models of dinosaurs, prehistoric reptiles, and whales, largely extinct, in the real spaces of the museum, after framing their skeletons with the mobile de-vice that supports the application. Among the applications that transform paintings into augmented installations, the Fourth Estate: Beyond the Visible represents a significant ex-ample of the use of augmented reality applied to a painting by Giuseppe Pellizza da Volpedo *The Fourth Estate* (1901). This is an initiative created by SMART - Augmented Culture in collaboration with the Museo del Novecento in Milan (Italy), which exhibits the work. Visitors are given the opportunity to know and interact with the painting in an unprecedented way. Through the AR, the picture becomes an access interface to learn about its history and the history of the characters represented. In fact, by framing the work through a mobile device, it is possible to activate an original form of interaction to access different content. At a first level of perception in which the image of the painting is placed, a second level given by the information on the painting is superimposed. The characters depicted seem to ‘come forward’ to meet the observer who can listen to stories and curiosities told through their own voices, in an experience that is both visual and auditory. The experience ends when the observer of the work ‘meets’ the character represented in the foreground, in the middle of the portrait, the man with the hat, next to whom one can pose for a photo to be posted on the main social media [45] Rembrandt Reality is the AR application released by the Mauristhius museum (in The Hague). Through this application, *The Anatomy Lesson of Doctor Tulp* (1632) by Rembrandt

van Rijn, exhibited at the Mauritshuis museum, it is possible to move inside the painting, closely observing the scene portrayed depicting the public dissection on the corpse of a just executed criminal. Once the app has been launched on their device, looking through the screen the viewer is faced with a portal. Inside there is a faithful reproduction of one of the towers of the public weighing in Amsterdam, which at the time of Rembrandt housed the headquarters of the surgeons' guild. A voice guides you during the visit, explaining the painting, its history, and its details. In this specific case, the application allows to enrich the world with virtual holographic projections projected and into the physical world, where users can interact with them. With reference to the exhibition events, the Pérez Art Museum in Miami has proposed itineraries in augmented reality. As stated by its director, Franklin Sirmans, the PAMM is a place for experimentation and laboratory of ideas, to allow visitors of all ages and backgrounds and to interact with the most innovative visual arts of our times. Specifically, the reference is to the exhibition by the artist Felice Godrin*, Ivasive Species* (2017). It is a digital exhibition accessible to visitors using iOS devices in PAMM's outdoor areas and in the Padma and Raj Vattikuti Learning Theater on the museum's first floor. The exhibition offers a reflection on the relationship between physical and mental territories, with particular reference to the transformative and unstable state of our ecosystem, influenced by climate change. To this end, the works in AR overlap with the physical spaces of the museum, interacting with its architecture, evolving and transforming its environment.

Augmented reality-based art learning in archaeological and art sites

Augmented Reality applies to outdoor mobile cultural access which provides visitors with the chance to move around the archaeological and art sites, viewing detailed contents and 3D images overlapping monuments, sculptures and contemporary buildings and places [59]. In particular, for works of ancient art and archaeological sites, real vision is enriched with the picture of the place as it was in the past (the way it was like compared to the way it is now) [60]. In this regard, some AR applications provide customized routes, tailored to the user's profile, automatically providing information based on the location (reconstruction of sites in ruins; simulation of ancient streets, ...). “Now that there are open-access, low-cost tools available to make virtual and augmented reality

models, more archaeologists are creating and using such technologies to reach out to the public through experiential learning. Projects range from static models of individual objects to entire landscapes that translate aspects of memory, phenomenology, and materiality into virtual or augmented reality experiences" [61, p. 305]. A significant example is offered by the *i-MareCulture project* (2016-2020) implemented in the submerged archaeological park of Baia, a protected marine area located to the north of the Gulf of Naples. The project, funded by the European Union, thanks to the Lab4DIVE project (Mobile Smart Lab for augmented archeological dives), aims to document and make known the submerged archaeological heritage through an experience in virtual and augmented reality that does not require the visitors to take a dive underwater. I-MareCulture consists of a 3D navigation that allows the users to view the current underwater heritage and compare it with a hypothesis of site reconstruction (prior to being submerged) through information and digital images created thanks to the collected material by divers. The application of dedicated underwater AR thus allows users to dive down to the seabed where the archaeological relics are located. Two modalities are proposed:

• with water, through a realistic representation of the environment and its characteristics;

• without water, through a decontextualized vision of the cultural heritage in such a way that the images are clearer and sharper.

The project with which an AR application (2014) was honed, realized on the occasion of an archaeological excavation conducted inside Palazzo Baldini, in the historical centre of Florence, is positioned inside an equally meaningful field. During the excavation, layers of different construction phases of the building emerged. The application offers the possibility to see the 3D model of the building, providing multiple levels of information, enriched with images, on the finds and on the original morphology of the building [60]. With reference to the use of AR in art parks, the Beyeler foundation introduced in 2020 a specific application "ART in the PARK" to discover the hidden features and history of five works in the Berower Park (Riehen, Switzerland): Thomas Schütte's sculptures *Hase* (2013), Jenny Holzer's *Living Series: You should limit the number of times ...* (1989-1989), Ellsworth Kelly's *White Curves* (2001), Alexander Calder's *The Tree* (1966) and Philippe Parreno's *Water Lilies* (2012). The application also allows people to interact with virtual works of art through a series of proposals

(Swing “The Tree”; Open “White Curves”; Play “Water Lilies”, ...). The experiences proposed here show how one of the most significant dimensions developed by augmented reality applications is represented by interactivity: virtual objects that increase real objects are not static but can perform movements and animations in response to user actions. Dünser states that the “[i]nteractions in AR engage learners with the content and allow for knowledge to be acquired through their [the students] own manipulation of content [...], as supported by constructivist learning theory” [22, p. 113]. This dimension is also linked to the improvement of memory skills that leads to the preservation of the knowledge acquired through augmented reality for longer. In this regard, Chang points out how “[the AR application] facilitates the development of art appreciation […], supporting the coupling between the visitors, the guide system, and the artwork by using AR technology, and helping visitors keep their memories of the artwork vivid” [62 p. 193]. In fact, many projects aimed at enhancing art and promoting art education paths with the use of augmented reality propose learning based on the discovery that, unlike “static” or “one-dimensional” learning, occurs as a multi-perceptive, immersive and engaging learning, with regard to multiple intelligences [43].

