The SciArt eBook

An innovative, inclusive STEAM approach for the study of cultural heritage in schools

SCIART

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CHAPTER 1. The SciArt approach

Chapter in a nutshell

The SciArt project aims to develop an innovative, inclusive STEAM approach to Cultural Heritage. Its' theoretical framework is based on both Science and Arts education, combining inquiry and problem-based pedagogies, Cultural Heritage studies and non-formal education. Cultural heritage (tangible and intangible) forms a space for STEAM education, offering the possibility for connecting different disciplines in a transdisciplinary examination of cultural artefacts, their specific characteristics, and socio-historical narratives. An innovative teaching and learning approach will be adopted, using archaeometry and inquiry-based learning in both Science and the Arts, promoting 21st-century skills.

1. Cultural Heritage through the lens of SciArt

1.1 The Project in brief

The SciArt project aims to develop an innovative, inclusive, inquiry-based STEAM approach to Cultural Heritage that emphasizes interdisciplinarity by combining STEM and Arts. The project will provide teachers with educational resources and the opportunity to enhance their self-efficacy in implementing STEAM activities, through inquiry with a strong A(rts) component. It will also offer students of diverse groups the opportunity to engage in meaningful STEAM activities on Cultural Heritage.

1.2 The Consortium

The Sci-Art Consortium consists of multiple universities, museums and schools from three different countries. More specifically the project is coordinated by the European University Cyprus (Cyprus) with the participation of the University of Western Macedonia (Greece), the Aristotle University of Thessaloniki (Greece), the Instituto Politecnico do Porto (Portugal), Anastasios Leventis Foundation (Cyprus), Museu Municipal Esposende (Portugal), the Museum of Byzantine Culture of Thessaloniki (Greece), the Falcon School (Cyprus), the Experimental School of the University of Thessaloniki (Greece) and the Agrupamento de Escolas Eugénio de Andrade (Portugal).

1.3 The projects' Implementation

The project based on the theoretical framework and guided inquiry activities especially developed for this purpose, will train primary and secondary educators in the three countries (Cyprus, Greece and Portugal) to implement the Sci- Art approach in their schools. The training course will be hosted in an open educational platform and will be offered to the public in an effort to disseminate the approach to the educational community within the countries and to relevant stakeholders worldwide.

1.4 Anticipated Outcomes

The Sci-Art approach aims to enable students and educators to

✔ learn about and use scientific methods for the study of artefacts through the employment of emerging technologies (such as augmented laboratory instruments) and inquiry-based activities.

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- ✔ study the (often conflicting) meanings, functions, and narratives surrounding heritage artefacts and the ways in which they relate with local and national identities, including European identity.

- ✔ discuss the connections between STEAM related subjects and social and political issues (such as issues of inclusion),

- ✔ enhance students' awareness and understanding of the multiple dimensions of cultural heritage and its role and function in contemporary societies.

- ✔ enhance students' 21st-century skills such as critical thinking, creativity, assessment of information, and collaboration.

The study of a range of artefacts is also expected to enhance students' awareness of their sense of identity, and how this is constructed at different levels (local, national, transnational, European, etc). This will allow students to critically discuss the diverse and multiple narratives of heritage objects at local level and the ways in which they have been used or can be used to construct and put forward a common European identity. In this way the project aims to open the platform for intercultural dialogues and exchanges, further contributing to acceptance and inclusion with the adoption of multiple learning methods and tools that are in alignment with the principles of Universal Design for Learning, Universal Design for Learning (UDL) is a theoretical framework teachers can use to design differentiated instruction based on three specific principles: providing students with multiple means of a) engagement, b) representation and c) action and expression (Meyer et al, 2014)(for more about UDL, see Chapter 5).

2. The role of Cultural Heritage in education

2.1 Introduction

The importance of Cultural Heritage, tangible (e.g. monuments or artefacts) or intangible (e.g. languages, music, literature, etc), is emphasized by many scholars (e.g. Deacon & Smeets, 2013; De la Torre, 2013) and UNESCO'S conventions mostly because its' values and principles help us to better understand our local, national, and European identities and to develop a sense of belonging at a national and/or transnational level. Although the notion of cultural Heritage was previously mainly studied in relation to materiality and issues of preservation, recent years, have witnessed a shift in focus towards the study of various social, economic and political functions of heritage in different communities (Charalambous, 2019) including its relation to identity politics.

In adopting this perspective, it is also important to examine the role that schools, and other non-formal educational institutions, attach to heritage and how it is used to shape future citizens. At the same time, adopting a critical perspective to what is considered heritage and for what purposes, can form part of inclusive pedagogies that embrace the different narratives, interpretations and values attached to heritage objects by different students. Having said that, the materiality of heritage objects can also be a learning vehicle allowing students to study heritage objects via different methods and perspectives.

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2.2 Non-formal education

The significance of non-formal education and its supportive and enriching role in school learning (Cândido Vendrasco et al., 2022; Col & Col, 2018; Falk & Dierking, 2016) has been stressed and highlighted in many studies besides arts and humanities, to also involve science education. Non-formal art and science education settings such as science centers or art museums can contribute significantly to students' interests and understanding, providing several opportunities to visualize and conceptually access information relevant to the contributions of both art and science to the development of societies, promoting a better understanding of how art and science are developed and produced (Cândido Vendrasco et al., 2022). At the same time, non-formal education promotes positive attitudes towards science (Tal & Morag, 2007) by generating wonder, interest, and enthusiasm for learning. The same applies for art. Recent studies (Tang & Zang, 2020) based on PISA (2015) results claim that non-formal science education, in particular, comprises a significant complement to effective school science affecting students' interests and performance and enabling them to acquire scientific literacy to a more advanced level. Both Avraamidou (2014) and Matthews et al. (2017), argue that non-formal education opportunities contribute to the formal science curriculum, enabling students to participate more actively, especially when inquiry and transdisciplinary approaches are utilized, promoting at the same time their teachers' professional development.

Additionally, non-formal education settings not only contribute to science education but also provide students with information and skills that would allow them to participate in contemporary life with a critical view and facilitate them to access aspects related to socio-scientific issues (Yun et al., 2022). Last but not least, non-formal science education is expected to welcome, support and value all audiences, despite their cultural background e.g. students from disadvantaged groups that have been traditionally excluded (Brown et al., 2020). This can also be enhanced by an alternative pedagogical teaching and learning approach e.g., inquiry, that has the potential to reduce educational inequality by enhancing learning opportunities for everyone (Florian, 2015).

All the above are considered in the Sci-Art project and in developing the Sci-Art approach. Suggested activities, including museum visits and studying cultural artefacts, become part of an integrated STEAM approach through inquiry-based approaches and using the tools of archaeometry, supporting and enriching school learning in both areas of science and the humanities (arts/culture) in an effort to include students from diverse backgrounds.

2.3 The STEAM approach

Over the last decade, we have witnessed a worldwide fascination with STEM (Science, Technology, Engineering and Mathematics) education, as the response to the demands of the 21st century challenges. Preparing students for the jobs of the future has required building individuals who are strong problem solvers, innovative and creative thinkers, who persist and take risks and are driven by their entrepreneurial capacities. At the same time, essential 21st-century skills include the ability for effective collaboration and strong digital competencies. However, STEM has fallen short in achieving better results in terms of students' performances in STEM-related subjects and has not produced as many

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professionals as expected in STEM-related professions. An equally important challenge for STEM education has been preparing future citizens with general capabilities for active participation in community and professional forums for addressing ethical issues associated with the global impact of science and technology (Taylor, 2016). In addition, STEM has proven limited as far as educational models are concerned that combine arts and sciences and encourage communities to think about sustainability (Clark & Button, 2011) and to meet the need for a culturally situated approach and a systemic design-thinking perspective (McKeown, 2019).

Responding to such shortcomings, a shift from STEM to STEAM has been witnessed during the last few years. STEAM - an acronym for Science, Technology, Arts and Mathematics - is the educational approach that acknowledges the significance of incorporating the Arts (including the visual arts, performing arts, linguistics and the humanities) in STEM subjects, aiming to offer a more integrated and transdisciplinary approach to teaching and learning. This approach merges the arts with STEM subjects for the purposes of improving student engagement, creativity, innovation, problem solving skills, and other cognitive benefits (Liao, 2016) while at the same time developing employability skills (e.g. teamwork, communication, adaptability) necessary for future career and economic advancement (Colucci-Grayet et al., 2017).

Empirical research has shown that education in the arts can enhance students' creativity, critical thinking, innovation, collaboration, and interpersonal communication skills (Perignat & Katz-Buonincontro, 2019). In addition, recent findings have also shown that the arts and humanities studies improve cognitive skills like spatial reasoning, abstract thinking, divergent

thinking, creative self-efficacy, openness to experience, and curiosity (Swaminathan & Schellenberg, 2015). Scholars declare that the STEAM approach offers contextual learning utilizing subject overlap for even greater understanding (Gettings, 2016). Through this newly expanded understanding give the opportunity to create artefacts that transcend all disciplines of STEAM (Peppler & Whlwend, 2018).

The SciArt project begins from these theoretical underpinnings and aims to develop an innovative, inclusive, inquiry-based STEAM approach for the study and teaching of Cultural Heritage. Addressing in particular the need for a culturally situated approach, through the use of material artefacts, the project will identify trends and issues relevant to places and local communities. In order to scaffold students through a mediation process during which cultural artefacts are examined through guided inquiry, students will be familiarized with specific procedures of the scientific method of archaeometry, in order to gain helpful information in order to understand the ways in which culture, histories and narratives are constructed through the use of objects. Science and specifically inquiry will facilitate students' processes of connecting the material characteristics of artefacts with interpretations and narratives relevant to the objects' sociocultural and historical background. Results from this inquiry-based approach coordinate harmonically with issues of identities and cultural heritage in this integrated STEAM approach, going beyond the boundaries of each discipline and combining them in an attempt to provide meaningful interpretations. Moreover, during this procedure, both science and art inquiry activities aspire to bring out interests, previous knowledge, experiences, and perspectives of students

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participating from different countries. Multiple contexts will be acknowledged and used as conduits to foster more effective both science and art interactions with the artefacts (Hernandez et al., 2013).

2.3.1. The Multiple Narratives of Cultural Heritage artefacts

The rationale of the project is based on the acknowledgement that heritage and its objects can be studied both in relation to their manifested forms and materials, adopting archaeometrical methods and tools used by scientists and archaeologists, and in relation to their cultural, historical and aesthetic dimensions. Combining the study of these heritage objects' materiality (which also carries information about the object's origins, history, functionality and historical uses) with an approach that emphasizes the practices and multiple narratives surrounding these objects allows us also to initiate discussions on issues of, inclusion, and identity formation, both locally and at a European level.

Museums, galleries and other non-formal education settings are traditionally considered the main places where Cultural Heritage objects are preserved and promoted. Their role, though, is not just to safeguard and exhibit heritage objects but also to narrate stories behind objects and to point out the relationships that develop between objects, places and people. In other words, to reveal "the complex social interactions and systems of values, meanings and exchanges" (Herle, 2003).

Blending formal and non-formal education within a STEAM transdisciplinary approach, in the Sci-Art project we will also focus on the multiple narratives associated with objects as they are told by museums and schools, as well as by students themselves.

2.3.2 Cultural Heritage artefacts as physical objects

As mentioned in previous sections Cultural Heritage can be both tangible and intangible. Given this project's focus on STEAM, we will mainly focus on the materiality of artefacts providing evidence to study and analyze the past and the narratives relating to these artefacts as well as possible culture values connected to them. The rationale of the project is based on the acknowledgement that heritage and its objects can be studied both in relation to their manifested forms and materials. Teachers can guide their students by specific inquiry and project-based activities developed to allow students to investigate the material aspects of the artefacts using their school knowledge and critically explore the role of artefacts in the formation of narratives and identities.

Teachers and students will try to study artefacts in relation to their cultural, historical and aesthetic dimensions by a method used by both scientists and archaeologists: archaeometry. For this purpose, nine artefacts from three different museums representing three countries and their diverse cultures were chosen to be studied. Selected artefacts either archaeological, historic or more recent, include religious icons, coins, pottery, glass or wood objects, and paintings. For each artifact, the Sci-Art project provides students with four instruments (ALI) to use in order to study the materials, shape, origins (time and location) of each artifact. Each instrument presented introduces students through animation or augmented reality (AR) videos to various scientific methods used by archaeometrists for the

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study of materials of heritage artefacts, such as XRay, Spectroscopy, SEM etc. Such activities are focused on the active participation of all students. Multimodality and immersive technologies, such as augmented reality utilized within a UDL-designed learning environment, can support the inclusion of all students (for more, see Chapter 5) and provide them with the opportunity to act as scientists and enhance and/or develop their 21st-century skills.

2.3.3 Inquiry-based learning

The SciArt project is focused on the active participation of students by giving them the opportunity to enhance and/or develop their 21st-century skills. Globally, there is much talk about the importance of learning 21st-century skills and practices (Picture 1), which go beyond traditional content learning, to include cross-cutting skills such as problem-solving and information literacy that span across disciplines e.g., arts or science as well as softer skills such as collaboration. The 21st-century skills' standards seem to demand explicitly and inexplicitly inquiry-oriented approaches for learning. Based on the above, the suggested activities by the Sci-Art project are constructed on the inquiry-based and the project-based approach.

Figure 1.1: *21st-century skills' standards (retrieved on May 29, 2023 from https://www.battelleforkids.org/networks/p21)*

Inquiry-based learning (IBL) is a pedagogical approach that engages learners actively in a knowledge-building process through the generation of answerable questions (Chu et al., 2021). This approach is related to problem and project-based learning, in which learners adopt an inquiry mindset in addressing epistemic issues or in developing and completing projects with a relatively open-ended set of answers. In Inquiry-based learning students follow methods and practices like those of professional scientists in order to construct knowledge (Pedaste et al., 2015). It can also be defined as a process of discovering new causal relations, with the learner formulating hypotheses and testing them by conducting experiments and/or making observations (Pedaste et al., 2015).

These procedures are viewed as an approach to solving problems and thus involve the application of several problem-solving skills (Pedaste & Sarapuu, 2006). In problem-based learning, students address authentic challenges like those they will possibly encounter in their professional life. It has evolved as a method to assist students build soft skills in an

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environment comparable to where these capabilities will ultimately be applied. Derived from inquiry-based learning (Hmelo-Silver et al., 2007) and constructivist theory (Jonassen, 1999), the project-based learning approach engages students with real problems, forcing them to produce a tangible artifact that demonstrates their emerging competence (Blumenfeld et al., 1991).

It has been argued that inquiry-based teaching is considered important in the teaching of science as it aims to familiarize students with scientific procedures based on active learning and the construction of knowledge (Vorholzer & Von Aufschnaiter, 2019). Engaging students in advanced inquiry practices contributes to effective learning, motivation, critical thinking, communication and collaboration, and an increased interest in science content (Schwartz, 2017), part of which are also identified as 21st-century skills (Partnership for 21st Century Skills, 2009). Other researchers focus on the fact that inquiry provides a reasonable background that helps students understand how scientific innovations are created and introduces them to both scientific content and scientific methods helping them to gradually build their scientific literacy (Tsaliki et al., 2022). Moreover, inquiry procedures familiarize students with the epistemology of science, giving the idea that science is a dynamic process, based on empirical evidence. At the same time, students may realize that the process of creating scientific knowledge can be also subjective as it may include assumptions and drawing creative conclusions in a specific sociocultural context (Lotter et al., 2016). Considering the above, inquiry approaches are regarded as supportive for education of sustainable development as they offer to teachers and students alike, the appropriate tools for ongoing learning and the understanding of both science and how science knowledge can be produced (Aldahmash et al., 2019).

