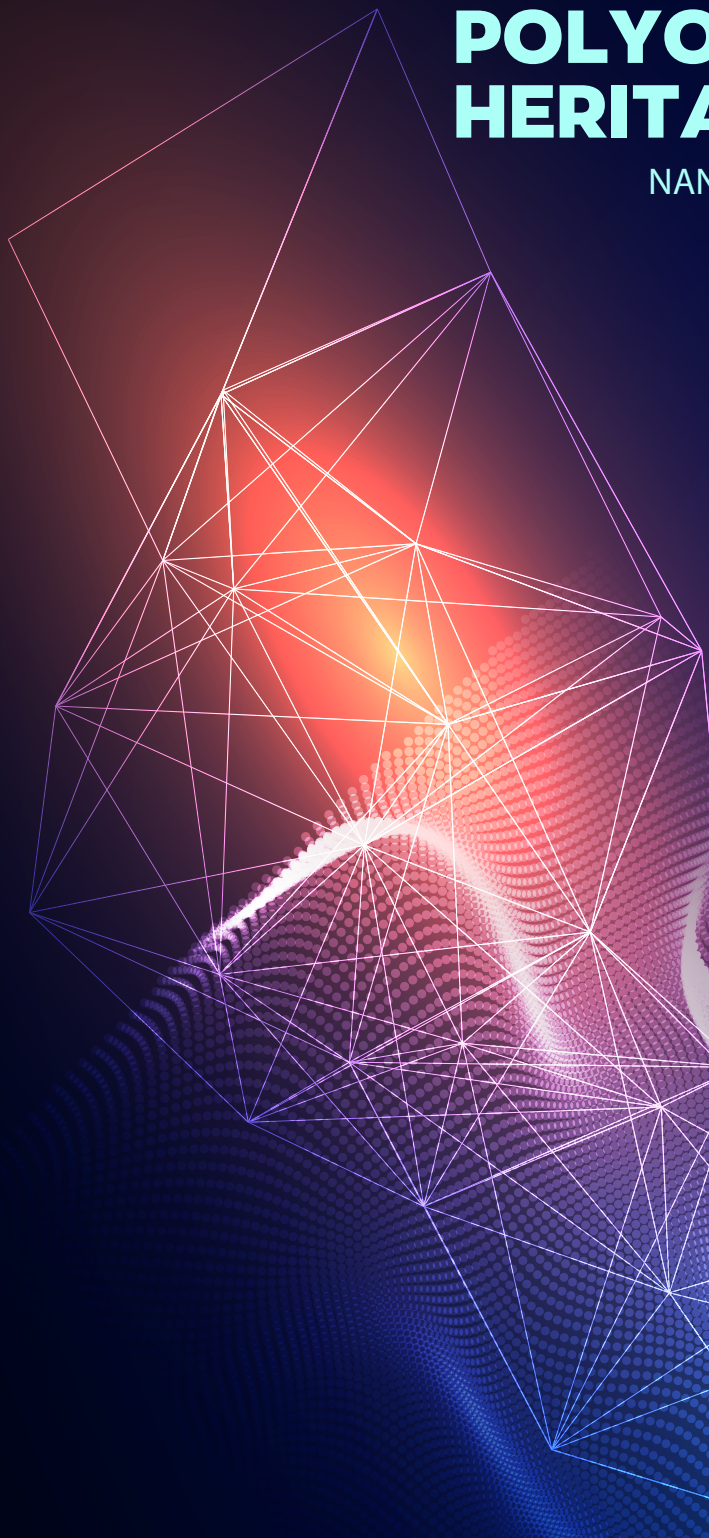
POLYOXOMETALATES FOR HERITAGE CONSERVATION

NANOSCIENCE SCENIC ARTS MANUAL

TEACHER'S WORKBOOK



UREK Art

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EUREKArt

Nanomaterials for Heritage Conservation

IN THIS WORKBOOK:

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EUREKArt

EXPLORING NANOSCIENCE

EurekArt is an innovative Erasmus+ educational project developed to promote and increase societal **scientific knowledge** among students aged 12 through 16. It provides broad social value through an educational synergy between the **visual and performing arts** framed by cutting edge research in nanotechnology.