2.2. Augmented reality-based learning and creative expression

Several sector studies highlight how augmented reality is understood not only as a technology for the use and knowledge of artworks, but also as a possibility of expression, reflection and critical thinking, as well as designing and testing significant and original paths of knowledge. In this regard, several artists have recognized these cognitive values of augmented reality technologies, which are of particular relevance in educational contexts.
An example of this is the work developed by the Danish-Icelandic artist Olafur Eliasson who created *AR Wunderkammer*, that is, a cabinet of curiosities in augmented reality that viewers can collect and experience: extraterrestrial rocks, insects and rare birds like the puffin, and various objects including the floating compass that always returns to true north; an insect; and a Little Sun, Eliasson’s solar-powered lantern, that can be charged by the AR sun. “The audience is invited to ‘bring the outside in’ by creating their own environment as they add AR objects, atmospheres and ‘imaginary friends’ to their own, personal space” [63].

Eliasson himself explains the significance of his work: “Today, where physical distancing guides our lives, it’s as crucial as ever that we surround ourselves with things and atmospheres that really matter to us. [...] The artwork is about challenging our perception of the everyday and actively welcoming that which lies on the boundary between the known and the unknown. It is about creating spaces that meld the everyday and the extraordinary spaces that evoke vivid perceptions and embodied engagement” [64]. Similarly, some young artists working in the digital field use augmented reality within the museum field in an original way and in a playful-collaborative dimension that stimulates users to deal with the works through a creative reinterpretation of some masterpieces in art history, developed in a modern way. A significant example is *ReBlink* – project hosted by Art Gallery of Ontario (Toronto) in 2017 – developed by the artist Alex Mayhew; thanks to this project the artworks displayed in the museum can be animated by means of a personalized application for smartphones and tablets. The development of the interactive dimension is fundamental to fully understand the “re-created” meaning of the exhibited works. The characters portrayed in some paintings, animated and brought into the contemporary world, begin to interact with the visitor (they leave the frame, take selfies…) [45]

In this way, reality and imagination become intertwined and as a result past art is put in relation with new generations and paves the way to creative experimentations. In fact, augmented reality as a tool used by young people to express themselves and re-elaborate their acquired knowledge, especially in education in art and cultural heritage, is becoming increasingly popular in school contexts. An exploratory survey carried out on national territory in 2018 by the research group of the Department of Education of the University of Bologna highlighted that the designing of didactic pathways through augmented reality is positioned within a constructivist and problematicist perspective [65, 66]. By means of augmented reality students learn to explore, search and construct new knowledge using creative methods; they structure and re-elaborate the information and the data collected, construct digital pathways/narratives, particularly within exhibition environments. This learning process is developed through successive phases: 1. the research, collection, selection and organization of information content about artistic objects, with particular attention to the reliability of the sources and content of network; 2. the search for images on sharing sites in creative commons and/or the creation of photographic shots; 3. the

construction of videos through the combination of text, images and audio recordings; 4. the construction and sharing of augmented content, capable of providing new readings of the artworks. Specifically, the students design didactic art projects with their teachers to be carried out in class within the field of augmented learning and learn how to observe, interact and finding out about the artistic heritage actively and interactively. Augmented reality indeed allows them to know, discover, reinterpret, each one according to his or her own vision, a cultural asset or a place, transforming the physical spaces into scenarios of a person imaginary to be shared both with the school community and with the community of the territory of belonging. In this way, historically relevant spaces from an artistic point of view offer creative and participatory ways of learning. In so doing, augmented reality produces an involving kind of learning on the motivational level, with a significant impact on attention, concentration, satisfaction, cognitive maturity and on the imagination. These aspects emerge in particular when augmented reality is used to re-elaborate the knowledge acquired about the artistic heritage, through the construction and sharing of personal content that allows them to provide new readings and interpretations. In this perspective, augmented reality enhances a kind of student-centred learning, in the direction of active learning and self-learning that allows the student to create study materials, the objects of learning process, in order to gradually reach the more complex stages of thinking [28]. Students thus become aware of the reality that surrounds them; they are no longer passive users but creators of innovative content. In this regard, Liu, Tan and Chu [67 p. 173] underlines how augmented reality "improves the ability to explore, absorb new knowledge and solve problems" with a consequent impact also on an emotional level. "Augmented reality arouses these emotions due to its potential to connect the power of the network, the power of technology and the power of communication in the transmission of content" [68, p. 26]. A further aspect that emerges from the school projects taken into consideration in the exploratory survey [65, 66] is the relationship between augmented reality and the development of a creative mind capable of reworking and reinterpreting art objects. In this sense, some educational experiences tend to forge a bond between creative expression and enhancement of the cultural heritage, both tangible and intangible, that students feel as their own.

3. Digital environments and augmented reality

3.1. Augmented reality as third space

The scientific literature highlights how augmented reality in the context of art education acquires particular relevance when it represents not only a privileged space for the enjoyment of art, but also for manipulation and experimentation [25; 36, 69, 70]. These aspects recall the concept of multimodality [71] used in reference to the multiple modalities used to communicate and express, through the creation and production of digital artefacts, bearers of original meanings within an eco-systemic perspective. Augmented reality thus places the user in a new space, a 'third space' [23, 72, 73], where virtual and real objects coexist through a process of digital addition; a hybridized space in which digital artefacts are superimposed upon reality perceived through the senses.

According to Flessner [73], in this third space, the formal and the informal, the presence and the distance, the "real" and the digital are recombined, building new meanings: it is possible to work to aggregate and re-elaborate materials and experiences from the first and second spaces, to reflect on them, to understand the experiences lived in the informal with the lens of theory and to rethink theories based on experiences. In this sense, digital environments as a third space are also augmented reality environments that in the contexts of art provide tools to personalize, build, enjoy and share new artefacts. This third space also looks like a space of flows as augmented reality technologies connect different places through the subjective practices of individuals who relate to each other; but it also looks like "distributed intelligent space in which it becomes increasingly difficult to distinguish between real and virtual and where mobile technologies mediate the experience of a new sense of space, which we can call augmented" [24, p. 22]. Thus, emerges the possibility of designing innovative art education activities based on augmented reality in relation to new approaches for accessing and building knowledge. In fact, increasing reality also means providing places for cognitive growth in which forms of collaborative construction of knowledge and skills that can be implemented gradually which, in the theoretical field, refer to connectivism. It attributes to the condition of always being connected a key value for the development of knowledge in the digital

age [34, p. 179]. Hence today, with the spread of the visual richness provided by technology and the development of the possibilities of interaction, digital environments become the place where both the instances of creativity and expressiveness can be connected in the educational sphere, as well as those of design and experimentation, to arrive at a concept of renewed and expanded knowledge [74]. The third space of augmented reality is provided by the combination of several elements: the application, the content, the interaction, the physical environment and subjects. The application is the program that allows us to organize and control the different aspects of the augmented reality experience, including the recognition of the physical world in reference to digital content and the synchronization between the physical and virtual world, in order to add digital elements to the user's vision. Augmented content, the digital layer, includes all objects, ideas, stories, and sensory stimuli. The interaction allows the user to observe the digital layer from different points of view or perspectives. Each augmented reality experience is closely linked to the physical environment in which it is made and to the real object that is augmented with virtual information. The actions and movements of the subjects influence the entire system of creation and reception of digital artefacts in AR. The experience with these artefacts is configured as a process or an evolution in space and time of actions, facts and behaviours linked to each other. Thus, the perspective of a third space between real and digital is realized, which offers different training opportunities: cognitive and affective purposes; historical adherence and scientific rigor; realization of expressive-creative experiences with high coefficients of imagination. With reference to this meaning of AR as a third space that enhances the dimensions of knowledge, creative re-elaboration and participation in the artistic and cultural heritage, two AR experiences are presented here: MoMAR and Snapchat augmented reality. The first was created in a specific museum context, the MOMA in New York; the second created in collaboration with Jeff Koons on Snapchat Art.