Inquiry-based learning is often organized into inquiry phases that together form an inquiry cycle. However, different variations on what is called the inquiry cycle can be found throughout the literature. In Sci-Art Project, activities are created by adopting an inquiry-based learning framework developed by Pedaste et al. (2015) presented in Picture 2. The framework derived from a systematic review of inquiry-based learning frameworks found in educational research literature as an attempt to cover many different implementations of inquiry-based learning. The inquiry cycle consists of five phases: a) Orientation, b) Conceptualization, c) Investigation, d) Conclusion and e) Discussion, and each phase as seen in Picture 2 includes sub phases. The arrows demonstrate possible different pathways through the framework. Although the cycle may usually start with Orientation, it displays flexibility in the pathways that can be followed.

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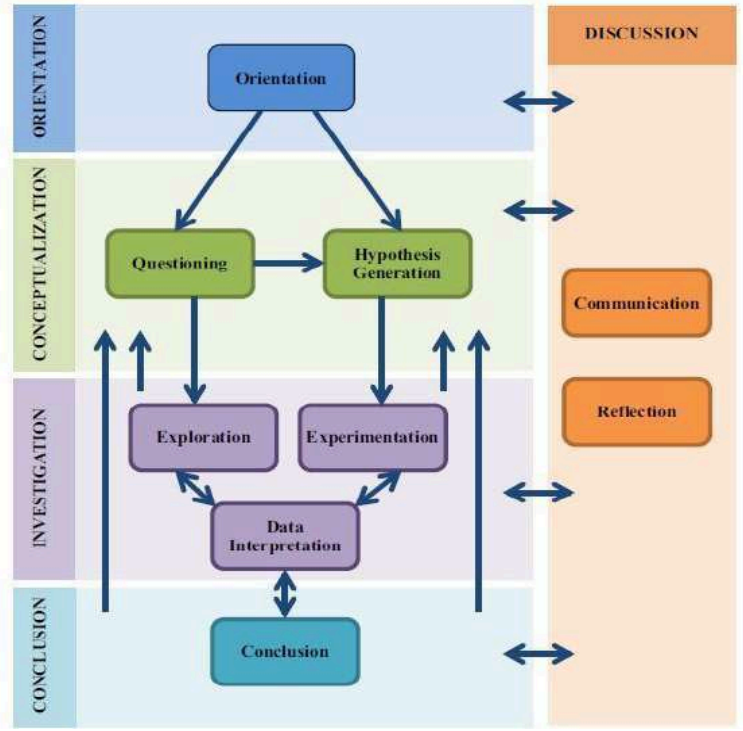

Figure 1.2: *Inquiry-based learning framework, general phases, sub-phases, and their relations (Pedaste et al., 2015, p 56)*

Adopting the inquiry-based approach in the SciArt activities design will allow students to be engaged in meaningful and engaging activities concerning cultural heritage, to build their knowledge and understanding and to draw the interconnections on the different aspects of cultural heritage.

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CHAPTER 2. Archaeometry, Science Education, and Cultural Heritage: Connecting the study of artefacts to primary and secondary Science Education

Chapter in a nutshell

The chapter introduces a connection between material science methods used on artefacts and school science while also discussing how these connections can provide an opportunity for building inquiry-based methodologies for teaching and learning across different disciplines. The connection of various scientific fields together with archaeology and cultural heritage artefacts is further supported using Archaeometry. Archaeometry is an interdisciplinary field of research that introduces the application of analytical scientific methods to help with archaeological problems. The importance of material studies is highlighted when considering the materiality of artefacts. Finally, the chapter introduces and explains the analytical methods used in the SciArt Project, in connection with school sciences.

1. Studying the Materiality of artefacts

Material artefacts are items made by humans and affected by technological evolution. For example, tools, everyday pottery and utility items, ornaments, paintings, jewelry, sculptures and reliefs, textile of any kind, leather items, parchments, paper, and books, etc are all considered material artefacts. These can be composed of a single material, but most often they are complicated systems of different materials, often carrying additional materials, such as residuals of use, deterioration and ageing materials and patinas, or burial remains. They may have survived over time in a good condition, they may have deteriorated leaving behind their mineralized imprint, or they may have been burned. In most cases, they can still carry on information.

The materials that artefacts are composed of can convey important information about their cultural context and technological history. For example, common stones, as received or with a simple processing, can be used as a blunt instrument and a basic building material in masonry and weapons. As technology progresses, artisans gain knowledge of how to use common materials more effectively. Following the example of stones, this technological progress led to the extraction of precious minerals and metals from ore, the making of ceramics and jewelry, pigments, etc. This testifies to the use of materials in close connection with human needs, and how technological advancements supported the design and production of a product with specific properties.

Every artifact that has survived, as well as the condition of its preservation, can offer invaluable information about the society in which it was created and made for. It also often provides details about trading routes; for example, the blue pigment from the semi-precious stone lapis lazuli, mined only in Afghanistan from ancient times, has been traveling through Europe giving its color to manuscripts and paintings. This traveling is responsible for the name of the pigment as ultramarine – “beyond the sea”.

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To sum up, artefacts are complicated systems of materials and techniques of manufacturing, from the most simple -in common eye- artifact, like a glass vessel or tesserae or a bead, to most complicated works of art, like paintings.

2.Introduction to Archaeometry

Monuments and artefacts -from everyday objects and tools to ornaments- are in close connection with materials and their science. The first recorded study of artefacts is attributed to the astronomer E. Halley in the early 18th c., with his geological examination for identifying Stonehenge prehistorical stones (Doménech-Carbó & Osete-Cortina, 2016), while the first recorded application of natural sciences methods for the analysis of artefacts goes back to the late 18th c. by J. F. Gmelin, a pharmacist, who analyzed and experimented with the color of glass tesserae, and with pigments collected from an Egyptian sarcophagus (Nadolny, 2003). Since then, there has been a variety of analytical techniques for the study of cultural heritage objects, especially after the mid-20th c., with the technological development of analytical instruments (Doménech-Carbó, 2008; Doménech-Carbó & Osete-Cortina, 2016; Madariaga, 2015) and the ever-increasing interest in the preservation and study of cultural heritage (Vandenabeele, 2007).

The term “archaeometry” emerged in the mid-20th c. and it is associated with the Journal Archaeometry of the University of Oxford (Doménech-Carbó & Osete-Cortina, 2016), as:

- “Measurements made on archaeological material” (Aitken, 1961),
- “Application and interpretation of natural science data in archaeological and art historical studies” (Olin, 1982),
- “Application of natural sciences for solving specific archaeological problems” (Liritzis, 2005; Liritzis et al., 2020)

Archaeometry is an interdisciplinary research field involving physical, chemical, biological, anthropological and other scientific methods with applications in archaeology, art history and conservation. Although dating objects and materials dominates as the best-known archaeometrical application, there are many questions that can be answered with material science, using methods that “characterize” matter, which means that these methods can provide information regarding a material, including its composition, structure, and morphology. This information can be used in many areas, such as authentication and origins of artefacts, provenance, conservation, environmental and geophysical approaches, etc., under the general purpose of gathering information about the development of human civilization (Jones, 2004).

2.1 Characterization Techniques and Methods in Archaeometry

As mentioned in the previous section, the characterization of materials involves the application of analytical techniques and the interpretation of their results, providing information regarding the materials that an artifact is composed of and their degradation state. Among other archaeometrical fields of application, characterization is considered fundamental as identifying the composition of an artifact can result to valuable information regarding the manufacturing technique of the artifact, its state of preservation,

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authentication and provenance, indirect and direct dating, restoration guidelines, and even the development of new materials, i.e. for protective, restoration and conservation reasons.

There is a plethora of characterization techniques that are used for archaeometrical applications, such as:

- Optical techniques (Microscopy, Photography, multi-spectral imaging
- X-rays Techniques (XRD, XRF, XPS, Radiography)
- Electron Microscopy techniques (SEM, TEM)
- Molecular techniques (FTIR, Raman)
- Thermal Analysis techniques (TGA, DSC)
- Luminescence techniques (TL, OSL, IRSL)
- Chromatography/MS techniques (GC-MS, LC-MS, Py/GC-MS)
- Spectrophotometry (UV-Vis)
- Archaeomagnetism, carbon dating, etc.

Most analytical methods of characterization demand the collection of samples (invasive techniques). However, one should take into consideration that artefacts are unique and vulnerable, and therefore, their study should be conducted with respect to preserving their integrity. Recent technological research, for instance, is focusing on minimizing the sample quantity (micro-invasive techniques) or developing methods that can be applied in-situ with direct study on the artifact and without any sampling (non-invasive techniques). Specifically, the analysis of an artifact -for example an easel painting- is conducted either with methods that are in situ applied, without the collection of a sample, or by collecting a minimum amount of sample with severe restrictions; the number of samples is kept to a minimum, the collected amount is in the microgram order, the sampling points are within areas of the artifact that don't interact with its integrity, and the samples are collected by qualified personnel only. Furthermore, it should also be taken into consideration that there is no analytical technique that is able to answer all questions; every method has its own limitations, and every method gives specific results.

The invasive techniques are further classified in the following groups:

- **Non-destructive.** The sample is not destroyed during the analysis, it can be used for performing additional analyses, it can be maintained and returned to the agency or museum that requested the analysis.
- **Destructive.** The sample is not maintained after the analysis, but it is destroyed; no further analysis can be performed with the same sample.

For the Sci-Art project, four analytical techniques will be used, which belong to the micro-invasive but non-destructive techniques, to emphasize the need to protect the integrity of the artefacts. At the same time, non-invasive techniques (with portable instruments) were avoided.

3. Archaeometric Methods of Study in the Sci-Art Project

The four analytical techniques used in the Sci-Art project are microscopy (optical and electron), energy dispersive X-ray spectroscopy (EDS), Fourier transform infrared

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spectroscopy (FTIR), and X-Rays diffraction (XRD). As mentioned above all these techniques are micro-invasive, but non-destructive of materials analysis and are widely used in Archaeometry. The chosen techniques for the Sci-Art project are often used in combination with each other as they provide complementary information about the artefacts. Each of the four techniques applied to the same artifact yields distinct information or results that mutually corroborate, providing a holistic characterization of the artifact. In addition, these four techniques can cover the analysis of most categories of artefacts (paintings, vessels, metallic artefacts, ceramics etc.).

Take, for example, a painting, which is a complicated sample for analysis because it consists of many successive layers that are not visible. Optical and electron microscopies reveal insights about its morphology and microstratigraphy, which are important because they provide information about the manufacturing technique and the state of preservation. EDS provides information about the elemental analysis of each constituent. For example, a red painting layer that is rich in mercury and sulphur, is a strong indication that vermillion was the applied pigment. FTIR spectroscopy can chemically identify organics and inorganics, from initial painting materials to degradation products; it can distinguish the different binding media (for example egg yolk that is used in egg-tempera technique or oil, as in oil paintings). It can also chemically identify certain pigments; the composition of many green pigments contains copper, like malachite, verdigris etc. If copper is found through elemental analysis, FTIR spectroscopy can further identify the pigment that was used. XRD analysis is also applied to help identify artefacts' materials, like pigments, but it is appropriate for the analysis of ceramics, metallic artefacts, and vitreous materials.

3.1 Optical and Electron Microscopies

Operating Principle

Microscopy is a method used to magnify matter. As an analytical technique, it is considered flexible, with a wide range of applications. In archaeological sciences, microscopes are used to examine the microscopic characteristics of artefacts, that are invisible to the naked eye. In what follows we will discuss optical microscopy, which uses light in the wavelength range from c. 380 to 760 nm, and scanning electron microscopy, which uses electrons to interact with matter. These two microscopies are chosen as they provide different magnifications and information about the artifact under study, as it is described in the following paragraphs.

Microscopes are tools that allow us to examine matter at a small scale by achieving magnification[1] of materials. Since the typical human eye has a resolution[2] of 200 μm (0.2 mm), optical microscopes were invented to have better insights, succeeding magnifications up to 1000×, with a resolution of 0.2 μm (200 mm).

In simple magnification using a magnifying glass (Fig. 2.1), the light from an object is refracted through a biconvex lens (a converging type of lens) and the observer perceives a

[1] Magnification: Although the term is connected with the action of making something larger, in microscopy it expresses the ratio of size between the produced image and the object, or how many times larger an object appears in comparison to its physical dimensions.

[2] Resolution is defined as the smallest distinguishable distance separating two objects.

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larger real image. Microscopes succeed the magnification of objects at higher scale as they consist of lens arrays: the objective lens, placed near the object to be studied, gives a real image, which is used as the "object" for the eyepiece lens to give a larger virtual image. To use a microscope, the object is placed on the microscope's stage, and the scientist observes the object through the eyepiece lens, choosing the right objective lens, and focusing using special knobs.

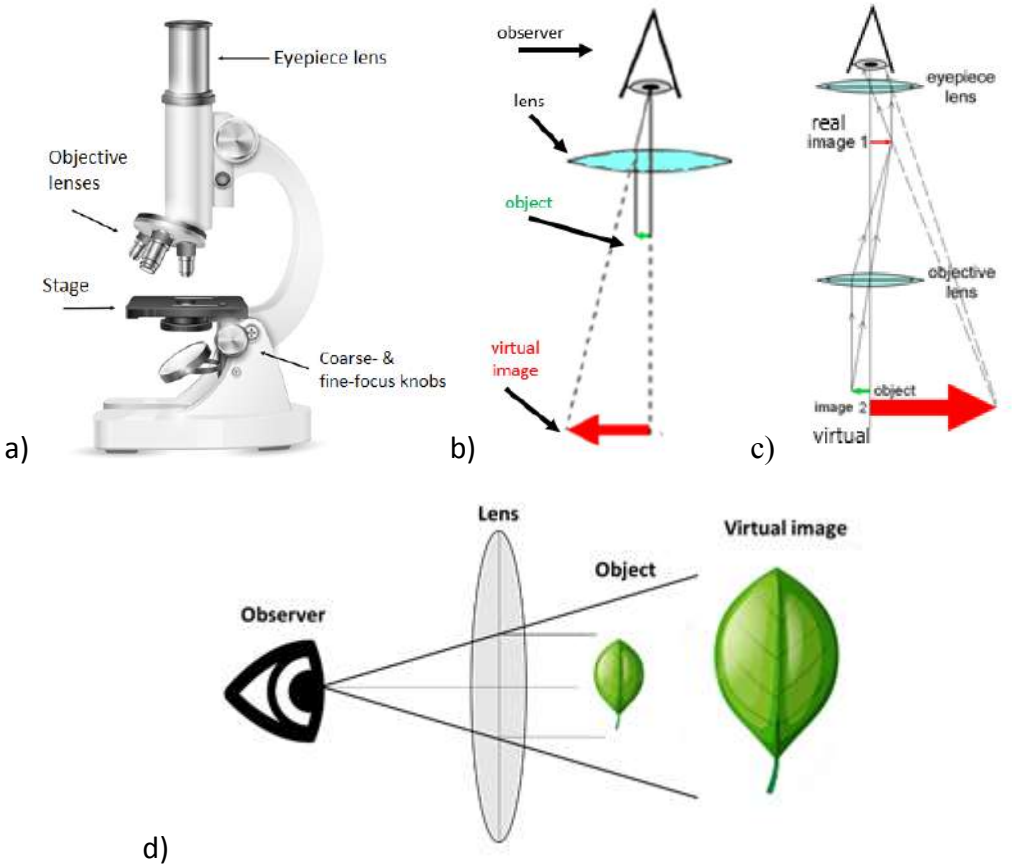

Figure 2.1. *(a) Schematic representation of an optical microscope, diagrams representations (b) in a simple magnifying lens and (c) through two lenses and (d) an example of magnification using a convex lens. (Images (a) and (d) by brgfx on Freepik[3], Schematic diagrams (b) and (c))*

Optical microscopy presents many advantages, such as relatively low-cost equipment, and little expertise to operate. The limitations of optical microscopes regarding magnification and resolution are related to the wavelength of visible light (c. 380-760 nm). To achieve higher magnifications, electrons are used instead of light, as they have a much smaller wavelength, which results to typical magnifications up to 200,000×. Scanning electron microscopes (SEM) use an electron beam; the electrons -produced by thermionic heating (emission)- are accelerated by applied voltage and the beam is focused on the sample using condenser lenses. Whilst optical microscopes use lenses made of glass to create the magnified images by refraction, electron microscopes usually use electromagnetic lenses. Secondary electrons, backscattered electrons, and characteristic X-rays are some of the

[3]https://www.freepik.com/free-vector/isolated-microscope-cartoon-design_26162355.htm#query=microscope&position=4&from_view=search&track=sph

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phenomena that occur when the electron beam interacts with the sample, and these are the signals employed in SEM analysis (Fig. 2.2). These phenomena originate from different depths of the sample under examination, and they are collected by different detectors that are placed inside the instrument. Secondary electrons -as a result of inelastically scattered electrons- emerge very closely from the sample's surface, they are independent of the sample's composition, and their signal provides morphological information of the sample in high resolution.