EurekArt aims to **generate connections** between different areas of education by means of the following actions:

- Encourage and develop **students' curiosity** about the process that leads from creativity to **culture creation**.
- Develop an interest in **scientific knowledge** with social value through an educational synergy between the **visual and performing arts** together with nanotechnology.
- Develop **innovative practices** in the field of education, by combining performing and plastic arts with nanotechnology.
- Provide young adults with the necessary **tools** and **skills** to find creative and innovative solutions that allow them to face unprecedented social risks and challenges.

Furthermore, it provides **useful tools for teachers who want to use the scenic and plastic arts in their school teaching curriculum**.

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ed objectives

CONNECTING TO SCHOOLS

This workbook contains a series of exercises to teach topics such as nanotechnology and nanoparticles to young students by using a scenic arts approach. Here we focus on **Nanomaterials used for Heritage Conservation**. In order to make our approach more exciting and useful, we will also suggest some soft skills and story writing exercises. This way the students will access this subject from a multidimensional point of view for a well rounded experience. More specifically, we will explore:

Scientific content

The topics treated in this workbook will link to a school science curriculum. More specifically, students will touch upon the topic of **chemistry, biology, materials science, and humanities**.

Creating connections

Heritage Science encompasses social science, humanities and the natural sciences. Those with interest in History of Art, Conservation-Restoration, Chemistry, Physics, Microbiology can come together as **a broad multidisciplinary team** to solve important societal challenges.

Soft Skills

Students will learn skills linked to **teamwork**, **public speaking** and **storytelling** during their work of co-creation of knowledge. Group activities will improve **critical thinking** and **negotiation** skills while enabling students to discover deeper meaning of the scientific topic.

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instructions

TEACHERS BECOME GUIDES

This activity has been created **for the teachers of every subject,** to allow them to introduce the topic of **Nanomaterials used in Heritage Conservation** connecting this issue to the school curriculum and at the same time to society.

At the heart of our approach is the idea that the students should find **ways to connect their own universes to each topic with a creative attitude,** while getting a general understanding of the science behind it. We propose that the teachers guide the students through a series of exercises where the students become **explorers,** taking a **voyage of discovery**. Teachers will also explore the topics with the students and **gain a potentially new awareness** around how such topics impact society and they will also learn a **new teaching technique.**

The approach we have used is that of **informal learning** where students don't face a typical frontal lesson, but they access the topics through a **learn-by-doing** approach.

Although being a science teacher could be useful when giving students some basic information about nanoscience, **teachers don't need to be science experts**: EurekArt is an **interdisciplinary project.** Students will be doing their own research to find scientific information and when the moment to write their stories comes, humanities teachers could find themselves in the right place.

What teachers really **must have** is an **open mind**! In the **Soft Skills workbook** teachers will find tips and exercises to give students (and themselves) a set of tools to begin their nanoscientific journey with.

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If you haven't read it yet, **start with the Soft Skills** workbook and decide which of the proposed activities would benefit the most for you and your students. Then **come back to this workbook** to get your hands dirty with nanoparticles!

TIMELINE OF THE PROJECT

To explore nanoscience through the lens of scenic arts requires several meetings with the students because of all the different aspects involved in the project. Here we suggest a possible path, but **teachers can personalise EurekArt**: change the order of the meetings, choose only the ones they need, or share the load with colleagues who teach different subjects, to make sure interdisciplinarity is on the plate.