MoMAR stands as a particularly significant experience that through AR transforms a traditional museum setting into a third space. In 2018, a collective of eight artists digitally transformed Jackson Pollock's gallery at the Museum of Modern Art in New York, with the aim of democratizing public spaces for art. The performance entitled *Hello, we're from the Internet* – preceded in 2010 by an analogue intervention by the title WeARinMoMA – acted on two perceptual levels: the first, visible to the naked eye; the second, visible only through the app. With

reference to the first level, visitors were able to observe Pollock's canvases, as they appear in physical reality; in relation to the second level, visitors were able to enjoy and interact with the original reinterpretations made by the artists of the collective. The gallery space thus became a third space and Pollock's works were the interfaces for access to new forms of visual interpretation. One of the AR installations, created by artist Gabriel Barcia-Colombo, transformed the White Light painting - one of Pollock's last paintings before he died in 1956 - into an interactive game. In the game, small skeletons quickly climbed up all sides of the painting. In this regard, the artist claims that: "I wanted to make an experience that played with the existing form but also commented on the painting itself" [75]. The installation created by Damjanski, called *One: Number 12811912112811950* (2018), presented visitors with a gif that merges the faces of Pollock and Ed Harris, the man who played the artist in the film Pollock: "I started questioning the value of representation and manifested these thoughts in a hybrid character of Jackson Pollock and Ed Harris playing him (…). This new character interrogates the lines between fact and fiction and what's 'real' and 'fake' [75]. Artists have made their MOMAR app open source as a means of encouraging participation, through release of an instructional PDF that allow anyone to make changes, even without specific skills in coding. The artist highlights: "it's the first iteration of a set of instructions to give people the power to show their work in any physical exhibition space around the world" [75].

In 2017 Snapchat launched an innovative project of artistic enjoyment which consists in proposing the works of Jeff Koons with augmented reality, showing them as 3D sculptures on the screen of one's mobile device. In fact, Snapchat allows us to admire artworks that do not exist in the physical reality and, for this purpose, it has published a page dedicated to artists, called Snapchat ART [76].

To launch this initiative, Koons has made available some of his sculptures which, elaborated in three-dimensional graphics, are virtually placed in various parts of the world. Through Snapchat's World Lenses function, users can admire and photograph Koons' works in augmented reality, also thanks to a notification message they receive when they are near the places where the virtual works of art have been placed; or they can consult the SnapMap to go directly to the places indicated for use (Central Park in New York, Hyde Park in London…). The sculptures thus become 3D stickers that users see only on their device's screen that they can also be added to their

photographs or videos [77]**.** In terms of participation, other artists can participate by adding their work to the virtual collection. A Chilean artist Sebastian Errazuriz even reworked a Koons augmented reality sculpture, Balloon Dog, situated in Central Park, covering it with tags, by superimposing a duplicate of the modified work upon the original. The same collective act, this time on the level of participatory enjoyment, determines the 'visibility' of Koons' augmented reality sculptures. In this specific case, it is the users/viewers who recognize the 'presence' of the artist's works in well-defined places and 'materialize' them on the display of their mobile device.

3.2. Augmented reality for creating digital artefacts

In educational contexts, the application of augmented reality is declined in two different ways:

1. as a *support* to students/users who, within an "augmented" environment, discover and frame the graphic elements that give access to the training content useful for describing and narrating a specific experiential context; in this context, augmented books are also included "which aim to enhance printed communication through the placement of paper markers on the covers and pages (...): photographs become films, paragraphs come alive and the columns give way to graphic and multimedia objects" [53, p. 43].

2. as a *product* of the students/users who, after having learned the basic principles of designing through augmented reality, create the augmented content with their smartphone/tablet, starting from the research and selection of study materials considered interesting and relevant. In this way "students can construct the contents and place them in context using their mobile phone or tablet, share them with other students, who in turn can add further contents" [34, p. 135]. In this sense, the digital artefact [78, 79] represents a form of knowledge processing supported by multiple languages and multiple ways of connection, starting from the subject's experience in formal and non-formal contexts. The graphic-visual dimension represents a fundamental characteristic of this typology of artefacts, whose design and construction refers to different intelligences, including the graphic-visual one. In fact, with reference to the theory of multiple intelligences [43], visual intelligence is in a complementary relationship with graphic intelligence and defines the fundamental cognitive abilities of cognitive processes. In this regard, it is recognized that the digital graphic-visual artefact has a strong impact on the motivational context of

the learning subject (pleasure, need, duty). In this sense, the visual digital artefact is part of a global learning process that integrates cognitive, socio-relational and emotional dimensions [79].

The design of these digital artefacts in AR is based on some fundamental actions: searching and selecting information; build the texts, images and videos that make up the overlays; associate the augmented content with objects / art images with a trigger function; share augmented content [80]. The production of digital artefacts goes beyond the pure theoretical dimension, promoting "different thinking styles, preparing for creative and divergent solutions to the problems of contemporary life" [81], favouring the implementation of an operational methodology of discovery, exploration and research. In regard to the digital artefacts made and accessible via AR, here we present the experience of the MAUA - *Museo di Arte Urbana Aumentata* and that of SketchAR, a specific AR application based on artificial intelligence.