Backscattered electrons on the other hand are dependent of the sample's composition, as they are the result of beam's elastically scattered electrons with the sample's atoms. In general, larger atoms (or atoms with high atomic numbers) result to more backscattered electrons, which results to images with contrast due to composition differentiation. Thus, secondary electrons give an image that emphasizes on the morphological characteristics of a sample, while the backscattered electron image gives compositional information[4]. The characteristic X-rays are explained in the next section.

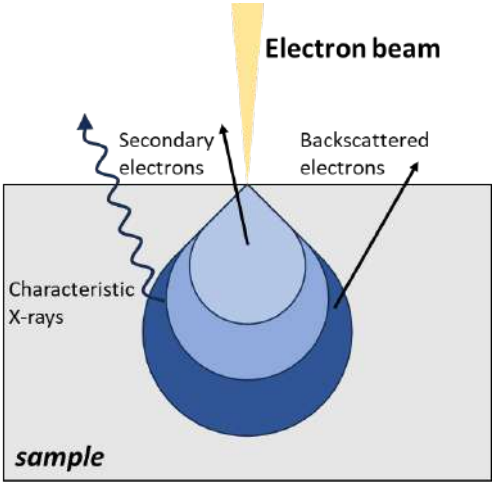

Figure 2.2. *Simplified schematic representation of the interaction of electron beam with matter.*

To sum up, SEM provides images with high resolution, and higher magnification in comparison with optical microscopy, allowing us to study matter down to the micro- and the nanoscale. Its disadvantages are its cost, relevant restrictions of the area to be placed, as well as the lack of color of the collected images.

Connecting optical and electron microscopies with school science.

Optical and electron microscopy helps us to teach the importance of proper sample preparation techniques. Moreover, it allows us to discuss how magnification and resolution affect the quality of an image and the ability to distinguish fine details in the sample, enabling the visualization of micro and nanoscale features. Interpreting information obtained from microscopy involves a systematic process of observation, analysis, and drawing of conclusions based on the displayed images. Exploration of the sample at different

[4] Readers can refer to the following link for comparison between secondary and backscattered electron images: https://www.jeol.com/words/semterms/20190129.113542.php#gsc.tab=0

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magnifications can gather a comprehensive understanding of its components. The microscope image can be the starting point for the identification of the key structures within the image. Measurement of dimensions, distances, areas, and other relevant parameters of interest could help in obtaining dimension quantitative data from the image.

Furthermore, the following principles and phenomena could also be discussed in the context of science education relating to optical and electron microscopies:

- Principles of optics and the behavior of light are related to optical microscopy. Concepts such as rectilinear propagation of light, reflection, refraction, Snell's law, and image formation in lenses can be taught in reference to optical microscopy.
- Geometric optics principles are relevant for understanding image formation in simple lenses and mirrors, while they can also help students, involved in inquiry-based activities, to explain the magnification produced by convex or concave lenses using ray diagrams. Reflection and refraction, which describe how light behaves when it encounters interfaces between different media, also relate to optical microscopy.
- Also, the law of refraction (Snell's law) relates the angles of incidence and refraction to the refractive indices of the media. The Fermat's principle of least time explains the behavior of light as it undergoes refraction and reflection

All the above principles could help understanding how lenses and mirrors in optical microscopes focus and direct light. To understand the resolution limitations of optical microscopes, the concept of diffraction can also be taught.

- **Rectilinear Propagation:** Light travels in straight lines through a uniform and transparent medium.
- **Reflection:** When light rays encounter a reflective surface, they bounce off the surface following the law of reflection. The law of reflection states that the angle of incidence (the angle between the incident ray and the normal to the surface) is equal to the angle of reflection (the angle between the reflected ray and the normal).
- **Refraction:** When light passes from one medium to another with a different refractive index, it changes direction. This change in direction is known as refraction. The amount of bending depends on the angle of incidence and the refractive indices of the two media.
- **The law of refraction (Snell's law)** relates the angles of incidence and refraction to the refractive indices of the media involved.
- **Diffraction:** A phenomenon that occurs when light waves encounter an obstacle or aperture, causing them to bend and spread out.

When handling electron microscopy in a didactic intervention, several principles, laws, and concepts of physics are relevant. To explain electron interactions with matter, concepts such as wave-particle duality, electron energy levels, and probability distributions are essential.

- **Electron-Beam Interactions:** Understanding how high-energy electrons interact with matter is crucial in electron microscopy. Elastic and inelastic scattering, secondary and backscattered electrons, and electron-sample interactions are concepts needed to interpret electron microscope images and spectra.

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- **Electromagnetism:** Electron lenses and magnetic fields play a critical role in focusing, scanning, and manipulating the electron beam in electron microscopes. Understanding electromagnetic principles is essential for optimizing electron optics.
- **Photoelectric Effect:** The photoelectric effect is the process by which electrons are emitted from a material when it absorbs photons. In electron microscopy, this effect is used in electron sources like tungsten or field emission guns to produce an electron beam.
- **Diffraction and Wave Optics:** Electron waves can exhibit diffraction patterns like light waves. Concepts from wave optics are used to understand electron diffraction, which is the basis for electron crystallography and selected area electron diffraction (SAED) in electron microscopy.

Handling these principles in reference to electron microscopy could help students, involved in inquiry-based activities, to understand the physics behind electron interactions, electron microscope operation, and the diverse applications of electron microscopy in various scientific disciplines.

Note: Didactical transposition

Didactical interventions focus in:

Image formation in a simple converging lens, basic use of a microscope, the concept of magnification, dimensions of samples to be examined vs wavelength of light, microscope distortions.

3.2 Energy Dispersive X-ray Spectroscopy

Operating Principle

Elemental analysis is a crucial method for materials characterization. Among many elemental analysis methods, this section deals with energy dispersive X-ray spectroscopy (EDS), as it is a method that is coupled with SEM, as we can collect elemental information from an object by studying the results of the interaction of the electron beam with matter. When the electrons collide onto the sample, some of their energy is transferred to the atoms' electrons of the sample. The latter are excited, but they quickly return to their original energy levels, releasing the excess energy in the form of X-rays, that are characteristic of the excited atom (Fig. 2.3). These X-rays are then collected by the special EDS detector and are used to identify the atoms they came from, as these X-rays are unique for every and each element. As an EDS detector is usually an integral part of scanning electron microscopy, elemental analysis is the second step when using SEM analysis; the sample under study is focused and its image is collected in an appropriate magnification. Then the elemental analysis takes place, choosing between different analysis modes; spot, linear or area analysis can be performed, providing elemental information of discrete characteristics, differences in composition of successive regions, and mean composition of specific areas, respectively. The X-ray signal is collected by the EDS detector, and the elements are identified by the

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appropriate software, also providing information regarding their quantity in the sample (Fig. 2.3).

Connecting Energy Dispersive X-ray Spectroscopy with school science

EDS analysis helps us to teach the fundamental concept that matter is comprised of atoms, highlighting the diverse elemental composition present in various materials. Furthermore, interpreting EDS spectra offers valuable insights into the elemental analysis of the studied artifact.

For science education that relates to EDS the following principles and phenomena could be also discussed:

When electrons interact with matter in an electron microscope, they can produce X-rays. Understanding X-ray generation and EDS principles enables elemental analysis of the specimen.

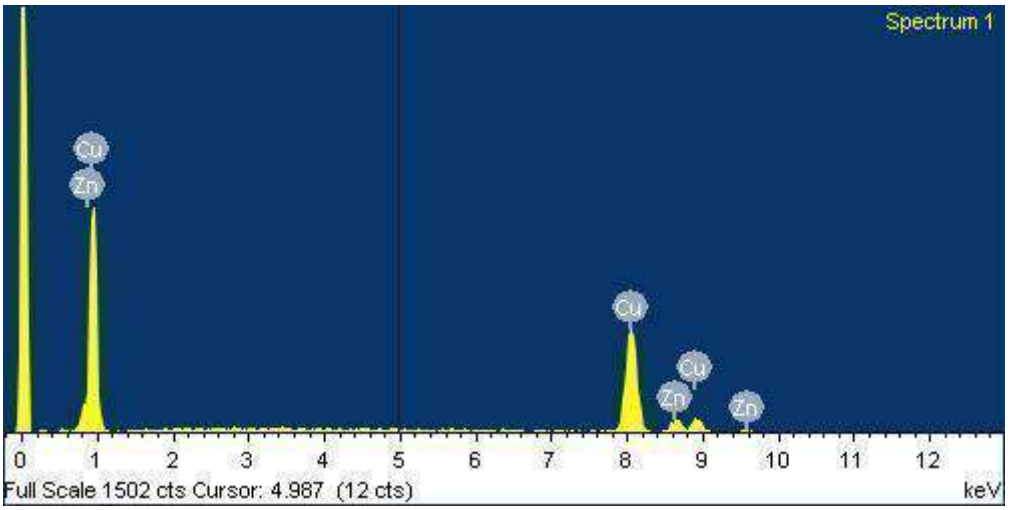

Figure 2.3. *An EDX spectrum, collected from the false gilding of a wall painting.*

Teaching EDS involves explaining the generation of X-rays through interactions between high-energy electrons and atoms in the sample. Concepts like inelastic scattering, excitation, and de-excitation of electrons, and the conservation of energy and momentum can be explored. Exploring how X-rays interact with matter offers a chance to introduce concepts like the photoelectric effect, Compton scattering, and Rayleigh scattering. Understanding these interactions is crucial for interpreting EDS data.

The emission of light from the de-excitation of atoms is a fundamental process in atomic physics. When an atom is excited to a higher energy state, either through the absorption of energy or collision with other particles, it can return to its lower energy state by releasing the excess energy in the form of electromagnetic radiation, which includes visible light (Fig. 2.4).

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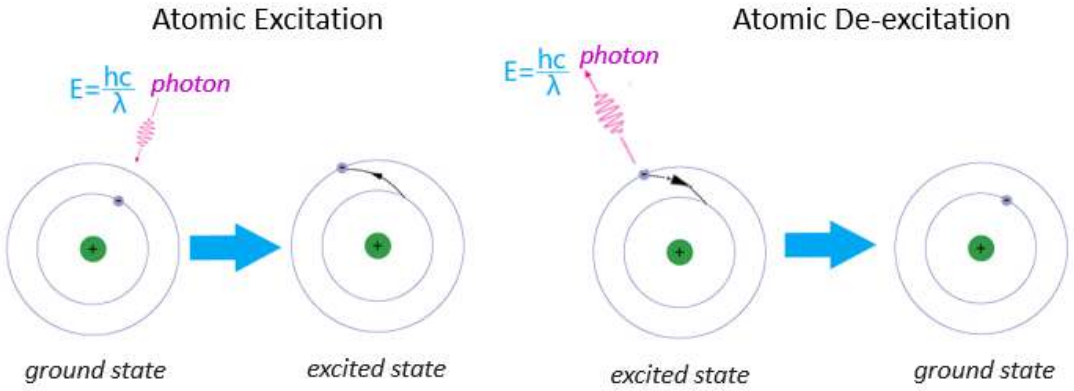

Figure 2.4. *Emission of light from the de-excitation of atoms.*

The de-excitation process occurs due to transitions between different energy levels within an atom. Each atom has discrete energy levels, often referred to as electronic energy levels or electron shells. When an atom is excited, one or more electrons are promoted to higher energy levels. The emission of light during de-excitation follows the principle of conservation of energy. As the excited electron returns to a lower energy level, it must release the energy difference between the two states in the form of a photon. The energy of the emitted photon corresponds to the difference in energy between the initial and final energy states of the atom. The specific wavelengths or colours of light emitted depend on the energy difference involved in the transition. Each element has a unique set of energy levels, resulting in a characteristic spectrum of emitted light. This phenomenon forms the basis for spectroscopy, which is the study of the interaction between matter and electromagnetic radiation. The emitted light can be observed as discrete lines or bands in the spectrum, depending on the complexity of the atom's energy level structure. For example, in the visible range, we often observe emission lines as distinct colours corresponding to specific transitions.

- **Atomic Emission Spectra:** Excited electrons transition from higher to lower energy levels, producing characteristic spectral lines. These lines are used to identify elements and analyze their composition.
- **Incandescent Light:** At high temperatures, atoms in a material can become excited, leading to the emission of a broad spectrum of light. Incandescent light bulbs are an example of this thermal emission.

The whole electromagnetic spectrum could be discussed with students with the visible range, infrared and X-ray regions to be noted (Fig. 2.5).

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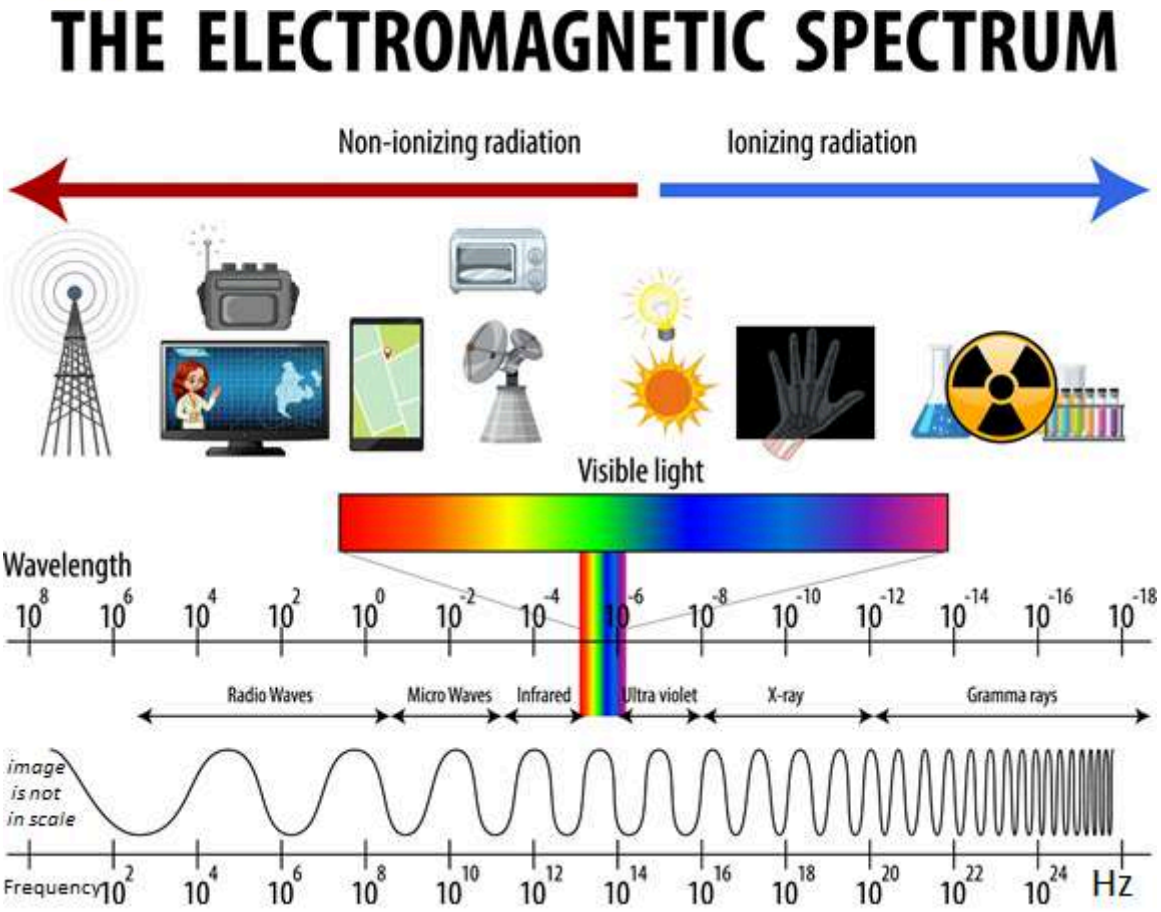

Figure 2.5. *The electromagnetic spectrum.*

3.3 Fourier Transform Infrared Spectroscopy

Operating Principle

Seeing the microscopic details of a sample, and identifying the elements that it is composed from is not enough to fully recognize the composition of a sample. As an example, millions of organic compounds are composed just from some elements (carbon, oxygen, hydrogen and nitrogen), while copper is found in many pigments, such as malachite, azurite, cuprite etc. For this reason, it is essential to use a technique that can accomplish “molecular” identification.