Suggested meetings (maximum 10 hours):

- Soft skills on scenic arts (1 to 3 h): especially needed if the students come from different classes and/or the teacher is not familiar with theatrical approaches or storytelling techniques;
- The hero's journey (1 h): brief frontal lesson or video resources;
- Introduction to nanoscience (1 h): go through the proposed keywords, background and curiosities and make research on what you want to know better;
- Scenic arts and nanoscience (1 to 2 h): physical embodiment of the scientific concepts to better understand them and... have fun!
- Story writing (1 h): recap on storytelling, analysing a famous story and collectively improvising a new one, plus giving the assignment of writing a story;
- Story reading (1 to 2 h): students read their stories to teachers and peers and get feedback. This meeting can be repeated multiple times to read the stories improved by the feedback.

Please note that when **introducing Nanoscience** to your class, you will only use **background** and **curiosities** sections of this workbook.

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The purpose is to **engage the students** around the topic. Then you can ask them to **search online** for some **keywords**, and discuss with them the meaning of what they found, using the content of the **keywords** section of the workbook as a backup.

It is important for the students to **learn how to make a research online** on their own and to understand that some **sources** are reliable, while some others are not. Later on, when they'll be writing their stories, they will have to search for proper sources of scientific knowledge. You could even ask them to take notes of the sources they consulted. It's a good exercise of **scientific citizenship**!

The suggested meetings are very important to give the students a sense of direction towards a goal, but after they receive their assignment, is fundamental that they can **count on the teacher(s) to ask for any clarification**. Make sure they know you will guide them in their research of information or with developing a good story. Teachers should make themselves available at least once to check in with the students on the developing of their work.

Remember that, for a student, the **most difficult** part of scientific story writing is... **science**! They may write a beautiful story but forget to make science an important part of it, or the other way round: they might write a complete explanation of a phenomenon but little to no plot. Be patient. Give them feedback on how to make their story shine and **get ready to be amazed** by your students' creativity.

The workbooks and the video resources on the EurekArt website contain everything you need to follow this path, but it's important that teachers feel free to change, modify and hack the proposed exercises. Nothing is written in stone! Depending on the class size and disposition, teachers can choose whether to make students work independently or in groups, explore variations of the exercises or even **invent brand new ones**!

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our journey

WE ARE THE HEROES!

EurekArt is a **journey of discovery** that teachers and students undertake together.

As stated in the **Soft Skills Workbook**, our adventure needs some basic ingredients: the **HERO**, who is the main character, a **COMPLICATION** to overcome, the **TRIALS** needed to overcome it and the **SOLUTION** to the complication. At the end of the story the hero learns an important lesson about life that s/he is ready to share with the world. We call this the **ELIXIR**!

In EurekArt, **we are the heroes**!

We face the **complication** of having to deal with new knowledge: **keywords**, **background** and **curiosities** on nanoscience could easily scare us. That's some hot stuff!

Now we have to tackle the problem with some **trials**, so we take **action**. We embody the nanoparticles to better understand the processes of deterioration and protection of our tangible cultural items. Our last, but finally successful action is **story writing**, which leads us to the **elixir**: we learn that the new knowledge we were facing can be part of our lives and we are proud to tell the world our stories.

EurekArt involves **performing arts** to promote **knowledge** and skills in **scientific areas** by influencing domains of **cognition** and **motivation**.

Let the journey begin!

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background

UNDERSTANDING IS POWER

WHAT IS CULTURAL HERITAGE?

Cultural heritage represents one of the most important global industries and a substantial economic benefit for host countries, regions, and local communities. According to the latest studies made by the World Travel and Tourism Council, in 2019, cultural tourism represented 40% of all European tourism, generating millions of jobs and producing more than 30 billion € in revenues every year. Besides the economic asset and tourist attraction, cultural heritage also has a significant value as an identity factor contributing to social cohesion.

STORY BEHIND THIS TOPIC

Microorganisms, such as bacteria and fungi, induce important problems in the conservation of our cultural heritage, which not only endanger the integrity of the object of interest, but the proliferation of pathogenic microbes can incur great economic costs and seriously threaten the health of workers, and museum, archive and library visitors. In this line of research, different types of molecular metal-oxides and inorganic hybrid nanomaterials are synthesised as novel antimicrobial agents to prevent the biodeterioration caused by microorganisms such as bacteria and fungi, in different heritage objects and architectures. Through self-assembly studies, the multidisciplinary team of researchers seeks to improve the design of these materials to address specific problems of biodeterioration of heritage objects.