The MAUA - *Museo di Arte Urbana Aumentata* (Milan), founded in 2017, is a sort of open-air gallery dedicated to animated street art that proposes novel cultural itineraries in the five most degraded neighbourhoods in Milan, through the involvement of the residents themselves. Indeed, in the initial design phase, the citizenry was asked to select the street art works most representative of their own area, which were then visually documented by students and neighbourhood associations, along with teachers of the school CFP Bauer. Among the documented street art works, fifty were selected that were then elaborated by just as many young animation designers. They transformed the street art works into augmented reality producing fifty digital artefacts. Today, the museum is made up of these fifty animated street art works in augmented reality. Specifically, the access to each of these works distributed in the peripheral neighbourhoods of the city, consists in the fact that each work can be framed with a mobile device (smartphone or tablet), generating a new work of digital art. On the level of the participation of the citizens, the cognitive dimension was activated in respect to those works of street art deemed to be most representative through a careful selection and documentation. This first level of acquaintance was followed by a phase of creative re-elaboration performed by young animation designers. They elaborated the images in augmented reality producing digital contents that animate the selected street art works, recreating and transforming them into digital artworks. In this wat, the augmented street artworks, whose location is marked from one time

to the next by one's own device, have become the chance to explore and know the city's peripheral neighbourhoods. The *Museo di Arte Urbana Aumentata* has thus proposed a diffuse and participated model of museum to attract a 'particular public,' made up of the inhabitants of the most degraded urban outskirts. The involvement of the inhabitants beginning from the phase of the selection of the street artworks has been translated into "an advanced experiment of diffuse curatorship" which has envisaged the collective identification of the works and the sharing of their meanings. The production of augmented reality digital artefacts has marked the shift from the condition of curatorship to a singular and novel experience of participated visit [77].

SketchAR is a mobile app based on artificial intelligence – from artificial vision to automatic learning, to neural networks – finalized to developing the dimension of creativity in contexts of art education, putting forward an interactive approach to drawing in augmented reality. Any AR product is indeed based on artificial vision. In this specific case, SketchAR uses a tracking system of markerless artificial vision. The application uses a technology based on the computerised vision of augmented reality, which allows for the space framed by the smartphone to be scanned and 'set' the virtual image on a real surface. This application with the feature of personalized virtual assistant refers to a machine learning system (automatic learning) that can help both the users to understand how to draw a particular object, and to analyse the habits of the users themselves, in respect to the drawing methods adopted. An algorithm collects this information and supports the users so that they can achieve their objectives in the graphic activity. Developing this core of artificial vision, different methods have been created: "Progressive markers" and "Predictable markers." This means that the lines traced by the user transforms into an anchor and improves the retention of the virtual object. An increasingly relevant relationship thus unfolds between action and knowledge, between action and perception [82, 83, 84, 85]. The augmented reality environments show characterisations relating to that specific milieu of study that analyses how the life spaces are structured in relation to the digital media, whose characteristics and functions need to be understood. Augmented reality thus represents a third space, syncretic and multimodal in nature, that brings into play a plurality of languages and heterogenous expressive forms in a unitary strategy of communication, finalised to the production of digital artefacts. Within

a pedagogical-didactic reading, these characteristics of augmented reality thus allow one to create a context particularly suited to the valorisation of the cultural heritage [86].

4. The language of images and augmented reality

4.1 The audio-visual language

Augmented reality is a visual method of presenting digital information that corresponds to the need to find ever more engaging and realistic ways of expression. Augmented reality can be used in a wide variety of application domains [87, 88, 89, 90]. It can be defined as a new form of audio-visual, together with other types of digital video, which are both texts and experiences [91, 92, 93].

As such it does conceal some pitfalls. It seems to be an immediate form of communication, but in actual fact, albeit fascinating, it is a complex system. This is shown by the fact that if to write a book you simply need to be a good writer, to produce an audio-visual you need different skills that correspond to different professions. The question "who is the author of a film" always leads one to reflect on the complexity of language and obliges one to reply in the plural form: scriptwriter, director of photography, editor, musical composer, director are just some of the skills involved in cinema production [94, 95, 96, 97, 98, 99, 100].

In an interview given to me for the Media Education LAboratory (MELA) of the Department of Education Sciences of the University of Bologna, the renowned Italian screenwriter, author and television host Carlo Lucarelli stated: "The audio-visual works have a true force, which we take for granted. They belong to a type of imaginary according to which something that is seen is simpler and more immediate that one that is read: but that's just not true. It is, however, always true that if you suggest to someone, above all a young person, that they should read a book or see a film, he or she will think they will understand things much faster and more easily by seeing a film. This makes the audio-visual language a good vehicle, but not a simple language. It is a good vehicle because

it draws the attention and curiosity that can then be shifted onto the written text, essential for getting into the complexity of the message.

Audio-visual language is not easy to understand because it is a sort of macrolanguage, a system of different languages that together form something more complex than the sum of the individual parts, each of which has its own ancient history and comes from pre-existing worlds to the film/television one.

The language of the texts

Every audio-visual product has a story to tell, a narration that is based on a written text, whether it is a simple schedule, a story or a full-fledged screenplay.

The language of filming

The language of filming derives from the pictorial language, going via photography, with the addition of the peculiarities given by the movement and the specific aspects relating to the special effects.

The language of lighting

From painting derives the art of illuminating that comprises the choice of the quantity of light, its distribution in space and its colour.

The language of the setting

The choice and the reconstruction of the milieu and the objects to have interact with the characters instead derives from the architecture, from the design and the scenic theatrical language.

The language of characterization

This deals with the external image of the characters that must be coherent with the history and the settings and derives mostly from theatre.

Body language

Movements, gestures and mimicry are as important as the dialogues and derive from the theatre.

The language of editing

This is the most innovative and specific language since it does not derive from the previous arts.

The language of sound

Ambient sounds help to create the overall atmosphere and affect the general impression that the viewer gets from the work. It is a specific variant of the sound language used in radio programs.

The language of music

Music contributes to giving emotion to the story and transforming a simple narration into experience.

The language of graphics

This is brought into play to produce graphic interventions and titles.

The use of the above-said languages in the forms of augmented reality, at least in the more evolved ones, conditions the successful outcome of the final product, characterized by many narrative facets. The text from which to start for the narration, any recorded images, the quality of the light, the forms of the setting, the images of the characters and their movements in space, the montages of the clips with sounds, music and graphics correspond to just as many design choices and make manifest the complexity of the narration with the audio-visual language.

4.2. Educational experiences

Sectoral studies show how visual perception is closely connected to the mental processes of exploration and selection: these are two activities that come into play when we visually perceive the elements of a context. The gaze is positioned on one object rather than another thanks to the attention mechanism [101, 102]. The visual elements thus perceived then enrich the subject's cognitive structure, conditioning the successive perceptive act, in a continuous process that involves the eyes and the mind together: perceiving and thinking are two interconnected moments that call for an active engagement of the mind, so that it can be stated that visually perceiving is thinking visually. Visual intelligence grasps in the context single visual elements that are associated to mental categories, proceeding by way of resemblances and associations [103, 104]. The objects and concepts are associated with patterns of reference, becoming full-fledged mental images. The process is influenced by emotive involvement: the more meaningful the experience, the more efficacious the perceptive experience is and the more long-term memorization is facilitated. As in impressionist painting, the images are not the photograph of the real but the result of impressions, that is of a selective and perceptive process conducted through the emotions [105,

106]. In that sense, such a process enriches the cognitive structure, thus configuring itself as a full-fledged form of thinking and intelligence. Visual thinking has in its elaborative-constructive function the most interesting aspect for the individual's cognitive growth, as it allows for the creation of mental images of the facts. Indeed, the visual instruments enable us to communicate and at the same time to structure ideas; an example of this are the mental and conceptual maps, graphs, tables and diagrams, animations, simulations, and virtual realities [107]. Moreover, visual thinking not only elaborates perceptive data but also creates new structures that, in turn, have a generative power vis-à-vis ideas. Indeed, the image is an interpretative model and not a faithful representation; for this reason, visual thinking is closely connected with the creative processes.