One of the methods that can accomplish this is Fourier transform infrared (FTIR) spectroscopy, which uses photons in the infrared region to "read" a sample. Matter consists of atoms. Atoms are joined by bonds to form molecules. These bonds are not stable, but can vibrate in various ways when stimulated with photons in the infrared region (Fig. 2.6a). This is exactly what FTIR "sees". These vibrations are unique for each bond in a specific molecule. What we collect is the FTIR spectrum of the material under investigation, where every FTIR band (or peak) corresponds to a specific eigenfrequency of a bond, and thus the identification is possible, either by using an appropriate software for spectral recognition, or using spectral libraries (Fig. 2.6b). Finally, FTIR spectroscopy is often coupled with

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microscopy, which allows the studying of very small objects, such as grains, making the method ideal for artefacts.

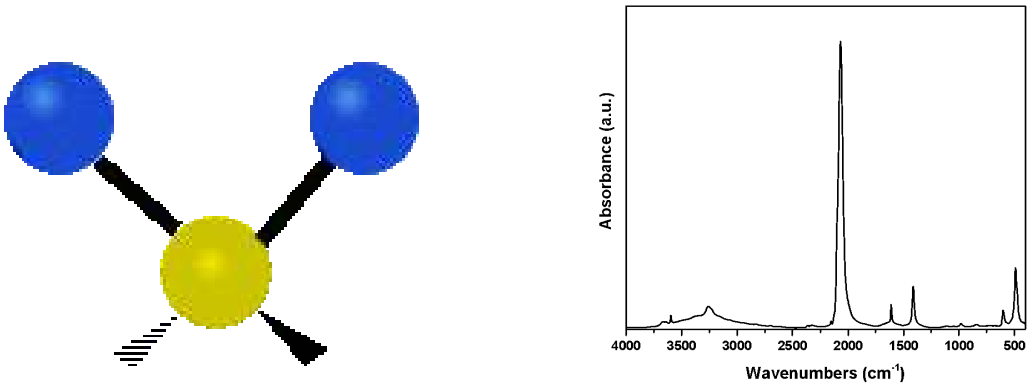

Figure 2.6. (a) *Symmetrical stretching (snapshot from a gif by Tiago Becerra Paolini[5]).*
(b) *The FTIR spectrum of Prussian blue, a blue pigment synthesized in the 18th century.*

Connecting Fourier Transform Infrared Spectroscopy with school science (didactical transposition)

FTIR spectroscopy helps us to teach the fundamental concept that matter is composed of molecules. Molecules are distinct from the individual atoms that compose them. FTIR helps to highlight the diverse molecular composition of various materials. Furthermore, interpreting FTIR spectra draws to conclusions about the sample's composition or structure.

According to the science related with FTIR spectroscopy the following principles and phenomena could be also discussed:

Fourier Transform Infrared Spectroscopy (FTIR) is a technique used to study the vibrational modes of molecules, providing information about chemical bonds and molecular structures. Electromagnetic radiation, molecular vibrations, spectral interpretation and molecular identification are some topics in physics that are related to FTIR.

- **Electromagnetic Radiation:** FTIR involves the interaction of infrared radiation with molecules. This presents an opportunity to introduce the concept of electromagnetic radiation, the electromagnetic spectrum, and the relationship between wavelength and frequency.
- **Molecular Vibrations:** FTIR involves explaining the different types of molecular vibrations, including stretching and bending vibrations of chemical bonds. Students can explore the forces that lead to these vibrations and their quantized energy levels.

[5] https://commons.wikimedia.org/wiki/File:Symmetrical_stretching.gif

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- **Spectral Interpretation and Molecular Identification:** FTIR spectra consist of peaks corresponding to specific vibrational modes of molecules. Students can explore spectral interpretation by peak assignments, and how FTIR is used to identify functional groups and compounds.

3.4 X-Rays Diffraction

Operating Principle

X-ray diffraction is a technique that uses X-rays to probe the atomic structure of materials. By analyzing the scattering pattern of X-rays, scientists can obtain detailed information about the arrangement of atoms, leading to a better understanding of the material's properties and behavior.

X-ray diffraction (XRD) is used to investigate the structure of materials at the atomic and molecular level. It provides valuable information about the arrangement of atoms, which in turn helps us understand the physical and chemical properties of substances.

The technique uses X-rays, a form of electromagnetic radiation, similar to visible light but with much shorter wavelengths (Fig. 2.5). Due to their short wavelengths, X-rays have the ability to interact with matter, as far as with the atoms in a solid material.

When an X-ray beam is directed at a sample material, the X-rays collide with the atoms present in the sample. These collisions cause the X-rays to scatter in different directions. In the case of a crystal or a crystallite powder, as we can see in Fig. 2.5, the scattering of X-rays follows a phenomenon called constructive and destructive interference. The scattered X-rays are then detected and measured; the peaks correspond to the elastic scattering of X-rays on crystal planes. This interference results in a unique scattering pattern. The scattered X-rays are captured by a detector, such as a photographic film or a specialized electronic detector. The detector records the intensity and angles of the scattered X-rays, forming a diffraction pattern. This diffraction pattern contains valuable information about the arrangement of atoms in the material.

By studying the diffraction pattern, we can determine important characteristics of the material, such as the positions of the atoms, the distances between them, and the angles between atomic bonds. This information provides insights into the crystal structure, symmetry, and other properties of the material.

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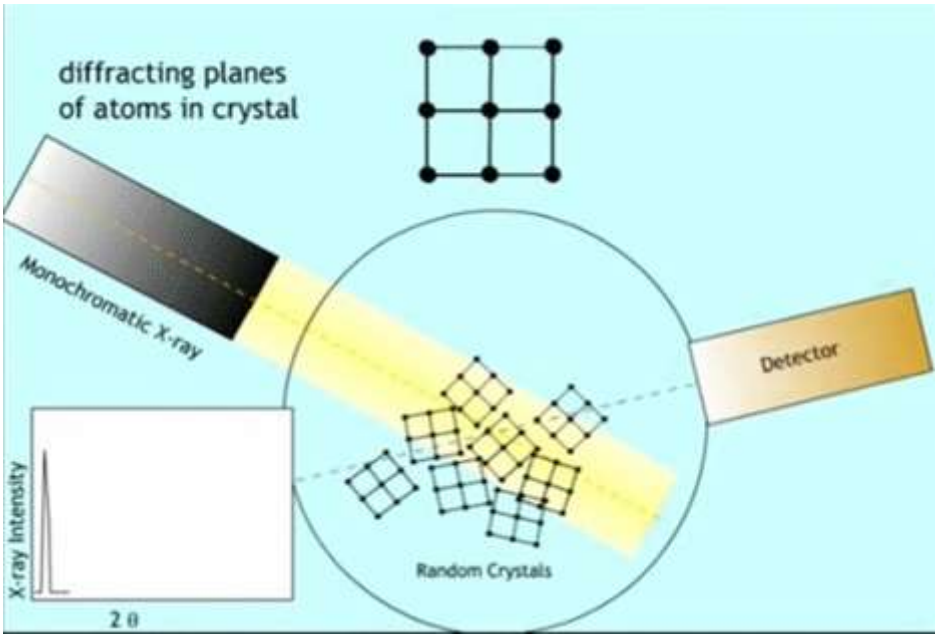

Figure 2.7. *XRD diffraction of a powder in a nutshell (snapshot from a gif by bunaro[6]).*

Connecting X-Rays Diffraction with school science (didactical transposition)

XRD helps us to teach that atoms are specifically arranged in precise spatial patterns when they combine to form matter. Furthermore, interpreting XRD patterns draws to conclusions about the sample's composition or structure.

According to the science related with XRD the following principles and phenomena could be also discussed:

X-ray diffraction (XRD) is a technique in materials science to study the crystal structures of solids. Crystallography, electromagnetic radiation, scattering and diffraction, X-ray generation, Bragg equation and structure determination are topics in the context of science related to the XRD.

- **Crystallography:** X-ray diffraction is rooted in crystallography, the study of crystal structures. Concepts such as unit cells, lattice structures, Bravais lattices, and Miller indices are essential to understanding how X-ray diffraction patterns are produced.
- **Electromagnetic Radiation:** XRD involves the interaction of X-rays with crystal lattices. This provides an opportunity to introduce the concept of electromagnetic radiation, X-rays as a form of high-energy photons, and their relationship to the electromagnetic spectrum.
- **Scattering and Diffraction:** XRD could help students to explore the scattering and diffraction of X-rays by atoms in a crystal lattice. The principles of constructive and destructive interference, as well as the Bragg's law, can be explored in this context.
- **X-ray Generation:** X-rays used in diffraction experiments are typically generated through processes like electron bombardment in X-ray tubes or synchrotron radiation. Concepts of X-ray generation, focusing, and collimation can be covered.

[6] https://makeagif.com/gif/x-ray-diffraction-pd_l_O

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- **Bragg Equation:** The Bragg's law, which is fundamental to X-ray diffraction, could help students to be involved in inquiry-based activities, in order to understand the relationship between the angle of incidence, lattice spacing, and the wavelength of X-rays for constructive interference.
- **Structure Determination:** XRD is used for crystal structure determination. Students can explore concepts like indexing diffraction peaks, solving crystal structures using XRD data, and interpreting structural information from diffraction patterns.
- **Applications in Materials Science:** XRD is used to analyze materials' crystal structures and phases. Students can learn about its applications in materials characterization, phase identification, and determining crystallographic orientation.

By incorporating these principles, laws, and concepts of physics into the teaching of X-ray diffraction, students involved in inquiry-based activities, could gain a comprehensive understanding of the underlying physics behind this essential technique in material sciences and related fields. They can appreciate how XRD provides valuable information about the atomic arrangement in materials and its significance in various scientific and technological applications.

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Further Information

Optical Microscopy

- https://www.nagwa.com/en/explainers/356107286405/
- https://www.ipl.org/essay/Importance-Of-Microscopy-In-Archaeology-FJPUBC6AQG
- https://micro.magnet.fsu.edu/primer/anatomy/anatomy.html

Scanning Electron microscopy

- https://www.nanoscience.com/techniques/scanning-electron-microscopy/components/

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- https://www.thermofisher.com/blog/materials/sem-signal-types-electrons-and-the-information-they-provide/
- https://www.jeol.com/words/semterms/20190129.113542.php#gsc.tab=0

Elemental analysis with EDX

- https://www.thermofisher.com/blog/materials/edx-analysis-with-sem-how-does-it-work/

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CHAPTER 3. Cultural Heritage and Identity: Exploring National and European identity through artefacts

Chapter in a nutshell

This chapter explores the notion of heritage and material culture, and its relation to identity processes and the politics of representation. Introducing concepts from Critical Heritage Studies (CHS) we problematise the notion of heritage, shifting the focus from defining what heritage is to understanding how heritage is managed and practiced and for what purposes. In doing so we emphasize the social, economic, cultural and political functions of heritage and its objects, and particularly its role in struggles for collective identifications in the past, present, and future.

We further examine the idea of heritage objects in museums and how these can carry multiple meanings, through their material qualities, already established narratives that are inextricably linked to their histories, and through the possibility of direct affective engagements with them. An emphasis on the 'material turn' in various disciplines offers here the context for questioning how experiences with heritage objects can inform the shaping of new shared stories – real or imagined – among diverse communities, and identity politics, both locally and at a European level.

The importance of heritage in identity politics and fostering a sense of belonging is evident in various contexts, including the European Union's recognition of cultural heritage in 2018. A critical approach to heritage helps understanding the EU's emphasis on heritage during times of political and economic turmoil, by focusing on how different stakeholders, including educators and museums, use, interpret and display heritage to promote certain narratives.

1. Definition of Heritage

Defining 'heritage' is an important, yet challenging task. Heritage can involve objects from the past such as buildings and monuments; it can involve artistic products or everyday life objects and artefacts; as well as natural environment and landscapes. UNESCO's distinction between tangible and intangible heritage allows also for cultural traditions, languages, songs, dances etc to be seen as heritage. As Tunbridge & Ashworth (1996) point out, all these different things that can be called heritage can create disagreements with regards to defining what heritage is, how important it is, and how it is exploited for political or socioeconomic purposes.

So, defining heritage is a task that has itself caused numerous debates. Issues of authenticity, ownership, and its relation to the past and history have been some of the issues dominating these debates. For the purposes of the Sci Art Project, drawing on Critical Heritage Studies (Smith, 2012; Waterton & Smith, 2010), we align with approaches that move the focus away from heritage as a 'thing' or as something given and taken for granted, and instead we focus on the social processes surrounding the meanings and functions of

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tangible and intangible heritage. In other words, the attention moves towards examining what is considered as heritage, why/for what purpose, and for whom, as well as on how it functions in a community or society. Heritage emerges therefore "as a social construction, imagined, defined, and articulated within cultural and economic practice" (Graham, 2002**:** 1003) and at the same time serves as "knowledge, a cultural product and a political resource" (ibid. 1007).

During the SciArt project, partners will particularly highlight the adoption of such notions of heritage through the use and study of specific museum artefacts, selected from the permanent collections of three different museums in Cyprus, Greece and Portugal. Thus, objects of material/tangible heritage (artefacts) – often displayed in museums – are here approached not as solely static, but also as active agents in the ways meaning is developed and constructed. Such heritage objects "are seen as one of several ways of narrating the past" and an integral part of how we construct our understanding of the present through the past (Pearce, 1994: 21).

Considering the relation between heritage, history, and the past is essential. Heritage is often seen as a product of the past that belongs to a different era. This view has often caused debates around the relevance of heritage in the present; for example, the notion of 'heritage languages' has been heavily criticised for constructing minority languages as belonging to the past rather than recognising them as part of a minority community's everyday life (Blackledge et al., 2008; García, 2014; Wiley et al., 2014). However, approaching heritage as a set of practices and processes moves our focus to how it functions in the present and the future.

> Heritage does not engage directly with the study of the past. Instead, it is concerned with the ways in which very selective material artefacts, mythologies, memories, and traditions become resources for the present. The contents, interpretations and representations of the resources are selected according to the demands of the present. It follows too that the meanings and functions of memory and tradition are defined in the present. (Graham, 2002: 1004)

Heritage is, therefore, not just about learning, remembering, and connecting to a past but also about interpreting, re-imagining, and reconstructing a past in ways that create certain memories, relations, and visions of the present and future.

The above discussion and the conceptualisation of heritage adopted here enables us to avoid 'romanticised' views of heritage as well as criticisms that the term is fixated onto a distance past. More so, it acknowledges that often, heritage objects in museum collections are bestowed with the "power of the real thing" as a trace of our historical lineage: a rather romanticized approach founded on the idea that these are suggestions of human activity (they once belonged to and were used by someone) which endured the passage of time, in ways that humans cannot.