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CONNECTION TO OUR SOCIETY

Heritage science is an interdisciplinary research domain spanning the humanities and sciences. It focuses on the understanding, care, use and management of both tangible and intangible cultural heritage so it can enrich people's lives, both today and in the future.

UNESCO works to promote the conservation, protection, use and enhancement of cultural heritage sites through the creation of knowledge and advocacy. Heritage conservation is one of the 17 sustainable development goals set by UNESCO for the year 2030: "strengthen efforts to protect and safeguard the world's cultural and natural heritage".

It is crucial that we are aware of how sustainable and respectful conservation can contribute to improving the economic, social, and environmental livelihood of towns, cities and regions.

In this context, there is a pressing need for innovative technological solutions to develop interdisciplinary conservation strategies for the benefit of future generations globally.

BENEFITS TO OUR SOCIETY

Besides the economic growth in developing countries, cultural heritage conservation represents an important social investment, since it provides a sustainable cyclic development opportunity by enhancing the citizens' sense of identity, feeling of connection, and improves people's well-being.

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BENEFITS TO OUR ECONOMY

Moreover, cultural heritage serves as a worldwide economic driving force, but especially in economically and socially marginalised communities in developing countries, since it helps to generate local jobs and create opportunities for income-generation especially for youth and women, better learning opportunities for all, reducing inequality between social status or communities, improving professional competitiveness in skilled jobs and promoting cooperation between stakeholders and professional entities, increase tourism, and improve the quality visitor experience.

WHY MORE NEEDS TO BE DONE

Despite the tremendous economic and socio-cultural benefits, very little attention and investment are usually given to conservation and/or to develop new strategies to modernise its practice activities. Machu Picchu, Taj Mahal, Petra or Angkor, among many other monuments with irreplaceable cultural heritage significance, are currently eroding at a noticeable rate and current global conservation activities are not completely succeeding in the implementation of quality and respectful conservation strategies to stop damage.

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curiosities

COOL THINGS TO KNOW

There are several renowned national and international institutions defending and promoting the conservation of our shared cultural heritage. Many of these have fantastic resources and examples of how tangible and intangible heritage nourish and enrich our everyday lives e.g., **ICCROM** (https://www.iccrom.org/section/heritage-science) and **International Institute for Conservation** https://www.iiconservation.org/

There is an excellent policy agenda by the **International Council for Monuments and Sites** (ICOMOS) which shows how the sustainable conservation of Cultural Heritage can act as a key driver of several of the **sustainable development goals established by UNESCO**, e.g. poverty, clean water, health, gender equality, among others. These specific examples are illustrated using international case studies from different countries. https://www.icomos.org/images/DOCUMENTS/Secretariat/2021/SDG/ICOM OS_SDGs_Policy_Guidance_2021.pdf

INMA (Instituto de Nanociencia y Materiales de Aragón - Spain), together with the Aragón School for Conservation and Restoration of Cultural Heritage, has designed a **teaching tool** to inspire students to study the interdisciplinary field of Heritage Sciences. This interactive activity uses a mummified cat and sarcophagus to illustrate how history of art, conservation and restoration, chemistry and physics come **together under one domain.** https://redoxactivematerialsgroup.com/2020/01/18/concienciaarte-la viajera-del-tiempo/

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Tutankhamun's curse

On November 26, 1922 Howard Carter opened the tomb of Tutankhamun. Of the 58 people present at that moment 11 of them died during the next few years. The news of these deaths spread all over the world and superstitious people thought that these people were hit by a terrible curse.

As a matter of fact science was able to explain it all. In the tomb there was a high concentration of pathogenic fungi that is likely to have caused Aspergillosis, a fungal infection that affects the respiratory system. In immunodeficient patients, it can be a severe or even deadly illness.