With reference to the theory of multiple intelligences articulated by Gardner [43], visual intelligence is positioned in a relationship of complementariness with graphic intelligence: it defines the cognitive abilities connected to the imagination and the capacity of "thinking by images," that is to mentally portray the concepts even before verbalizing them, allowing one to make an immediate experience of the world; graphic experience concerns the capacity to integrate perception, thinking and representation of reality to create artefacts finalized to the acquisition and the construction of new knowledge [103, 108; 109]. The vision/production of an image allows the student to activate cognitive explorative processes, those of categorization, memory, prediction, comprehension, emotion, and empathy [41]. In this regard, Clark and Lyons [110], in identifying some functions of the images concerning attention, the activation of knowledge, the minimization of the cognitive load, the support to motivation and, in particular, the images, can exert a function of mediation, anticipation and modelling in respect to knowledge [4].

Images and learning

Images play a precise role in the formation and development of learning. Historically, illustrated fairy tales for childhood have represented a language endowed with an autonomous force, capable of constructing their own discourse on the text of which they become an alternative narrating voice. The illustrations often represent the child's gaze where everything appears huge and boundless. At other times they strip the fairy tale of its

metaphorical coating and reveal the underlying message with a precise pedagogical intentionality. That master of creativity and fantasy, Gianni Rodari, enjoyed reading comics, images in succession inserted within environments that have a narrative function as much as words did: in the passage from one image to the next the child must carry out operations of recognition and connection, making an effort to fill with meanings the blank spaces between one vignette and the other [111]. It is the game between Antoine de Saint-Exupéry's *Little Prince*, who by drawing his famous lines asks his aviator friend, and thus the reader, to recognize the drawing as it gradually evolves and to imagine the 'implicit' sense in the passage from one from to the next.

The birth of cinema and moving images has caused the use of a language, that of the audio-visual, capable of fostering particular psychological and emotive conditions thanks to their undoubted seductive power. For this reason, the moving images accompanied by sound have often helped the adult in their most authentic educational task, that of teaching, contributing at the same time to developing the need to train children towards a critical sense and the conscious reading of the visual stimulus [112].

The "educational value" of the film has been recognized at various times and with different valences through the twentieth century. The pedagogical debate, amongst others, has given rise to opposing positions between those who believed in the utility of film for the transmission of contents, and those who, focusing on the cinematographic experience in general, identified the educational function in the emotive strength and in the undeniable psychological stimulus of audio-visual education [113]. The two different visions have led to different uses in school: on the one hand documentaries were searched for, in which the cinematographic language was conducive to the educational purpose; on the other, there was the tendency to use films chosen on the grounds of ideological or moral criteria, with the aim of showing models to be imitated or from which to draw some teachings. Only at the end of the twentieth century was there an overturning of the reflection on the didactic use of film, reaching the conclusion that it is neither necessary nor useful to look for a film with a clearly educational purpose: attention ought to be placed in the didactic project, thus in the process of teaching and in the strategies deployed to insert the film everyday school life [112].

Digital images and media education

The culture of information today is mainly visual culture and digital media are the way in which information is presented in various areas. The digital gives image a new dimension and unexpected perspectives. The computer monitor revives the cinema screen in unpredictable contexts and gives audiovisual communication a central role [54, 114].

Digital media objects, including films, are the new cultural products and affect the kind of experience through relations and the environment. They should be read by means of a pragmatic paradigm, as for the Internet in general, according to the rationale of the practices of knowledge-building and exchange of meanings that are rooted in the contexts of belonging of the individuals, albeit in the presence of digital mediation[115]. The educational experience also requires a spatio-environmental space in which to give rise to relations and to learning, thanks to a precise pedagogical intention. The digital spatial environment has its own characteristics that lead to new meanings and to different modalities in knowledge-building [116]. In this scenario, the artistic dimension of digital audio-visual language requires a greater effort in the direction of a media education understood as education towards reading and the interpretation of such a language, to start distinguishing, albeit in the multiplication of the spatial environments of interaction (from the cinema to places of public projection, from the single device to the monitors distributed in the indoor and outdoor public spaces), the styles and the functions, the genres and the perspectives, the message and the meanings, the art and the propaganda.

Today media education must find a way to renew itself and it can do so by adhering to a pedagogical design that, in line with the resources of the territory, can integrate different cultural and social perspectives, communicative multi-modality, active didactic strategies and those for the social knowledge-building, adherence to the everyday. What we feel we need is not so much a ‘technical’ education (relating to the procedures and the resources) as a broader education relating to the horizons of meaning and to cultural and value elements. For this reason we suggest a declination of the concept of media education that corresponds to the following paradigms of reference: ‘political’ education, which forms the instruments for an autonomous knowledge-building, interpretative capacities, project-building, the choice of a definite cultural direction; ‘critical’ education for the reading of the image

and for the recognition of the fundamental principles of the audio-visual grammar and the rules of cinema; 'artistic-creative' education for the development of minds sensitive to art and capable of recognizing the high quality artistic productions and to embrace a creative attitude [8, 117, 118, 119, 120, 121].

4.3 Augmented reality and educational experiences with arts

Designing and developing augmented digital environments is an opportunity to enhance digital communication skills in the production and dissemination of images and knowledge relating to art and heritage

The digital environment can be used for a simple transmission of contents but also to favor cognitive and perceptive immersion in spaces and objects, thanks to particular techniques of processing moving images and sounds that allow us to live real-life, sensory, cultural and artistic experiences. In any case, we can also speak of learning experiences, as the subject develops knowledge and skills based on the relationship with objects, materials and intellectuals, and on sensory and emotional actions and perceptions.

If we allow ourselves to be oriented by the pragmatist principle of John Dewey, the aesthetic experience can overcome the merely contemplative function to foster full-fledged knowledge processes. For this to come about, the experience has to be the result of the interaction between body and environment and must develop aesthetic qualities and perceptions that have a very intense emotional character. It is above all emotion that leads to the accomplishment of the knowledge process by generating meanings: the situation, in this case created by the artist but that can also be produced by a teacher during educational moments, if it generates emotions then develops new perceptive and cognitive modalities. In Dewey's conception experience can also be just intellectual and not necessarily tied to objects or materials; it must however be a right balance between actions and passions to generate knowledge. The teacher is thus compared to the artist as they create situations in which both the object of the learning and the subject that is learning play a role, through action and experimentation of situations, tasks and roles. So, the quality of the experience and its emotional valency determine the quality of the learning itself [122, 123, 124].