Such understandings of heritage as the abovementioned, also acknowledge the manipulation/exploitation of heritage as an inherent part of processes of selecting, establishing, and displaying something as 'heritage' – frequently also strongly linked to memory (as discussed later). Material heritage, especially museum artefacts in particular,

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have been consistently regarded as one of the most powerful tools in processes of determining institutional power and control through their selection and display. Historically, museum artefacts were purposefully and systematically used for showcasing colonial authority and as evidence of domination of one nation over another[7]. In his seminal work *Imagined Communities*, Benedict Anderson (1993) explained how different states used artefacts as ways of showcasing the nation's competences and how this imagined the nation as extending beyond its borders.

Later in the twentieth century national museums used their objects as means of materializing the idea of belonging, in conscious attempts of escaping their colonial pasts and as the result of nation-building ambitions. As Mary Bouquet states:

> Whether through the revolutionary transformation of an existing royal palace of the construction of an entirely new building, national museums were supposed to materialize the nation and contain its specific collection of treasures, recalling past origins and glory as a connecting link with the contemporary public (2012:36).

These are important issues to consider when looking at the relation between heritage and identity in the following section, as well as when examining the role of heritage objects and museum artefacts in the construction of local, national, or European identities.

2. Heritage and its Objects: The 'material turn'

When seeing heritage as social, cultural, and political practice, identity politics and power relations emerge at the heart of these discussions. Afterall the term 'heritage' implies relations of possession, as well as distinctive identity relations - there are 'legatees', 'inheritors', 'disinheritance' etc. (Tunbridge & Ashworth, 1996:6). Therefore, heritage has been widely used and displayed to serve certain identity narratives and to construct relations between people, objects, and spaces.

In turn, when investigating heritage objects, and especially museum artefacts, these act as means of representation. In other words, objects not only function as documents, a form of documentation, and evidence of the past, but they can also be viewed in a wider context of critique that potentially challenges our normative understandings of our sense of belonging. Objects are always fragments of the past, and as such they speak of the discontinuous experience of history, the impossibility of a complete reading and of the fact that the past "can never be precisely located, neither as a 'there' nor as a 'then'" (Wasserman, 2007:160). In this project we begin from recognizing that objects can reveal not only parts of the past but also – and perhaps even more importantly – the gaps of historical narration.

Heritage objects, as representations, are always fragmentary and incomplete. John Tagg (2009) has identified this as the problematic nature of representation when discussing images, and the impossibility of escaping a *politics of the image*. He writes: "For the evidence of the image, there was no escaping the long trek across the more uncertain

[7] Further discussion on the politics of display and the role of museums in presenting and constructing nationalism and/or identity narratives are presented in Chapter 4 of the Sci-Art ebook.

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ground of the conditions of witness, the status of documentation, and the politics of disputable meanings" (2009, 211). More so, meanings can never be isolated from the object's mode of presentation and accompanied information, as well as the biases inherent in our engagement with them, which are equally idiosyncratic and spatio-temporally specific. Sundra Dudley (2010) argues that it is about time we pay attention to the materiality of the object, treating the material not simply as a surface upon which meaning is inscribed. Instead, we need to see it within attempts of enriching 'an existing "interpretive preoccupation with the symbolic, representational and communicative dimension"' which has left the emotional, sensational, and material unexplored (2010:7).

Such emphasis on the object's materiality is aligned with the 'material turn' in anthropology and related disciplines over the last few decades, highlighting the significance of looking at an object's properties along with the object's social lives. While discussing photographs as objects, social anthropologist Elizabeth Edwards points out that the interlinked dynamics of an object's "social use, material performance, and patterns of affect" are put to work "through their material substance" (Edwards,2012:222). The ways in which objects have been used by peoples in the past has unearthed important insight relating to the values and meanings objects acquire, as the result of usage and performance. It has often also been the case that such analyses diverted the attention from the tangible and very real actuality of objects, missing out on learning more about "the sensory modalities through which we experience" objects (Dudley, 2010:2).

The SciArt project attempts to bridge the two, the study of the materiality of selected museum artefacts (through archaeometry)[8] and their social lives. Ultimately, the aim is to explore some of the contexts in which heritage objects carry multiple meanings, through their particularly unique qualities, already established narratives that are inextricably linked to their histories, as much as through the possibility of direct affective engagements with them. By extension, the project also investigates the ways in which such experiences can inform the shaping of new shared stories – real or imagined – among diverse communities. It also illustrates how material forms might relate to the shaping of memory (Macdonald, 2013). Such attempts offer an interpretive framework within which we could also begin considering identity politics, both locally and at a European level.

3. Identity Politics and Shared Narratives

"Europe has become a memoryland – obsessed with the disappearance of collective memory and its preservation" says Sharon Macdonald (2013:1). This has been linked to the introduction of terms such as 'heritage industry' that describe a fascination and a fever with the past, especially with processes of its memorialization and preservation. Madnald (2013) asserts that the terms memory, heritage, and identity are tightly interwoven as a complex: a meshing of parts and tendencies. In her understanding of the memory complex, what is of interest and relevance to us is how she places particular significance on the un-patterned

[8] The different methods of archaeometry that are selected for use in the SciArt project, as well as the rationale behind these selections, are extensively described and analysed in Chapter 2 of the ebook.

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and unpredictable combinations of socio-cultural practices, affects and physical things / objects leading to open narratives about a shared identity.

We must, of course, maintain that the notion of a shared European identity is unavoidably an imagined one. In *Building Europe*, Cris Shore documents some of the policy initiatives that were set in place at EU level to produce a new set of symbols for communicating shared values and ideas, affirming a common cultural heritage (cited in Macdonald, 2013:34). Other examples illustrating the fictitious nature of a shared and common identity among all Europeans are the 12 stars on the EU flag symbolizing perfection but also exclusionary alluding to Christianity and classical antiquity (the twelve apostles, the hours of the day, the months etc), while the imagined bridges and buildings depicted on the new currency are again void of references to specific locale or nation yet alluding to a preferred inclination towards roman and classical antiquity, the renaissance etc. So, the question of how diverse groups of people both at European and at the local level can build a shared identity in a more democratic and inclusive manner remains unanswered. Similarly, the question lingers about how heritage can play a crucial role in shaping Europeanization, without neglecting "much of the deep-rooted symbolic identifications with Europe's dissonant pasts" (van der Laarse, 2019:84).

Drawing on the work of Lowenthal, Graham (2002:1008) outlines four interrelated characteristics of heritage that bond people together. Firstly, heritage serves to bestow a sense of respect through an elevated "status of antecedence", conferring a feeling of continuity, and consequently, a feeling of progressive societal evolution. Secondly, heritage functions as a bridge that seamlessly connects the present to the past, forging an unbroken trajectory. Thirdly, heritage plays a role in shaping how we perceive change. By remembering and valuing the past, heritage contributes to envisioning change, as the act of recalling past events may also suggest a sense of closure and termination of the events that happened in the past. Lastly, heritage provides a framework for constructing linear narratives. It offers a structured sequence that allows individuals to contextualize their lives within a coherent continuum, effectively linking past, present, and future experiences in a meaningful and interconnected manner.

According to Macdonald (2006:10)

> "The idea that heritage shores up and even performs peoples' sense of themselves as a recognisable and worthy group or people is widespread […] heritage is deployed to show that the collective identity in question—perhaps that of a nation or a region—has not just been formed in the very recent past but somewhere further back, preferably 'in the mists of time' or deepest antiquity. Age—the 'age' of 'heritage'—commonly confers legitimacy. Heritage presents identity—which literally means sameness—as persisting over time. The cultural equation at work here is that being of the past confers the right—or even creates a demand—to continue into the future."

Within such relations forged by the use of heritage, conflict and disagreement are often to be expected. Indeed, there are several terms in the literature that try to capture the contestations and identity politics involved in heritage management: e.g. dissonant,

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unwanted, 'dark' heritage, dissonant heritage, conflicted heritage (see for example Charalambous, 2019; Macdonald, 2006; Šešić & Mijatović, 2014; Tunbridge & Ashworth, 1996).

Despite the fact that different terms have been associated with different cultural contexts, they all try to account for the disconnect or conflict between the perceived values or significance of a heritage site, object, tradition, or cultural practice arising in different social, political or cultural contexts. Debates on authenticity and ownership are commonly cited in the literature, whilst dissonant/conflicted heritage may also arise when there is a discrepancy between the often idealized, romanticized, or nostalgic representation of a cultural asset put forward by dominant national narratives, and the complex, sometimes controversial, or uncomfortable realities of how people have experienced it. This discrepancy can lead to tensions, debates, or challenges in how heritage is understood, interpreted, preserved, or presented to the public.

More specifically, the notion of 'conflicted heritage' (Charalambous, 2019) brings to the foreground a set of complex relations between individuals, communities, spaces and historical narratives and it becomes particularly relevant in contexts where certain communities have been minoritized and marginalised, as well as in contexts of colonialization. It is also relevant for communities with a legacy of violence and conflict. Conflicted heritage, therefore, often emerges in postcolonial or post-conflict settings, where the legacy exploitation, war, or other traumatic historical events is either overlooked or selectively highlighted to construct a specific narrative of the past. In these cases, various stakeholders, including local communities, scholars, governments, and heritage organizations, may have different perspectives on how to acknowledge and interpret as well as display (or not) a heritage site or practice.

At the same time, heritage has been also used to restore relations after conflict, or to facilitate multiculturalism and the recognition of different communities in peace and unification narratives. International bodies like UNESCO, the World Bank and the Council of Europe, as well as national and local non-governmental organizations seem to also consider heritage as important in post-conflict and/or identity building processes, and through various actions they promote shared heritage to recognize common history or celebrate diversity. However, some critics question the use of heritage as a healing mechanism and point out ways in which heritage can be used to perpetuate and accentuate conflict, and to "hurt" rather than "heal" (Giblin, 2014:500).

Acknowledging and addressing dissonant or conflicted heritage in education is important for implementing inclusive pedagogies and for not marginalising groups of students that may have different experiences and narratives than the mainstream heritage discourses promoted in school practices. Still, it remains a challenging task for teachers as it involves navigating multiple historical narratives and collective memories, recognizing multiple perspectives, and fostering productive dialogue in the classroom that does not marginalise certain points of view whilst foregrounding others. It also means that educators need to acknowledge aspects of heritage that may create 'discomfort' as it they may challenge established and cherished beliefs (Porto & Zembylas, 2022; Zembylas et al., 2012). In this effort art has an important role to play as it allows for engagement with difficult histories,

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collective trauma, and pain in ways in which language may not be able to do so (Holmes & Peña, 2022; Porto & Zembylas, 2020).

More specifically, art allows us to reposition and reframe historical representations, difficult heritage, and silenced stories, creating alternative conditions for re-encountering our past in the present (Stylianou & Eleftheriadou, 2023). This occurs not as a utopian possibility of restoration of the past in the present, a way of 'having-been-there' (as cited in Tagg, 2009) but as a means of critically re-imagining the past. This is especially relevant considering the inevitable erasures, forms of denial and processes of forgetting that are integral to history-making, as much as they are sometimes essential for a nation to exist. As Hall and Pick state, "[r]emembrance may consolidate an 'imagined community'; so too, may occlusion and erasure – even major archives, of course, have sometimes been 'misplaced' or 'lost' in the service of national interests" (2017:8). Thus, artists and cultural institutions alike are nowadays called to action: to align, in order to "expose, inform, and even amend issues that demand reconciliation, reflection, and remorse" (Stylianou & Eleftheriadou, 2023: 274), revealing alterative, hidden and marginalized stories that have been either wilfully neglected or omitted by orthodox historiographies. Renewed forms of engagement with heritage and its objects – especially with the use of art and emerging technologies[9] – can serve such acts of revisiting the past in various educational settings.

4. Approaching heritage from an educational perspective

In their attempt to create a model for examining heritage, Tunbridge & Ashworth (1996:8) identify the following components that may also be useful to take into consideration when using heritage as part of educational activities:

1. The **resources**: what is available to choose from, what else is out there that could be considered as heritage, but it isn't?
2. The **transformation process**: the ways in which the selected resources are converted into heritage products through 'interpretation' and the narratives accompanying these interpretations.
3. The **heritage product**: Studying the material or non-material artifact. In relation to the product Tunbridge & Ashworth point out that "the product of the transformation process is not synonymous with preserved relict historical resources. The heritage product is a response to the specific needs of actual or potential users" (ibid.) in the present and future and hence it should be also studied as such. And this takes us to:
4. The **heritage consumer**: What are the "consumer demands" for which heritage products are produced; in other words, what purposes do heritage products serve.

Overall, as it becomes evident, when adopting a critical perspective to heritage, issues of selection and choice are unavoidably involved in any definition as are issues of interpretation and 'consumption'. At the same time, it is also important to pay attention to

[9] Further details on emerging technologies used in the SciArt project are presented both in Chapter 2 for the purposes of Archaeometry and studying object's materiality, and in Chapter 5 for the development of educational material and activities with students during the implementation phase of the project.

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the "the value and meaning one gives in specific uses or denials" (Constantinou & Hatay, 2010: 1602) of certain semiotic resources considered as part of a heritage (see also Charalambous, 2019).

Furthermore, when studying objects of heritage – tangible and intangible –, it is vital that we understand that these are the product of situated interactions between people and things (Dudley, 2010; Wehner & Sear, 2010) and as such "objects function[ed] not simply as symbolic artefacts 'standing for' human experience, but equally as performative material forms that embod[y] and shape[d] the experiences and actions of human subjects" (Wehner & Sear, 2010: 146). So, instead of simply looking at how heritage objects were used and/or what they are made of (material) we should focus on the more complex processes of their production, exchange, and consumption (Edwards, 2001). The comprehensive notion of 'object biographies'[10] can serve us well here.

Kristen Wehner and Martha Sear (ibid) when developing object biographies for the collections of the National Museum of Australia, set forth the following components as essential:

- The physical form of the object (example of style, locating the object in relation to its ancestors.
- The materials from which the object is made, and the techniques used for its production.
- The life history of the object, including its cycles of use, production, and circulation.
- The social contexts in which the object has lived.
- The values and meanings associated with the object as these emerged from the ways people used it and engaged with it.
- How these meanings are performed and enacted within a community.

In studying heritage and its objects in various educational settings, such guidelines can prove useful in better understanding the broader relationships between objects and people, materiality and sociality, history, and heritage. Finally, the objects' potential to bring people together in co-creating narratives and building a shared sense of identity within a European framework lies on the activation of these multilayered understandings of how heritage objects were produced, used, and existed, in the past as well as continue to communicate histories, engage people, and evoke meanings in the present.

[10] Elizabeth Edwards also discusses the idea of social and cultural biographies when analysing photographs as objects of material culture, arguing that these are useful terms in examining photography's "polysemous nature, lack of fixity and content-dependant modes of making meaning" (2001:14). She further argues that photographs – and this can be thought of objects in general – are active as objects as they are active as ideas, and both are subject to cultural processes that bestow and impact upon meaning during our interactions with them.

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CHAPTER 4. Museum Artefacts and Local Narratives: Building a common European identity

Chapter in a nutshell

The chapter focuses on museum politics, methods of display, selection criteria, and processes for the management of artefacts; and their respective contribution for the construction of shared identities in their respective communities and regions. After a brief overview of concepts, context, and background, the chapter proceeds to a comprehensive understanding of how artefacts selected and displayed by museums help to construct local narratives and structure cultural territories, while connecting those narratives to a shared notion of European identity.

1. Introduction.

In an era of globalization, the concept of identity has taken on new dimensions, both on an individual and collective level. This is evident in the so-called notion of European identity, that builds upon the rich cultural diversity and historical heritage that characterizes Europe. Museums are vital institutions that not only preserve and exhibit cultural artefacts but also play a crucial role in shaping our understanding of identities, histories, and the collective memory of local communities. Therefore, they also play a crucial role in the construction of a shared common notion of European identity. More specifically, the role of museums and their artefacts can contribute to a broader sense of belonging and collective memory within the European framework.