So **there was no curse**: just some really bad fungi!

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keywords

LET'S TEACH SOME TERMINOLOGY

Metal-oxide nanoparticles

Nanoscale crystalline solids formed from metal cations (molecules with overall positive charge) and oxygen anions (molecules with overall negative charge). They possess unique chemical and physical properties, compared to the bulk material, so they play a significant role in many areas of physics, chemistry, and material sciences.

Polyoxometalates (POMs)

POMs are inorganic cluster ions, charged molecules formed by the combination of ions or atoms or molecules of one or two chemical species. They are nanoscale molecular metal-oxides composed of transition metal ions (such as tungsten, molybdenum, or vanadium), which are linked together by shared oxygen atoms to form closed cluster molecules.

Antimicrobial nanomaterials

Many nanomaterials are antimicrobial. Importantly, many types of metal-oxide nanoparticles exert their activity via non-specific bacterial toxicity mechanisms (i.e., they do not bind to a specific receptor in the bacterial cell), which not only makes the development of resistance by bacteria difficult but also broadens the spectrum of antibacterial activity.

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Biodeterioration

The undesirable degradation of materials by microorganisms, insects, and plants.

Heritage Science and Cultural heritage conservation

Cultural heritage refers to the legacy of tangible items (i.e., buildings, monuments, landscapes, books, textiles, paintings, or archaeological artefacts) and their intangible attributes (i.e., folklore, traditions, language, or performance arts) that are inherited from the past by a group or society and conserved for future generations due to their artistic, cultural, or historic value. The act of preserving cultural heritage is known as Heritage Conservation, and it mostly focuses on doing everything possible to delay the natural laws of deterioration on tangible items to support the transmission of its significant heritage messages and values for future generations.

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actions

LEARNING BY DOING

Basic philosophy of these exercises

Through movements, actions and **personification of scientific ideas** and pretend-embodiment, the students will get a sense for nanoscience. They will also experience the power of **metaphors** making it easier to use them in their storytelling exercise. Moreover, this is a powerful **team building** activity, especially with students from different classes. Here we will work on **Heritage Conservation**!

Exercise 1 - Restoration

location: empty room/ free space

The class is divided into two groups: A and B. The teacher plays a happy song. At the sound of the song the students of group A will walk at good speed tracing the form of a big snake. Group B pays attention to what is happening... Each member of group A will have a specific "personality". One will move the arms in a certain way, another will walk in a particular way.. and so on. Group B must pay close attention to what they do. At the end of the song (or when the teacher decides that it is time) group A will stop. Now it is up to group B to reproduce what they just saw. The teacher plays the same song again and group B must reconstruct the image of group A: what was the order? Where did they begin? What was each member of group A doing? If they are successful in doing it while the song is still playing, group B has won the challenge. Ask group A if the reconstruction was successful and precise.

At the end, when happy with the results, reverse roles and repeat!

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Exercise 2 - Microbes and antimicrobial nanoparticles
location: empty room/ free space

The group of students is divided evenly in three groups: A, B and C. Group A will position themselves so that their combined figure is "a work of art" like a statue or a painting. Group B are the microbes trying to ruin the work of art while group C are the antimicrobial nanoparticles that have to protect it. Now the competition begins! Group B will perform a little show (a song? A dance? Whatever works...) and then group C will also perform a show. Which show was most convincing? Group A will decide! If group B wins, the work of art will be dismantled, if group C wins the work of art has been saved.

Very important: Be creative! Ask the students of group A to be truly honest in their judgement, and to reach a decision without talking, only with non verbal communication... play with the possibilities!

Exercise 3 - The twisty snake
location: empty room/ free space

The group is split into two: group A and group B (group B is made up of a maximum 3 people). The students in Group A will connect to become a very long snake, holding each other by the hands. This snake will have a head and a tail. Now, group A will entangle as tightly as possible, the head will move in and out and around making knots and twisties (passing under the legs, over the arms, etc)... up to the point that the snake cannot move anymore. Now group B has 60 seconds (or whatever the teacher decides is the right time) to disentangle the snake. They do it without touching it and also without using words, only non verbal communication!