The Deweyan reflection leads us today to rethink the relationship between art and technique. In particular, in the artefacts of augmented reality, which use techniques of the figurative arts and multimedia languages, the interactive and virtual media acquire a role of redesigning reality that goes beyond the mere contemplative or transmissive function to acquire, in the relationship with art, an educational role as learning mediators. Being a question of media of an iconographic type and strongly characterized by moving images, they use the audio-visual language in a predominant way. As for cinema, for these products as well we can wonder what relationship they have with art, on the one hand, and education on the other.

The artistic and education worlds have a space of intersection, as we have also been taught by Dewey, which can be inhabited by many expressive realities amongst which also cinema, with its languages, its forms and its knowledge mediators. This is an active space, which garners structures and stimuli from both worlds ending up resembling a little of one and a little of the other. The fact that cinema is art has been proven in the twentieth century by the "Philosophy of Cinema." Film is considered to be an art form in that it is the means with which to arouse thoughts and emotions and to arouse questions, reflections and new world views [125]. The concept of experience returns, in that film, besides being a cultural artefact, offer the spectator the fullness of a living experience, since it includes temporality and movement, a multi-perspectival vision and the emotional impact. Its extraordinary capacity to offer multiple points of view is ensured by the possibility to put together what the character sees and what the camera captures, the first and the third person, to tell with the intermediation of different techniques of shooting, photography, montage, sound [126]. Viewing becomes experience and an artistic experience even before being technological. As an artform it survives in time before every expansion of contemporaneity and thus before every change of the means and of the technique [127, 128].

The relationship with technique is portrayed in the image as a separate bubble yet immersed in the same fabric of experience. Together with it there is the other element characterizing art, education and cinema: dream. Cinema is the expression of the soul and of the sentiments: it paints the soul of things and at the same time the artist paints their own soul in things [129].

The primary vocation of cinema is poetry and the dream is a predominant part of it. The “cinema of poetry” is the artistic and metaphorical experience of the experiences and the emotions [130]. For Pier Paolo Pasolini cinema is the artistic language, in that it is an arc and never a direct or philosophical conceptual expression; it belongs to poetry and not to the novel or to theatrical writing. Cinema contains an irrational element that cannot be eliminated. The effort to transform cinema into pure technique has produced the effect of pushing back the unconscious and oneirical element to the background, concealing it from a superficial vision. This has allowed for a manipulative use of cinema, the search that is of a form of rationality through the adhesion to pre-established formats and the productions of standardized films.

On the contrary, the director who proposes an art-house movie is aware of using a non-conventional vocabulary because it is their vocabulary, the one relating to their own ideological and poetic vision of reality. True cinema, as a consequence, can only be metaphorical, that is the one in which the dream has a predominant and ineluctable part [131]. Pasolini often reiterates the audio-visual nature of cinema, in which the image, words and sound have the same importance and contribute together towards the final product. Their connection, which is above all implemented in the montage, creates endless expressive and stylistic possibilities and requires of the spectator an elevated competence in the reading and interpretation of the audio-visual product that modifies, as narrative, the relationship between man and the reality represented [132].

The artefacts of augmented reality contain many of the technical and narrative elements of cinema. Their production and enjoyment recall the experience of production and enjoyment of the audio-visual products; their strongly multimedia connotation requires the same knowledge of the audio-visual and multimedia language that also a film puts into play. The Web is one of these spaces, as are the mobile applications and the Augmented Reality software, which read and reconstruct narrations by means of images and sounds. We believe that to make these experiences really educational there also has to be the contribution of the characteristics of the aesthetic and cinematographic experience, with the languages of poetry and the emotions of art.

4.4 Augmented reality: art for the sake of art

Communication is one of the primary functions of art, by virtue of its potential universality and its being intrinsically expressive [123]. Bruno Munari [133, 134] starts from this assumption to theorize a new concept of the artwork, highlighting the communicative function and the visual language it uses. The artist, or in any case the author of a visual work, albeit with their own personal and intimate vision of the world, must worry about transmitting messages that are as objective as possible, so as not to risk entering the world with personal codes, so that certain messages are only understood by a few people.

Munari today would probably look carefully at the forms of augmented reality applied to art, as they offer the opportunity to build stories in a digital visual format, like the project "Tap the artwork" (ARTAP) funded by Heritage Srl, a start-up founded in Turin in 2013 that operates in the field of Smart Cultural Heritage. The aim of this project is to create a guided museum tour by trying to integrate the new technologies with the narration of a story. The user is put at the heart of their experience in that the application aims to make them responsible in the active learning of knowledge and is not limited to the mere transmission of knowledge; the individual is called upon to take part actively in the structuring and the personalization of their museum tour.

Specifically, ARTAP is proposed as an instrument with which to utilize a museum service whose objective is the involvement and satisfaction of the user thanks to the use of the digital storytelling technique. Indeed, the narrative element and the meaning of the works that must be clear and accessible are important for the understanding of the visit. The narration technique not only provided contents but poses new questions, novelties and stimuli for the user who participates in the construction of meaning.

The visitor follows a narrative that guides them in the exploration of the works and their meanings through insights, settings, audio or video supports, visual elements and a geo-localization of space; these elements overlap the physical work thanks to the mediation of a device: to access these ways, just "tap" on the work via your smartphone. The app provides the chance to view a narration on the screen overlapping the framed works, increasing the reality that the user experiences. The user can go back, visualize the information several times and interact with it. ARTAP integrates the narrative dimension with the new technologies such as Beacon, touch mobile, Virtual Reality, Content Management System and the new forms of communication: storytelling.