From their origin as spaces for exhibiting private collections to their modern-day role as public institutions, museums have evolved to become significant cultural spaces that bridge the past, the present, and the future of societies. Understanding the context in which museums operate is essential to grasp their impact on the construction of common identities and cultural territories. In this chapter, we understand cultural territories as geographic areas that define themselves by their specific cultural practices, values, and prominent ways of life. By showcasing and interpreting artefacts that embody collective memories, museums also become sites of cultural negotiation and dialogue.

Museum politics of display also highlight the complex decisions and considerations involved in presenting exhibits to the public and shed light on the intricate processes involved in curating and displaying exhibits. From acquisition and conservation to exhibition and interpretation, museum professionals face numerous challenges and considerations while performing their functions, which requires strong decision-making skills, capable of balancing preservation, accessibility, and audience engagement.

The politics of display within museums are crucial aspects to be explored. Museums have the power to shape narratives, influence perceptions, and challenge established historical interpretations. Besides, museums contribute to shaping collective memory and preserving cultural territories. By examining their approaches to curating and displaying artefacts, we

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can uncover the strategies employed to foster a sense of common identity, while respecting the nuances and diversity within European cultures.

Overall, this chapter aims to provide a comprehensive understanding of the role of museums in constructing common identities, local narratives, and cultural territories throughout Europe, always bearing in mind the challenges of museum management and the politics of display. By understanding these complex dynamics, we can appreciate museums' potential as catalysts for intercultural dialogue and for the construction of inclusive and diverse cultural communities with their specific narratives.

2. Museums: Concepts, background and evolution.

The social and cultural role of museums has evolved dramatically over the last decades. Nowadays, museums play a vital role in society not simply as repositories of knowledge and culture, but mainly as places for education, research, and civic engagement. Museums contribute to the construction of common identities in their respective communities and regions, while sharing the common goal of preserving and presenting the material and cultural heritage of humanity. Museums can be public or private institutions, non-profit, and can serve local, national or international audiences. Many museums have also undergone significant changes in recent years to become more inclusive, diverse, and accessible, with a focus on engaging with audiences from all backgrounds and perspectives.

Taking a historical perspective, museums have their origins in ancient civilizations, where artifact collections were displayed for public observation. Public museums began to arise in the 18th and 19th centuries, spurred by a desire to educate and inspire the general public. Wealthy individuals and scientists began assembling "cabinets of curiosities", which were private collections of natural and cultural items, during the Renaissance and Enlightenment periods. These collections served as the foundation for modern museums. Since then, museums have evolved from elite institutions shaped by personal interests to democratic institutions that strive to respond to widening social demands.

In 2022, the Extraordinary General Assembly of ICOM – International Council of Museums approved the following proposal for a new definition of museum:

> A museum is a not-for-profit, permanent institution in the service of society that researches, collects, conserves, interprets and exhibits tangible and intangible heritage. Open to the public, accessible and inclusive, museums foster diversity and sustainability. They operate and communicate ethically, professionally and with the participation of communities, offering varied experiences for education, enjoyment, reflection, and knowledge sharing. (ICOM, 2022).

Contemporary museums aspire to meaningfully engage their audiences, while guaranteeing that varied cultures, viewpoints, and voices are represented in their collections and displays. In order to achieve this purpose, they have to work attentively on creating engaging and informative displays with interactive features to increase visitor engagement, always focusing on educational and public programs. The administration of museums has also

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developed throughout history and into contemporary times, in order to adapt to changing cultural expectations, technology improvements, and a larger understanding of the museum's position in society.

To ensure the effective management and growth of museums as cultural, educational, and community-oriented organizations, museum professionals now apply a variety of skills and good practices. The use of digital technology, online platforms, and virtual experiences is fundamental for reaching a larger audience and improving accessibility. Likewise, museums have been working with local communities, schools, and organizations to create programs, partnerships, and events that appeal to a wide range of people.

Although museums have become more democratic and inclusive institutions, their politics still depend on a very complex set of social, cultural, and economic factors that influence and are influenced by how museums are funded, governed, and operated/managed. Museums are often subject to political pressures and demands, both from external sources such as government agencies, donors, and interest groups; and from biases of internal sources such as museum staff, curators, and trustees. These can all shape the way museums collect, interpret, and display artefacts, as well as their policies regarding access, ownership, and cultural sensitivity.

3. The evolution and challenges of the politics of display.

Over their evolution, museums have reflected shifting societal ideals, cultural developments, and power dynamics, that influence their politics of display All these factors play a fundamental role in the way museums represent and build cultural territories and local identities, namely in the way museums exhibit and preserve cultural heritage, foster cultural exchange, promote cultural education, engage with local communities, and encourage cultural production.

The politics of display pertains to how museum's exhibit and interpret their collections to the public. Decisions regarding how to organize and show artefacts; what information to provide about them; and how to engage visitors with the displays are all part of the museum's politics of display. In the past, museums often prioritized the display of artworks and objects that were considered prestigious and associated with elite cultures. This approach reinforced social hierarchies and perpetuated a narrow perspective of history and culture.

During colonial times, European museums played a relevant role in showcasing cultural artefacts forcibly taken from colonized regions. This practice often resulted in the exclusion of indigenous perspectives and the perpetuation of colonial narratives, with their symbols and discourses of power and oppressive national identities. This approach contributed to the dominance of Western narratives and Eurocentric interpretations of history.

Contemporary museums are attempting to represent a greater range of cultures, voices, and perspectives, through more inclusive and diverse exhibitions. This includes widespread efforts to decolonize collections, question dominant narratives, and emphasize the inclusion

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of underrepresented communities. Museums are now increasingly collaborating with grassroots communities and stakeholders to co-curate exhibitions and integrate various views. Collaborative approaches recognize the value of community knowledge and challenge the museums' traditional authority in the interpretation of artefacts and artworks. With this approach, contemporary museums are inviting visitors to question preconceptions, engage in debate, and examine multiple points of view. Museums are increasingly striving for more cultural awareness by respecting the rights and values of the communities from whom artefacts originate. Addressing repatriation difficulties, maintaining adequate documentation, and engaging in ethical standards for the exhibition and interpretation of sacred or sensitive artefacts are all part of this renewed approach to the politics of display, which also promotes a more complex understanding of history and culture.

Nonetheless, the ways museums present artefacts and their narratives also involve relevant questions of power, representation, expression, and cultural ownership. Curators, museum directors and other stakeholders may engage in intricate negotiations to balance issues that may include aesthetic considerations, cultural sensitivity, and instructional value, among others. Indeed, museums can be sites of controversy and conflict, particularly when they are seen as representing dominant or exclusionary cultural narratives. As Sharon Macdonald states, the museum "selects certain cultural products for official safe-keeping, for posterity and public display – a process which recognizes and affirms some identities and omits to recognize and affirm others" (Macdonald, 2006:4). Thus, museum professionals must be attentive to issues of cultural sensitivity, ethical representation, and social justice, while performing their work.

Many museums are grappling with the legacy of colonialism and the need to handle the restitution of cultural artefacts plundered from colonized regions. The main difficulty that ensues is harmonizing the existence of historical collections obtained through questionable (often immoral) means and striving for repatriation or constructive collaborations with the communities of origin. It is a constant challenge to ensure meaningful representation and inclusion in museum exhibitions. To minimize tokenism and assure authentic narratives, museums must address representation gaps, particularly towards marginalized populations, and actively involve communities of origin in decision-making processes. Figuring out how to interpret objects and artworks in exhibitions is a difficult task, therefore curators must strike a balance between presenting historical background, diverse perspectives, and critical interpretation, while avoiding simplifying or imposing their biases.

In fact, museums are bound to walk a narrow line between cultural appreciation and cultural appropriation. Displaying objects from many cultures implies a careful consideration of cultural sensitivity, respect for traditional practices, and avoidance of cultural reductionism or commodification. When showing sensitive objects such as sacred artefacts or human remains, museums frequently face ethical dilemmas. In order to achieve a balance between public access and respect for cultural and religious beliefs, extensive discussion and engagement with local communities is required. Museums frequently strive to portray universal themes that appeal to a wide audience, however, these narratives must be balanced with local and specific perspectives. Nevertheless, this can become problematic, because it requires acknowledging the diversity of experiences actually available and challenging dominant cultural assumptions.

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Museums also strive to improve visitor engagement and experiences by utilizing interactive displays, immersive technologies, and participatory activities. However, as museums embrace digital technology for display and participation, issues of equity for all audiences arise. The digital divide, poor internet access, and the exclusion of particular populations from technical advances can all be hurdles to fair participation.

All in all, addressing contentious issues or engaging with difficult narratives can be hard for museums, when combining the complex tasks of managing political sensitivities, dealing with public impressions, and promoting critical discourse. These issues require continual debate and collaboration, careful planning, as well as a commitment to diversity, sensitivity, and transparency. To ensure responsible and ethical display politics, museum professionals must constantly analyse and reassess their methods, involve key stakeholders, and remain open to new, emergent and evolving perspectives.

4. Museums as experience and educational sites.

Nowadays, museums are not just places where visitors look at exhibits and artefacts; they have become a comprehensive experience. Visitors' experiences have changed due to the various emerging technologies (such as Augmented Reality, Mixed Reality, Virtual Reality, and Artificial Intelligence[11]) used for creating more interactive and immersive environments in the space of the museum. A well-designed museum experience can leave a lasting impression on visitors, inspiring curiosity, and learning.

In fact, museums are adopting a public-oriented mission, which helps them, and their collections become more accessible and engaging for the public. The use of multimedia and interactive features, such as virtual reality, plays a significant role in this new orientation (Aalst & Boogaarts, 2002; Zukin, 1995). Emerging technologies have become more and more relevant and advantageous, because they offer the opportunity to enhance not only the multiple perspectives of exhibitions but also the engagement of communities. Especially after the Covid-19 pandemic, museums have increasingly embraced the virtual realm through online collections, virtual tours; exhibitions, educational resources, live events, and webinars; social media, and online engagement.

Additionally, emerging technologies also offer visibility to historically marginalized or under-represented groups, namely indigenous people. This is a way of compensating for the fact that tangible artefacts concerning indigenous people or marginalized cultures are often excluded from museum collections. This exclusion may happen because many of these artefacts need to be under climate-controlled conditions and maintained to prevent damage, as they date back to colonial times. However, exclusion can also happen because of

[11] AR or Augmented Reality, in computer programming, is a process of combining or "augmenting" video or photographic displays by overlaying the images with useful computer-generated data (Hosch, 2023). MR or Mixed Reality is an emergent technology that blends virtual reality and augmented reality (Adobe, nd). VR or Virtual reality uses computer modeling and simulation to enable a person to interact with an artificial three-dimensional (3-D) visual or other sensory environment (Adobe, nd). AI or Artificial Intelligence is the ability of a digital computer or computer-controlled robot to perform tasks commonly associated with intelligent beings (Copeland, 2023).

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the current debate around the claim that museums should return tangible artefacts to their original countries (Griffin & Paroissien, 2011). As Nidhi Ponkshe (2022) states, “Artefacts harbored by museums should be repatriated as a means for restorative justice.” In this context, digital restitution becomes an option to preclude the possibility of physical return of the artefacts.

Many museums have been using digital storytelling by incorporating narratives, plot points, and characters, in digital presentations. For instance, the National Museum of Australia in Canberra, in 2022, organized an immersive experience entitled *Connection: Songlines from Australia’s First Peoples*, which brings to life the stories, art and culture of Australia’s First Peoples, using multi-sensory projections and dynamic immersion (Streak, 2022).

These types of immersive experiences include a wide range of topics related to local identities, such as the history of specific communities and the contributions of local people to a region. In this way, they reinforce the role of museums as supporting structures of local cultures and their respective narratives. At the same time, museums reinforce their engagement with community members, particularly those from historically marginalized or underrepresented groups, and encourage creativity, cultural diversity, acceptance, and citizen participation. This allows communities to increase the visibility of their cultural identity, both at the national and international levels (Anico & Peralta, 2007).

The role of museum staff, including experts and educators, whose responsibility is to produce, save and share knowledge, is also critical for the overall museum experience. Friendly and knowledgeable staff can help visitors navigate the museum and provide context and information about the exhibits. Educational programs – such as guided tours, workshops, and lectures – can also enrich the museum experience and provide opportunities for deeper learning and engagement. The human element is fundamental to understanding the whole museum experience, both in terms of the staff working within the institution and the public for whom the museum is envisioned.

Likewise, museums have always been important sites of education, in the sense that they provide opportunities for lifelong learning and discovery, well beyond the traditional classroom setting (Robbins et al., 2021). In this regard, the educational function of museums has evolved significantly over the past few decades, transitioning from a primarily passive role of artifact display to a more active and dynamic role as centres of learning, engagement, and community involvement (Desvallées & Mairesse, 2010). Museums can offer a unique learning experience, as they allow visitors to engage with real artefacts and exhibits that illustrate significant concepts, ideas, and themes. They play a pivotal role in promoting equity and inclusion in education and contribute to the preservation of local narratives by working with local schools, communities, and educational institutions.

By providing access to exhibits and programs that reflect diverse perspectives, different experiences, intercultural representations, cross-cultural comparisons, dialogue, and discussion, as well as understanding of cultural sensibilities, museums contribute to emphasizing the common experience that connects humanity. This fundamental role ensures that local narratives are included in educational curricula and that students have the

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opportunity to learn about and engage with the history, culture and identity of their community.

5. Common identities and cultural territories

As we debate the concept of a museum, we should also look at the complex concept of identity, which is something multi-dimensional, never fixed and always shifting. As a first approach, identity refers to the specific characteristics that distinguish individuals and groups and construct their sense of self and belonging. According to the social identity perspective, people derive their sense of identity from the social group with which they identify, including family, ethnicity, religion, nationality, and profession, among others. The personal identity perspective focuses on the construction of self through experiences, memories, and beliefs, also promoting a sense of uniqueness and distinction among others. The interplay between social and personal identity perspectives provides an insight into the complex ways that shape human experience.

According to Raymond Williams (1989), common identities are a set of shared beliefs, values, and practices that individuals use to define themselves and particular groups. Common identities refer to a community of people who view each other as members of a common social group, often defined by cultural, national, or regional affiliations. Again, common identities are also a dynamic and fluid concept that changes over time, as the individual and the collective sense of self encounter new experiences and challenges. Conflict, migrations, and globalization are some of those challenges, which affect the construction and preservation of common identities. Conflict leads to the destruction of structural sites, artefacts and documents, to the displacement of communities, and to dramatic changes in their way of living. Migrations may also pose difficult challenges, as the contact with other cultures and the weight of the dominant cultural identity may lead to tensions, misunderstandings, oppression, and cultural deletion, while affecting the whole process of intercultural coexistence. However, forcefully displaced communities often maintain strong cultural, ethnic, or national identities, even as they adapt to their new environments. Last but not the least, globalization has a significant impact on common identities by both shaping and challenging them.

Globalization can lead to the spread of global consumer culture, where multinational corporations promote products, lifestyles, and values that transcend national and cultural boundaries. This can result in the homogenization of cultures, as people around the world start adopting similar consumer habits, fashion trends, and cultural references. As a result, common cultural identities may become more similar across the globe. While globalization can promote cultural homogenization, it can also lead to cultural hybridization or syncretism. As different cultures come into contact through globalization, they can blend and influence each other, leading to the creation of new, hybrid cultural identities. Likewise, globalization has enabled the emergence of transnational identities that transcend traditional national boundaries. People can now identify with global communities based on shared interests, values, or lifestyles rather than solely with their nationality or ethnicity. On the flip side, globalization can also fuel identity conflicts. As people are exposed to different cultural and

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ideological perspectives, they may become more aware of their own cultural or national identity. This can lead to a resurgence of local or national identity in response to perceived threats from globalization. Identity-based conflicts can arise when groups feel their identity is being eroded or marginalized by global forces. In summary, globalization affects common identities in complex ways. It can lead to both convergence and divergence of identities, as well as to the emergence of new, hybrid forms of identity.