Very important: the students of group A must make sure they never let go of their friends' hands, otherwise the exercise will not work! Also, the more students in the snake, the better!

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story writing

SCIENCE IN STORY

Finding the Hero
Now it's time for the students to **write their own story**, exploring the scientific topic of **Nanomaterials for Heritage Conservation**. Going from physical embodiment of nanoparticles to story writing seems like a big jump, but it's easier than you could think!.

At first you can **analyse together a story everybody knows** and look for the elements of the **hero's journey**: status quo, complication, trials, solution and elixir. A good **example**, containing unexpectedly accurate science, is *Finding Nemo*. Let the students help you **go through the plot**, step by step, and guess what's true or fiction. Then check the answers online: do turtles migrate? Do clown fishes live in anemones? And so on. Of course you can use other examples. Point out the difference between a fiction based on actual science, like *Gattaca* or *Interstellar*, and a pure science-fiction, like *Transformers*.

The next step is more creative: **inventing a collective improvised story**. One after the other, in a circle, each student will tell a bit of a story, starting with the status quo and getting to the elixir. It's an **experiment**, so you will have to **guide** them through each step, giving them **hints** like "who is the hero?", "now we need a complication" and so forth, until the story ends. Was it too easy? Let's take the game to the next level: **a story about science**!

Students will have to work autonomously: choose a hero, invent a plot and find online reliable sources of contents about nanoscience. Teachers can guide them, but students have to do the job!

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The importance of our heritage

Who are we and what defines us? How do we decide what actions to take? We sit on the shoulders of giants, so they say... and for us, as a society, the giants are those that came before us, **our common heritage**. But all that can be lost very easily if we don't pay attention: everything, even the hardest and strongest of things, will eventually be eaten up by time and microbes! Even the mighty Titanic is slowly disappearing, consumed little by little by iron oxidising bacteria, deep under the ocean surface: a good example of biodeterioration.

So, why not ask the students to reflect upon these issues and **write a story** that inspires them to save our heritage? They will work in **small groups** and could even use **different artistic expressions**, if they feel more inclined to **music**, for example, or **painting**, or making a **graphic novel** or an entire story with **memes**. As long as their creation contains all the basic steps of the hero's journey, it's a story!

If the students are stuck, here's a possible start: “a very motivated nanoparticle scientist wants to **save precious heritage artefacts in the local museum**. But s/he finds no money to support their research because the Council of their city has already decided to invest all the money in a mega shopping mall that, it says, will revive the local economy. But the paintings too can become a wonderful tourist attraction and what about the scientific advances that will be made? Those too can be sold to other museums bringing new finances to the local economy!” So... **how will the story develop?**

Once the students have finished creating the story, why not **share** it with the class? Instruct the students to read it aloud if they wrote it, or present their artistic creation to the rest of the group. If they feel very adventurous, why not **try to act it out**?

With the **feedback** from their peers they'll see if what they wanted to say actually went through. If it did, they found the **elixir**!

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the elixir

YOU ARE THE HERO

What did I learn from this experience?

Teachers and students should dedicate some time to understand what lesson they are taking home from this experience. Just like the protagonist of any story at the end goes back to their world with an "elixir", so should the **teachers** and the **students**. After all, they **are the protagonists of their own stories**!

Let's ask the students these questions: ***if you were to explain to a friend what Nanomaterials for heritage conservation are, why are they important and what they are useful for, how would you do it? What would you say?***

Also, let's think about our journey, and ask the students: ***Did you find that telling a story about nanoscience could be easier than explaining in scientific terms what nanoscience is? Did you find it engaging? Did you like to use storytelling to explain science?***

Now, **let's ask ourselves the same questions**!

Note: if you have any comments or suggestions regarding this workbook and the exercises and tasks included in it, please don't hesitate to contact us at *direzione@arditodesio.org*

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