5. Digital competences and augmented reality

5.1 Augmented reality and digital innovation

Following the Covid-19 pandemic, which has led to rapid and profound cultural and social transformations, museums have found themselves having to face a series of important challenges. In fact, if before then the museums had been using augmented reality apps, audio-guides, visors for virtual tours, stations for virtual reality and immersive installations, only upon completion or in support of the experience of the visit, with the health emergency have they increased their online presence by delivering contents and offering new cultural and educational provisions [135, 136, 137]. In this scenario there has been a renewed awareness that questions the future of the museums in two directions: the development of a digital strategy of audience development in the mid-long term, for an access to knowledge that is increasingly open and democratic and a necessary investment in the training of museum personnel that will have to work to make the assets accessible, also on the digital platform. In this sense, the museum is experience an organizational and cultural change that coincides with the recent definition of the 'phygital' museum [138] in which the physical space and the digital space are part of an ecosystem and the availability of instruments of mediation in the museums, on the territory and on the digital platform translates into new possibilities of learning and participation. The investment that derives from it is thus based on the development of digital competencies for all the museum personnel [139, 140], in a sector in which these competencies are fragmented [141, 142, 136] and the internal planning of the training activities is not very apparent [143]. The museum professionals will thus have to be involved in dealing with this challenge by asking themselves about the methods and the instruments that can progressively be adopted, while also paying particular attention to sustainability. In this sense, rethinking the use of easily accessible digital devices may result to be relevant not only for the public but also for the personnel of the museum who, inside the workgroup, will be involved in the various phases of analysis, design and development of the applications. In this regard, in view of

the potential of the use of augmented reality (AR) in the museums, it emerges from the many studies [144, 145, 146] how this technology allows the experience to be more involving and interactive, providing new learning opportunities and a personalized access to the contents. If then AR can be considered as a technology that can bring an added value to the learning experience, less evident is instead the reflection in the accessibility of the use of the instrument by the museum personnel. It is indeed presumed that in the upcoming future also the museum professionals will deal with designing and developing new applications in which AR will be ever more interconnected with artificial intelligence systems (AI). Indeed, it is very likely, as demonstrated by the new developments on the subject of AI, that the demand for the skills required will change as the supply will change, new and different ways of leaning will emerge and this will lead to a reorganization of the activities and a rethinking of the educational systems of the professions that will have to adapt to the changes in society [147]. In the specific case of AR, it is evidenced how this technology is already amply used in many contexts and will become, in the near future, ever more indispensable in the educational environments [148].

Considering, therefore, the design and the development of the AR applications for didactic purposes, it is believed that the museum educator can become, along with other professionals, a principal reference for the museum. In this regard the project Mu.SA [149] has worked to define at the European level four new professional profiles indicating, for each of these, the digital and transferable competences. Specifically, the workgroup has identified among the professions of the future the Digital Interactive Experience Developer who specifically deals with "designing, developing and implementing innovative and interactive experiences providing a meaningful experience for all types of visitors" [150, p. 48]. This figure, who has among their key responsibilities those of "carrying out audience research and observation analysis; developing accessibility tools for all types of visitors; facilitating communication flows between various different museum teams and external high-tech companies" [151, p. 7], seems very closely related to the profile of the museum educator who has among their tasks that of promoting the assets to a heterogeneous public, designing and managing recreational activities and cultural animation, performing activities of monitoring and evaluation [152]. The museum educator, adequately trained in the digital field, can put at the disposal of the museum their pedagogical and didactic competencies to adapt

the AR applications to the demands of the users [153]. The museum educator can also design the didactic pathways on the digital platform, contribute to the creation of augmented educational contents and propose different modalities of navigation of the contents to the visitors, depending on their learning goals.

Before the exponential increase in digital resources available on the Web, the choice of reliable and authoritative sources for the creation of augmented contents turns out to be a meaningful practice to be pursued. In this regard, the joint work with the curators, archivists, art critics and communications managers, is relevant in order to evaluate the reliability of the sources that will have to give value to the heritage and at the same time be accessible to the public with involving and multimodal languages [71]. The knowledge of didactic methodologies and strategies of mediation with the heritage allow the educator to design the education pathway according to precise pedagogical goals, not oriented to entertainment for its own sake but to a broadening of the knowledge in which the cognitive dimension is added to the emotional and social one. Another important collaboration for the museum educator is that with the curators, artists and public who are involved in the production of the contents. In this sense, creativity is not born from the technology in itself; this must be fed by an intellectual activity that avails itself of technological instruments to give rise to novel creations.

If, as has been said, AR technology allows the visitor to enrich and deepen the visit by overlapping additional information to what is already there, on the design side it is a matter of deploying targeted choices, antecedent and successive to the pathway, on what the visitor will find themselves observing, on the time of use of the device, on the behavioral responses, on the movement in space. For the sake of example, the locator system (GPS) allows the user to be more easily guided to find points of interest in the museum space but, at the same time, the technology can also outline their itinerary during the visit by providing the museum personnel with important spatial data. The user's experience, which is put at the forefront, thus becomes the object of observation for the educator who, in relation to the feedback he or she receives and the interactions in the contexts, can study his or her public and work for the overall improvement of the educational experience.

Again, regarding the design, the museum educator can choose how to make meaningful a specific didactic itinerary, including AR devices with more traditional routes, along the lines of the guided tour. In this way the

educator remains a fundamental figure who accompanies the visitor through the museum collections and technology becomes functional to the visit in that it enriches it. Furthermore, it can happen, as demonstrated by some devices already available in the museums, that the tour is conducted by a digital guide, in which case the museum educator can study and choose the most suitable and enticing modalities (visual, tactile, auditory) to interest and involve the users. By way of example, an AR application can be used in the course of a guided tour to allow the user to deepen the augmented contents individually at first; subsequently the educator can return to the traditional tour by having emerge questions and observations in the wider group. The development of associations between the information added by the educator and those yielded by the technology, together with the personal experiences of the visitors, can enrich the learning by fostering the development of new interpretations. The choice to proceed in this way cannot be random but is connoted by a precise conceptual positioning that inevitably acts as a guide for the design of the application. In the specific case outlined here this conceptual choice, always more in line with the developments of the contemporary museum, refers to a constructivist learning model in which known is situated and distributed and in which the visitor is not considered as an acritical consumer of knowledge but as an active user, stimulated to search for new meanings, starting from their own prior experiences.

The AR devices can be designed to become flexible instruments of self-learning, allowing the user to construct their own pathway in complete freedom; the prior knowledge is thus combined with the new experience that can be enriched by way of the interaction with other subjects. In the design of AR devices, the social dimension of learning is thus taken into account by the educator who constructs didactic pathways in which the user can share their own experience and compare with other users to reflect on the experience itself.

To conclude, the AR technology, if properly valorized, can increase the value of the heritage and at the same time give a meaning to the individual and social experience of the users. It thus follows that museum education can become a resource for the development of innovative AR approaches. The museums will be called upon to promote routes of continuous training for their professionals. It will also be necessary to revise the role of museum educator that, as we have tried to show in this contribution, is the bearer of a corpus of methodological and didactic competencies that still need to be valorized [154, 155].

5.2 Augmented reality and digital competences of museum educators

The current modernization, digitally speaking, of the museum and the skills of the different profiles connected to it, further valorize the role of the museum institution as an intentionally educational agency, both physical and virtual, capable of existing, alongside and in a synergic relationship with other educational realities, for the raising of the educational and cultural quality of society, valorizing the cultural assets and offering to the whole citizenry educational opportunities for the construction of the transversal competencies of identity, civil, social, digital, values, entrepreneurial, citizenship [156] that can contribute to making them critical and responsible actors.