In the face of all these conditions, museums must work on the preservation and protection of common identities, by promoting the dialogue between different groups and implementing the recollection and safeguarding of cultural heritage. The revitalization of traditional cultural practices, the promotion of local cultures and identities, the support to new cultural forms and practices, as well as the exercise of intercultural learning and dialogue are ways to respond to the challenges of the contemporary world. In order to achieve this goal, museums should also include a greater recognition of the diversity of cultural identities, increase their collaboration with other cultural institutions, use new technologies, and recognize their own role in the promotion of social justice, namely by encouraging diversity and inclusion and by providing safe spaces where marginalized communities have a voice.

Common identities also play an important role in the construction of cultural territories. According to Jaime Urrutia (2009), “the territory is the primary basis of any cultural identity”. Perafán and Oliveira (2013) state that the identity of a specific territory is an element of the territory’s character. The territory represents the set of referential and symbolic elements, such as traditions and customs, that build the identity of a community and, consequently, of a certain cultural territory. Thus, though initially the idea of territory is linked to a geographic space, from the cultural point of view, it is a demarcated area that is related to a particular cultural identity.

Cultural territories are not necessarily defined by physical boundaries but by the presence and influence of a specific culture. For example, the sea and fishing communities represent specific cultural territories in Portugal and other European countries, where the necessities and opportunities offered by the sea transform the concept of group and individual identity. More specifically, factors that impact on the formation of cultural territories include, among others, geography, language, religion, and history. Geographical factors are the physical landscape and the environment that contextualize the community and shape their cultural identity and practices. For the aforementioned fishing communities, the necessity of using the sea has developed cultural practices related to transportation (such as boat construction, repair and maintenance), to product selling and transformation. Communities that developed, by use, a linguistic heritage, also create a specific sense of belonging and practice traditions that express particular ways of life. A common language serves as a foundational element in constructing cultural territories by facilitating communication, shaping identity, transmitting cultural knowledge, and fostering social cohesion. As far as religion is concerned, common beliefs, a shared faith, and the respective practices promote a sense of connection between members of a specific cultural territory. Such practices may include traditional prayers, artworks, pilgrimages, and processions, among other religious expressions. Finally, historical events, interactions, and migrations that took place over time also contribute to the development and shaping of cultural territories. Portuguese fishing

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communities, for example, are identified by their regular waves of migration, which play a significant role in the construction of cultural territories. Migrant communities tend to maintain a strong bond with their 'home' cultural territory and are eager advocates of the culture from which they descend.

The edification of cultural territories fosters the sense of belonging among a specific community, because the promotion of a shared cultural space offers individuals the opportunity to celebrate their heritage, encourage new experiences and perspectives, and build a network that provides support and a sense of legitimacy. Communities within cultural territories are often bound by a sense of belonging and mutual understanding. As a shared belief, common identities may also be a source of resilience and resistance for cultural communities, as they face external pressures and challenges together, sustained by their group security. This sense of 'belonging' helps to mobilize cultural communities for the protection of their traditions and identity. Therefore, when associated with the concept of cultural territories, common identities may provide a sense of belonging, coherence, and continuity, all characteristics that are strengthened by common traditions and practices which, in turn, encourage cooperation and collaboration.

We may here refer to several historical and contemporary examples of cultural territories defined by common identities and shared cultural practices. Both Cyprus, Greece and Portugal have long maritime borders, which led to the development of traditional fishing communities that created their own cultural territories.

Taking the example of the traditional fishing communities in Portugal, like Nazaré, Peniche or Afurada (Vila Nova de Gaia), among others, they have developed a distinctive language, terminology, cuisine, and architecture, as well as specific forms of religious devotion, social organization, and artistic expression. The profound connection of these communities with the sea and the natural resources it provides has shaped their cultural traditions and practices over time, which is evident in their fishing techniques, boat-building methods, and religious celebrations.

In Greece, fishing is also an extremely important activity in the creation of cultural territories with their own narratives and identities. In many areas along the Mediterranean, like Keri Lake, a small fishing town on the southwest side of the isle of Zakynthos, traditional fishing activities have survived across generations and small-scale fishermen still play a significant social role in the community. As Kira Coley (n.d.) states, practices, and techniques such as "the manufacture of the tool, the identification of the shells' marks on the seabed, the movement of the fisher's wrist at the moment of capture" have become fundamental elements of the intangible cultural heritage on the coasts of Greece.

Likewise, Cyprus also possesses a significant maritime tradition. Islanders have taken advantage of the surrounding sea for trade and commerce with neighbour countries. But the numerous settlements linked to traditional shipbuilding and fishing activities have also contributed to shaping local cultural identities, with their narratives, practices and artefacts. The Cypriot craft of shipbuilding has been known across the Mediterranean for centuries; however, as the population grows older and globalization impacts traditional activities in general, there is a fear that such crafts may lose their true essence. Bearing this possibility in

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mind, projects like the Intangible Maritime Cultural Heritage Project have been trying to "preserve the different crafts related to the fishing industry, such as sail making, sponge diving, and shipbuilding" concerning, in this specific case, the fishing communities in the region of Paphos (Interreg Europe, 2019).

Under the threats of a competitive globalized economy, maritime communities like the ones above face serious challenges in the preservation of their cultural heritage, forms of subsistence and identities. Nevertheless, they are fundamental for the understanding of Portuguese, Greek and Cypriot culture, and offer a comprehensive insight into how cultural territories and local identities are constructed and narrated.

6. The role of museums in the narrative of (common) local and European identities

Museums are fundamental for understanding the particularities of common identities and cultural territories, as they preserve and display artefacts that function as representations and expressions of specific communities. Fostering local common narratives in museums is essential for preserving and celebrating the unique histories, cultures and identities of specific communities and cultural territories. Therefore, local narratives enrich the museum experience and educational role, while connecting visitors with the heritage of a particular cultural territory, namely through:

a) **Community involvement:** engage with local communities to co-create exhibits and programs. Invite community members to share their stories, artefacts, and expertise. This collaborative approach ensures that local narratives are accurately represented.
b) **Oral history projects:** conduct oral history interviews with local residents, elders, and community members to collect personal stories and firsthand accounts. These oral histories can be incorporated into exhibits or made accessible through audio recordings.
c) **Local artist collaborations:** partner with local artists, artisans, and craftspeople to showcase their work and connection to the territory's culture and history. Art exhibitions, workshops, and installations can help convey local narratives.
d) **Exhibit flexibility:** design flexible exhibit spaces that allow for rotating displays and temporary exhibits. This flexibility enables museums to highlight different aspects of local narratives and respond to community interests and events.
e) **Multilingual interpretation:** provide interpretive materials in the languages spoken by the local community, ensuring accessibility to a broader audience and honouring linguistic diversity.
f) **Interactive exhibits**: create interactive exhibits that encourage visitors to engage with and explore local narratives. Hands-on activities, touchscreens, and multimedia displays can make the learning experience more immersive and enjoyable.
g) **Local collections:** build and maintain collections of artefacts, photographs, documents, and memorabilia related to the territory's history and culture. Regularly curate and update these collections to reflect the evolving narrative.

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h) **Educational programs:** offer educational programs, workshops, and guided tours that delve into local history, traditions, and customs. These programs can cater to schools, families, and adults interested in learning about the area.

i) **Local partnerships:** collaborate with local schools, universities, libraries, historical societies, and cultural organizations to access expertise, resources, and potential guest-speakers for events and exhibits.

j) **Local heritage festivals:** host or participate in local heritage festivals or cultural events. These events can serve as platforms to showcase local narratives through music, dance, food, and storytelling, among endless other possibilities.

k) **Digital initiatives:** use digital technology to create online exhibits, virtual tours, and multimedia resources that extend the reach of local narratives beyond the physical museum space.

l) **Visitor feedback:** encourage visitor feedback and contributions. Create opportunities for visitors to share their own stories and connections to local narratives, fostering a sense of community engagement.

m) **Interpretive signage:** develop clear and engaging interpretive signage that provides context and background information for exhibits, helping visitors understand the significance of local narratives.

n) **Archival and research facilities:** establish on-site research facilities and archives that allow scholars, researchers, and community members to access and contribute to the documentation of local history.

Fostering local narratives in museums requires a commitment to inclusivity, community engagement, and ongoing dialogue. By valuing and preserving the unique stories and cultural heritage of a region, museums can strengthen their connections with local communities and enrich the visitor experience.

Likewise, while playing a crucial role in shaping and promoting local common identities, museums can also contribute significantly to building a common European identity. Europe is a diverse continent with rich histories, languages, and cultures, but there are several ways museums can foster a sense of shared European identity:

a) **Promote cultural exchange:** museums can facilitate cultural exchange by hosting exhibitions, events, and collaborations with institutions from different European countries. This can help people from various backgrounds learn about and appreciate the diversity of European culture, as well as shared values and stories.

b) **European history exhibitions:** create exhibitions that focus on key historical events and figures that have had a significant impact on the development of Europe as a whole. Highlight common historical threads and connections between different European regions.

c) **Multilingual interpretation:** provide information in multiple languages, including the official languages of the European Union, to make exhibits more accessible to visitors from various linguistic backgrounds.

d) **Collaborative projects:** museums can collaborate on joint projects that explore shared themes or issues, such as migrations, wars, revolutions, or technological advancements, which have affected multiple European countries in similar or diverse ways.

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e) **Digital initiatives:** leverage digital technology to make museum collections and exhibits accessible to a broader European audience, as well as potentially connect different museums across Europe for exhibitions on similar themes. Virtual tours, online exhibits, and interactive educational resources can help bridge geographical and language barriers.

f) **Educational programs:** develop educational programs and workshops that promote European cultural literacy. These programs can target students, teachers, the community, and the general public.

g) **Storytelling and narratives:** use storytelling techniques to connect visitors emotionally to European history and culture. Personal narratives, oral histories, and interactive exhibits can be powerful tools in this regard.

h) **Cross-border exhibitions:** organize exhibitions that travel across European countries, showcasing the common heritage and shared experiences of the continent. These exhibitions can help foster a sense of unity.

i) **Inclusivity and diversity:** ensure that museum staff, collections, and exhibits are inclusive and diverse, representing the full range of European identities. This can help visitors from different backgrounds feel represented and included.

j) **Public engagement**: engage the public in discussions about what it means to be European. Museums can host forums, debates, and dialogues on topics related to European identity and culture.

k) **Collaborate with European institutions:** work closely with European Union institutions, cultural organizations, and initiatives, such as the European Year of Cultural Heritage, to align efforts and promote a shared European identity.

l) **Promote peace and unity:** highlight the role of museums in preserving and commemorating the peace-building efforts in Europe, particularly in the aftermath of World War II. Museums can emphasize the importance of unity and cooperation among European nations.

Building a common European identity through museums is a complex and ongoing process that requires collaboration, inclusivity, and a commitment to highlighting both the shared and diverse aspects of European culture and history. By implementing these strategies, museums can contribute to fostering a sense of European identity among their visitors.

7. Conclusion.

Museums are powerful agents in the promotion of cultural exchange by presenting cultural traditions and interpreting them according to different cultural groups. As discussed above, they provide educational experiences to the public by fostering learning, debate, and interaction with both artefacts and artists. As a result, museums can engage with local communities, acknowledging the importance of their cultural practices and belief systems. Besides, museums promote the cultural heritage of communities, providing those with new experiences and learning opportunities, and even instilling a sense of pride, cultural ownership, and agency, while highlighting the preservation and promotion of common local identities.

The selection of artefacts is an emblematic representation of the construction of common identities. For example, the display of selected artworks and artefacts, specifically associated

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with a particular group or cultural territory, stresses their distinctive identity, again strengthening the connection between territory, community, and identity. Artefacts of cultural, historical, or scientific significance – carefully curated and displayed in order to tell relevant stories – play a crucial role in the creation of local narratives. Such artefacts often reflect and contribute towards creating a societal and cultural context within a particular local identity (Robbins et al., 2021).

By collecting and displaying artefacts that represent the shared cultural heritage of communities in a particular region, museums foster a sense of belonging and pride among people. Museums contribute to intercultural understanding and dialogue by presenting multiple perspectives and narratives, or by engaging in collaborative projects with other museums, cultural institutions, and communities. The term "community" itself reflects a strategy of inclusion and relevance that can be developed by museums, in their attempt to tackle emerging social concerns, fight exclusion, and promote development (Crooke, 2006). The construction of a common narrative is extremely important for the creation of a cohesive and meaningful relationship between communities and museums. By preserving and sharing local narratives and reflecting on the unique cultural heritage of a particular group or region, museums become important places of "intercultural encounters, open dialogue, and empowerment for local identities" (OECD & ICOM, 2019).

The experience of the museum has been changing and, now more than ever, it values immersive, subjective, educational, and interactive perceptions, highlighting cultural territories and common European identities (Wu, 2019). The use of virtual reality in museums complements the institution's physical extension and renovation, allowing new ways to represent and display artefacts. Thus, now, it is possible to view an object – or rather an image of it – by using virtual tools, in ways that might not be possible in the museum itself. However, it is important to state that, although virtual experiences cannot fully replicate the physical experience of visiting a museum, they offer unique opportunities to engage with audiences beyond geographical constraints, extend accessibility to diverse populations, and serve as valuable resources for remote learning and research. By embracing the virtual realm, museums can continue to fulfil their educational mission and connect with audiences in new and innovative ways, thus, reflecting the diverse perspectives and experiences of the communities they serve.

Indeed, we can state that the experience of the museum has evolved a great deal over the years because museums are themselves constantly evolving structures (Desvallées & Mairesse, 2010). The role of museums must take into account the social and technological transformations, the historical inequalities, the policies and shifting balances of power that characterize the globalized world we currently live in, so that they can continue to adapt and thrive in the dynamic cultural sector.

The contribution of museums to the construction and maintenance of cultural memory and heritage provides the opportunity to further develop distinct interpretations about communities, multiplying perspectives and constructing alternative narratives. This ensures that the representation of cultural identities is accurate and beneficial for the community they seek to represent. In this way, museums become primordial spaces for dialogue,

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cross-cultural understanding, and exchange of traditions and practices, while promoting acceptance and appreciation of diverse cultural territories.

Overall, museums play a fundamental role in preserving and sharing common narratives and identities, helping to connect community members both to their cultural heritage and to their common European identity. This mission must be achieved by always bearing in mind the understanding and appreciation of the diversity of perspectives and experiences that make up local and global communities alike. As a two-way street, museums may build a safe and thriving space for interaction and sharing, which again reinforces the bond between people, culture, identity, and narrative.

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CHAPTER 5. Inclusion through Multimodality and AR

Chapter in a nutshell

This chapter describes the perspective that the SciArt project adopts concerning Inclusive Education and explains the UDL framework and Guidelines that teachers can use to form more inclusive learning environments. Additionally, the chapter introduces multimodality and augmented reality as an example of multimodal technology and discusses their role in supporting the inclusion of all students in teaching and learning. Finally, the Storyjumper and ARTuror platforms are briefly presented as they will be used in various project activities.

1. Inclusion of all students: The Why, What, and How of learning

1.1 Inclusive education

During the last two decades, there has been an increasing focus by international organisations and scholars on the need to develop and foster more inclusive practices in education (U.N., 2006). Acknowledging the importance of the UN Convention on the Rights of Persons with Disabilities, inclusive education is now recognized as going beyond disability to serve a wider objective in contemporary and future education.

The United Nations (UN) 2030 Agenda for Sustainable Development (U.N., 2005) is a universal call for action for "Quality Education" (SDG 4) and for reducing inequalities (SDG 10), issues that are extremely related to inclusive education. SDG 4 aims to achieve a number of objectives, including free, equitable, and high-quality primary and secondary education, the eradication of gender inequities in education, and ensuring that all disadvantaged groups, including people with disabilities, indigenous peoples, and children in situations of vulnerability, have equal access to all levels of education and vocational training. SDG 10 strives to empower all people and encourage people to participate in society, the economy, and politics, regardless of their age, gender, disability, race, ethnicity, origin, religion, economic or other position. Through that broad perspective, the European Agency describes that inclusive education aims to provide "high quality education in mainstream schools that effectively meet the academic and social learning needs of all the learners from the school's local community" (European Agency for Special Needs and Inclusive Education, 2015, p.2).

Based on this wider understanding of inclusion and inclusive pedagogy and education, within the SciArt approach, deficit conceptions of diversity and ability are rejected, and involvement in the learning process enriches the experience of every student in the classroom community (Florian & Linklater, 2010; Kozleski et al., 2014). In the context of the SciArt approach, inclusive pedagogy is defined as "an alternative pedagogical approach that has the potential to reduce educational inequality by enhancing learning opportunities for everyone" (Florian, 2015, p.5).

Based on this perspective, one of the priorities of the SciArt approach is to foster the inclusion of all students in the project by giving meaningful opportunities to all students to

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engage, participate and express themselves. To achieve that goal, all the materials and the activities designed as part of the project will be developed based on a framework that ensures the project's outcomes are accessible to all students. For that purpose, the SciArt approach is aligned with the Universal Design for Learning (UDL), a framework for improving and optimising teaching and learning for all people (Center for Applied Special Technology (CAST), 2018).

1.2 Universal Design for Learning

The concept of differentiation emerged as a response to increasing calls to address students' diverse needs (Blamires, 1999): "In a differentiated classroom, the teacher proactively plans and carries out varied approaches to content, process, and product in anticipation of and response to student differences in readiness, interest, and learning needs" (Tomlinson, 2001, p.7). That idea turned pedagogical thinking from teaching for the majority of students, to one that engages and provides opportunities for active and meaningful participation for all (Florian & Linklater, 2010). Despite the fact that differentiation is extensively defined and elaborated in the literature, in practice, some teachers believe that it is referring to a "recipe" model for special education, with "special practices" for "special needs' learners" (Mavrou & Symeonidou, 2014).

UDL, which stands for Universal Design for Learning, is in turn, an approach to the design and development of curricula that can help teachers plan and carry out differentiated instruction that is not simply for "special needs learners. UDL was originally based on a social model perspective of disability (see additional material below) and diversity (Barnes, et al., 1999), and it represents a movement toward how educators look at learners' differences (Meo, 2008) and into methods in which the curriculum can include all learners. Thus, UDL is a process in which a curriculum (goals, techniques, resources, and assessment) is consciously and systematically developed from the outset to meet individual differences (CAST, 2018). In place of the standard one-size-fits-all approach, UDL gives an outline for establishing instructional goals, methods, resources, and evaluations using approaches that may be customized to meet learners' particular needs (discussed in the following sections).

1.3 Principles of Universal Design for Learning

UDL is based on three principles: a) providing multiple means of engagement, b) providing multiple means of representation, and c) providing multiple means of action and expression. Each of these guiding principles has the potential to be implemented by considering "concrete suggestions that can be applied to any discipline or domain" (cast.org), which are the building blocks of the UDL Guidelines. Working with the UDL Guidelines could assist teachers in developing activities that provide students with relevant and challenging learning opportunities. In what follows, each of the principles will be briefly described (along with concrete suggestions for each principle) and links to additional resources, based on the description of the Centre for Applied Special Technology or CAST (https://udlguidelines.cast.org/).

Principle I: Providing Multiple Means of Engagement

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A singular mode of engagement cannot be deemed as the most effective for all learners across all settings. It is imperative to offer a variety of engagement alternatives. This is particularly supported by theories of affect which relate to how students get engaged with learning and remain motivated. The role of affect in the learning process is of paramount importance, and there exist significant variations among learners regarding their ability to be engaged or motivated to learn. Individual differences in affect can be attributed to various sources such as neurology, culture, personal relevance, subjectivity, background knowledge, and other related factors. There exists a variation in the level of engagement among learners with respect to spontaneity and novelty, as some individuals exhibit high levels of engagement while others display disengagement or even fear towards these aspects. The latter group tends to prefer a structured routine. Specific individuals may prefer independent work, whereas others may be inclined towards collaborative work with their peers. The table below shows how the first principle of UDL is translated into concrete suggestions for instructors to recruit students' interest, sustain their effort and persistence, and promote self-regulation.

Multiple Means of Engagement
Recruiting Interest *Spark excitement and curiosity for learning.* • Optimize individual choice and autonomy • Optimize relevance, value, and authenticity • Minimize threats and distractions
Sustaining Effort & Persistence *Tackle challenges with focus and determination.* • Heighten salience of goals and objectives • Vary demands and resources to optimize challenge • Foster collaboration and community • Increase mastery-oriented feedback
Self Regulation *Harness the power of emotions and motivation in learning.* • Promote expectations and beliefs that optimize motivation • Facilitate personal coping skills and strategies • Develop self-assessment and reflection

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Principle II: Provide Multiple Means of Representations

The second principle is connected with how students collect facts and categorize them. There are variations in individuals' cognitive processes when it comes to perceiving and comprehending information presented to them. Individuals with sensory disabilities such as blindness or deafness, learning disabilities such as dyslexia, and those with language or cultural differences may all approach content in different ways. Some, for instance, may have a higher aptitude for comprehending information through visual or auditory modalities rather than written text. The utilization, thus, of multiple representations facilitates learning and transference of learning by enabling students to establish connections within and between concepts. In summary, it is imperative to offer multiple means of representation as there is no single mode of representation that can be optimal for the learning needs of all individuals. The table below shows concrete suggestions that a teacher can embed in instruction to overcome possible obstacles of students concerning representations.

Multiple Means of Representations
Perception *Interact with flexible content that doesn't depend on a single sense like sight, hearing, movement, or touch.* • Offer ways of customizing the display of information • Offer alternatives for auditory information • Offer alternatives for visual information
Language & Symbols *Communicate through languages that create a shared understanding.* • Clarify vocabulary and symbols • Clarify syntax and structure • Support decoding of text, mathematical notation, and symbols • Promote understanding across languages • Illustrate through multiple media

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Comprehension
Construct meaning and generate new understandings.

- Activate or supply background knowledge
- Highlight patterns, critical features, big ideas, and relationships
- Guide information processing and visualization
- Maximize transfer and generalization

Principle III: Provide Multiple Means of Action and Expression

The third principle is connected with processes of planning and performing tasks during learning. Different individuals might navigate learning environments and articulate acquired knowledge in diverse ways. For instance, diverse groups of learners, such as those with language and cultural barriers, those with movement impairments (e.g., cerebral palsy) and those who struggle with strategic and organizational abilities, exhibit distinct approaches to learning tasks. Individuals might have the ability to effectively articulate their thoughts and ideas through written communication, yet struggle to do so through verbal means. Conversely, some individuals may excel at verbal communication but experience difficulty expressing themselves through written text. It is imperative to acknowledge that action and expression require a significant amount of planning, rehearsal, and coordination, thereby constituting yet another domain in which learners may exhibit diversity. In reality, a singular approach to action and expression cannot be deemed as optimal for all learners. Hence, it is essential that educators provide alternatives for action and expression. In the table that follows concrete suggestions for educators that could help them to provide students with multiple means for action and expression are presented.

Multiple Means of Action and Expression
Physical Action *Interact with accessible materials and tools.* • Vary the methods for response and navigation • Optimize access to tools and assistive technologies

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Expression & Communication
Compose and share ideas using tools that help attain learning goals.

- Use multiple media for communication
- Use multiple tools for construction and composition
- Build fluencies with graduated levels of support for practice and performance

Executive Functions
Develop and act on plans to make the most out of learning.

- Guide appropriate goal-setting
- Support planning and strategy development
- Facilitate managing information and resources
- Enhance capacity for monitoring progress

In order to offer more concrete examples of the utilization of UDL guidelines in teaching and learning, some case studies in which the UDL framework is utilised to foster the inclusion of all students in different classroom settings are presented in the section **Additional Material** at the end of this chapter.

2. The role of Multimodality and Augmented Reality

2.1 Multimodality and Augmented Reality

In recent years the concept of multimodality is widely used in communication studies as well as in education, to highlight the diverse ways that people use for creating, representing, distributing and communicating meanings (Bezemer & Jewitt, 2010).

> *Multimodality questions that a strict 'division of labour' among the disciplines traditionally focused on meaning making, on the grounds that in the world we're trying to account for, different means of meaning making are not separated but almost always appear together: image with writing, speech with gesture, math symbolism with writing and so forth. It is that recognition of the need for studying how different kinds of meaning making are combined into an integrated, multimodal whole that scholars attempted to highlight when they started using the term 'multimodality' (Jewitt et al., 2016, p. 2)*

In the SciArt project modes such as linguistic, visual, audio, spatial and gestural refer to culturally and socially formulated meaning-making resources (Kress, 2014). It is also worth noting the difference between modes and media. While modes refer to the way of creating and communicating meanings (e.g., linguistic or visual), media refers to the resources that are used to communicate the meaning (e.g., book or computer). The examples of book and

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computer as different media highlight not only the material character of the medium but also the evolution of the media with regards to technological advancements (Bezemer & Kress, 2008),

In order to meet the aim of forming more inclusive environments, educators create educational settings that offer to both them and students different ways of meaning making and communication

In general, in modern learning settings, multimodality seems to be directly connected with various uses of emerging technology including (but not limited to) augmented reality.

Augmented reality (AR) is a technology that allows the overlay or projection of visual objects into the physical world of the user (Garzón, 2021). There is an increasing interest by scholars and educators about the use of augmented reality for educational purposes because it seems to increase students' involvement, engagement and focus, understand abstract concepts better, simulate rare situations and promote pro-active learning (Akçayır & Akçayır, 2017; Boyles, 2017). Also, AR seems to offer solutions and improve the access of students to content by eliminating potential barriers (Velázquez & Méndez, 2018).

2.2 Supporting inclusion through multimodality and augmented reality technologies

In the context of Universal Design for Learning, teachers are encouraged to offer multiple means of engagement, representations, action and expression and hence multimodality emerges as an important concept. Augmented reality technologies can offer new means to teachers in order to support all three principles of UDL, not only by offering multiple representations of what they want to communicate to students but by also giving students' various opportunities to express their ideas through different modes and media, , and by engaging them in a more authentic and immersed learning situations (Stylianidou et al, 2020) to enhance their engagement and motivation (see also Helping Nemo! in **Additional Material**).

Based on the above, augmented reality technologies will be used for the development of the Sci-Art multimodal activities and resources to foster engagement and participation, as well as support the communication of abstract ideas and phenomena relating to the arts, sciences and heritage. In parallel, students will have the opportunity to use multimodal means, including augmented reality to express their ideas and opinions (e.g., findings, conclusions, reflections) through multimodal and/or augmented reality books by using two user-friendly educational platforms: a) Story-Jumper and b) ARTutor.

3. Tools for teachers and educators

In the SciArt project, training material for educators will be developed for Storyjumper and ARTutor 4 platform. Teachers will be trained to use both platforms with their students and they will be expected to use both tools during the development of the teaching material and its implementation in schools at the later stages of the project.

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AR Tutor 4 will be used by the project's partners to develop the Augmented Laboratory Instruments that will help students in their study of artefacts selected from the three partner museums (A.G. Leventis Gallery in Cyprus, Museum of Byzantine Culture of Thessaloniki in Greece and Museu Municipal Esposende in Portugal) Teachers and students will use both of these two tools (AR Tutor and Storyjumper) to create multimodal and/or augmented books for the purposes of presenting their study of the artefacts and related narratives produced during the implementation phase of the project. In what follows, a short description of the platforms and their capabilities is presented.

3.1 Storyjumper

StoryJumper is an enhanced reading or storytelling platform that enables the creation of enhanced books, with images, music and recorded sound and voice. The user-friendly interface can allow teachers not only to create a form of enhanced reading, but also to involve students in the creation of a book.

3.2 ARTutor 4

ARTutor 4 is an augmented reality platform created for educational use only by the AETMA Lab (International Hellenic University). According to its creators, ARTutor platform was created to offer educators the ability to create their own augmented materials completely free of charge, free of features unrelated to educational use, in a user-friendly environment. At the same time, it allows for the integration of new features that are useful in the educational context. AR Tutor enables the user to augment his/her material with images, video, sound and 3D objects.

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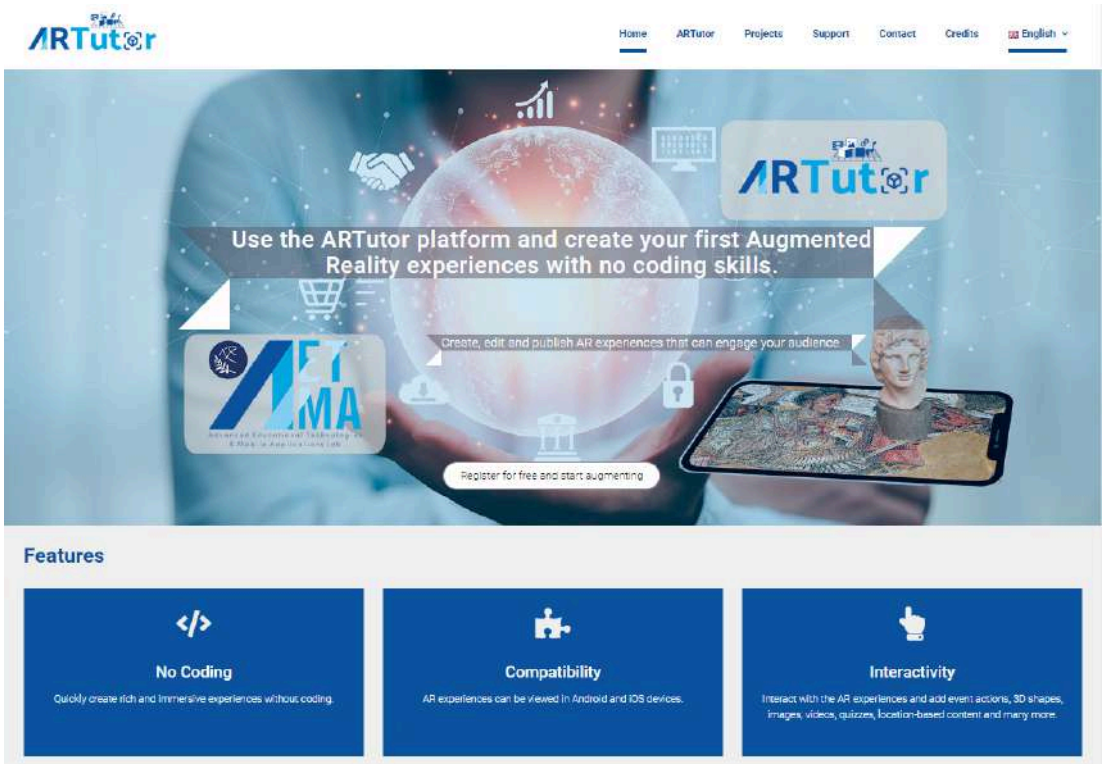

Like other augmented reality platforms, AR Tutor has an online platform (authoring tool) for the development of the material and an application for mobile devices (Android and IOS) for using the augmented material (reading the images that initiate the augmentations and overlay the visual objects to the physical worlds). Both the platform and the application have the name ARTutor.

4. Summary

This chapter introduces readers to inclusive education and discusses how the SciArt project perceives it, as a mindset that allows scholars and practitioners to provide learning opportunities for everyone. It is also explained, both theoretically and with concrete suggestions through the UDL guidelines, how multimodality and in particular augmented reality technologies could be used to help teachers form more accessible and inclusive learning environments for all students by offering them multiple means of engagement, multiple means of representations and multiple means of action and expression. At the end of the chapter, two specific tools that will be used in the project are briefly presented.

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Additional Material

- About UDL
- The UDL Guidelines
- "Helping Nemo!"—Using Augmented Reality and Alternate Reality Games in the Context of Universal Design for Learning
- Improved Lesson Planning With Universal Design for Learning (UDL)
- Codesigning learning environments guided by the framework of Universal Design for Learning: a case study
- Social Model of Disability
- ARTutor
- StoryJumper

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