The professionally trained museum educator should embrace such demands and consider the acquisition, on the part of the different publics, of digital, media and data literacy skills as an objective and a strategic opportunity to answer the challenges of the 21st century, in view of an active, informed, reflexive, critical participation creating a sense of responsibility towards the process of construction and co-construction of knowledge within an everydayness increasingly connoted by the dimension of the so-called *onlife* [157]. The concept proposed by Floridi marries and interweaves with that of augmented reality: the AR experiences are placed *in continuum* vis-à-vis the real experiences inside the museum, positioning the publics in a hybrid space in which the body and the experience are at the center of the learning processes and in which the reality and the physical environment are enhanced, broadened, integrated, blended in their different components, dilating vision and perception and stimulating the learning processes in a novel way. We can consider AR to be an ingredient of creative complexity, thanks to which the spatio-temporal limitations of the present, of the 'here and now,' are implemented by proposing to us 'new where's' and 'new when's,' shifting the experience of the subject to a 'where' and to a 'when' that are, indeed, 'augmented.'

On the grounds of what has been stated, it appears opportune to train professional capable of promoting in the users' reflexivity, metacognition, critical skills, participation and active knowledge-building. Given the critical aspects at the international level regarding the recognition of a specific professional role of the museum educator [154], the present contribution aims to outline some of their ineluctable competencies.

Starting from some of the peculiarities of the profile of the Digital Interactive Experience Developer [140, 150, 151], we propose a conceptual and operational framework [144] which considers the museum educator as a professional who relates in a systemic way with the publics and with other museum professionals. Such a professional is capable of designing, realizing, managing and evaluating *diffuse* didactic-educational pathways, accessible and sustainable, both inside and outside the museum, via the use and the personalization of interactive and innovative installations based on the needs of the different publics who exploit the potential of the physical, digital and augmented museum environments for the promotion of the museum heritage and the digital and key competences for lifelong learning in the different publics. We consider first of all as the pedagogical scenario of reference the *distributed* TPACK framework [158, 159], a model that outlines the knowledge domains underpinning teaching/learning processes in which technology plays a substantial role [160]. As a consequence, the digital competencies of the museum educator will have to interweave, on one side, with those relating to the museum heritage, on the other, with transversal pedagogic-didactic competencies relating to a design that takes into consideration, among its resources, the potential offered by AR as a further *third space* [23] to be explored by the different publics, on the grounds of the specific needs – also special ones – and in consideration of different interpretations of learning. While from the contents point of view the museum educator will be supported by several different figures, such as by the collections curator, archivists, art critics and by the artists themselves, from the digital point of view they will have to possess competencies relating to the 5 areas identified by the European frameworks of reference [161, 162], that is *information and data literacy*, *communication and collaboration*, *digital content creation*, *safety*, *problem-solving*, shifting from levels of 'foundation' mastery and 'intermediate' to the levels of a mastery 'advanced' and 'highly-specialized'. From the pedagogical standpoint, it is a matter of integrating in the design of inclusive and sustainable museum pathways that exploit the potential of AR, the different methodologies and didactic approaches that hark back in particular to 3 specific dimensions of learning [163] interweaving them with the eight key competences for lifelong learning [156], in order to determine goals of cognitive, social, identity competencies to be achieved.

In particular, we suggest here the following three different exemplifications.

a) Learning by doing and cultural re-elaboration

Learning by doing and *cultural re-elaboration* involves cognitive domain of *remembering*, *understanding*, *applying* and *evaluating*, together with digital competencies of *information*, *data literacy* and *safety*, with particular attention to knowledge dimension as cultural re-production of the museum heritage *in continuum* between real environment and AR. The museum educator must develop that critical thinking essential for researching, selecting, analyzing, comparing and evaluating the credibility and the reliability of the data and the digital contents to create their own strategy of critical and responsible navigation. It is a question of acquiring specific competencies for organizing, managing, archiving, recovering digital museum data and contents, re-elaborating them and structuring them considering the needs – also special ones – of the different users, to propose educational pathways in real, virtual and *augmented* environments, that are safe both in terms of reliability of the contents and in terms of safety of the augmented reality and the protection of personal data. The ultimate objective is to propose to the different public experiences of enhancement and broadening of the vision of reality and the physical environment, through a perfect integration between real context and virtual objects; 'entering' the art work, flanking the artist is their different phases of realization; knowing a physical object also through specific localized digital information; knowing landscapes, scenarios, architectures through their augmented historical reconstruction, broadening the knowledge about a given phenomenon, event, etc.

b) Learning by construction

Learning by construction involves cognitive domain of *metacognition*, *creating* and *'knowledge building,'* together with digital competencies of *communication*, *collaboration* and *problem solving*, inside of which we find dimensions of subjective cultural re-elaboration of the museum heritage together with the sphere of participation with other users, aiming at building up a fruitful confrontation, an exchange of different points of view to find out similarities and differences in reality and augmented reality perception. The museum educator must be capable of evaluating resources, instruments, competencies present within an educational situation, together with the needs of the single users, to match such needs with possible solutions and the digital applications of AR. Furthermore, they must develop transversal competencies in regard to active listening, critical thinking, problem-

solving, communication strategies, negotiations and mediation, team working, the management of situations of individual and collaborative learning, the spirit of initiative and entrepreneurship to transform their own ideas and those of others into educational opportunities. Lastly, they will have to acquire the capacity to work in collaborative mode inside their own professional team, in order to design, manage, evaluate situated didactic pathways, meaningful and personalized, motivating the users and valorizing their experiences and their cognitive and emotional development. The ultimate aim is to develop in the public the skills not tied to learning for its own sake, but that allow one to move and act with awareness, competence and creativity, using effectively the content, digital and transversal knowledge learned by recombining it and producing new acts for the resolving of 'situational' problems, in the individual and group context also thanks to the contribution of the others in a constructivist and co-constructivist vision of learning [164] and in a dimension of lifelong learning.

c) Learning by discovery

Learning by discovery involves the cognitive domains of *insight* and *invention*, together with digital competencies of *content creation*, conceived as possibilities of exploring adventure educational dimension of adventure both on an individual and social level through AR, where finding out new cultural paths becomes the purpose, always open and never definable beforehand. The museum educator must, supported by the ICT teams, develop *augmented* digital contents, integrating them and re-elaborating them so as to make them personalized and developed around the needs – also special ones – of the different users. The aim is to valorize the personal history of each user stimulating and giving space to the creative thinking and the emotional processes, proposing an 'immersion' in the art work, analyzing it as a whole or dwelling on a detail, decomposing and recomposing it several times over, making it one's own and reinventing it by choosing completely novel pathways for themselves, thereby formulating new interpretations of the real. The user can, based on personal suggestions produced by the AR, create physical and digital artefacts in different formats and using materials, to express one's own ideas, opinions, emotions in an original way.

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