Science Beyond the Boundaries

**Art conservation in Herculaneum and Pompeii**

**Teacher notes**

**Intended learning outcome**

Students understand how processes for conserving and interpreting ancient artworks can emerge from scientific research; and how the development of these applications is shaped by combining understanding and expertise from disciplines across the sciences and beyond.

***Commentary:***

In 79CE, the eruption of Vesuvius buried the towns of Herculaneum and Pompeii under many metres of ash and other volcanic debris. Both towns were effectively frozen in time and many features preserved until Pompeii was rediscovered in the sixteenth century and Herculaneum some time later in the early eighteenth century. Today, large multi-disciplinary teams work round the clock on both sites: conserving and investigating the huge wealth of discoveries on each site, piecing together the most complete record of Roman life that we have.

Both sites have been popular tourist attractions for many years. Tourism disrupts and interferes with work on the sites, but it also pays for much of that work. A careful balance needs to be found between opening up the sites for the public to learn about and enjoy, the need for careful study, and the conservation of the sites and their contents for future generations.

The rediscovery of Herculaneum and Pompeii offered unprecedented opportunity for historical insight as no other sites quite like them had been found before. But initial excavations merely plundered the sites for treasures. Over the years, new methods for excavation and conservation were devised and implemented. In that time, measures were needed to protect the sites against all sorts of factors including: the weather; water damage; earthquakes; wear and tear by tourists; and even vandalism and theft.

When investigating and conserving historical sites and artefacts, the approaches taken will be determined by both practical and political considerations. All the stakeholders (including local people, tourists and researchers) need to be included in a clear plan for the sites. Multi-disciplinary teams are needed to plan and co-ordinate conservation. Co-ordinated mapping, assessment and recording of the sites is necessary to allow work to be prioritised most effectively. Methods and strategies need to be developed for conserving buildings and artefacts. This often involves experimentation and innovation. Cutting edge technology can sometimes provide new solutions to conservation issues, or opportunities for further study.

The conservation teams and researchers working in Herculaneum and Pompeii illustrate how a range of experts from many different fields can co-ordinate their efforts and expertise to great effect.

**Outline of teaching unit**

For this unit, students work together with the end goal of producing a set of information boards for an exhibition to explain conservation and investigative techniques used in Herculaneum and Pompeii. The class organise themselves into teams that share and maximise the skills and expertise within each work-group, in order to achieve the best possible outcome for the whole-class project. In this way, they explore and experience the utility of inter-disciplinary collaboration.

At the end of the project students are invited to evaluate their individual roles within the collaborative work they have undertaken.

**Bold sections are classroom-based activities,** those not in bold can be completed either in or out of the classroom.

**Phase 1.**

 **Introduction to the 79CE eruption of Vesuvius and its impact on Herculaneum and Pompeii. The final task that students will be working towards is described, which is to work in teams to curate a small exhibition in which several pieces of art are selected from the sites, and for which information boards are created to inform the general public about each artwork, about its conservation, about why it should be conserved, and about the methods used to unearth its secrets.**

 **Teams are organised for the task based on students’ individual skills and expertise. The class is invited to work together to create a set of teams, which each have all the necessary attributes to produce a piece of work of the best quality for the final joint exhibition. It is the exhibition as a whole on which the students will judge themselves and not the output of the sub-group they are working in.**

**Introduce tasks for phase 2**

Phase 2.

Students explore online videos – documentaries, virtual tours and so on, to find out about Herculaneum and Pompeii. They can record their observations and thoughts using a recording proforma, that is provided, which can help them focus on developing ideas for the overall task.

**Phase 3.**

**1. Members of each team investigate one ‘technique’ used at Herculaneum or Pompeii with a view to explaining it to the rest of their team. There are five tasks to be completed to find out about:**

* **Conservation of mosaics**
* **Conservation of frescos**
* **Use of 3D Laser scanning**
* **Use of UV-C radiation to destroy biofilms on paintings**
* **Herculaneum scrolls, and how modern physics may enable them to be read.**

**One member of each team can find out about one of these and report back to their group at the end of the exercise. If time allows, members of each team can complete more than one of these activities, each one takes 15-20 minutes.**

**2. Students share their findings from the previous task (activity 4) within their team. Using this information together with ideas gained from watching documentaries (the phase 2 task), each team decides on a short-list of two ideas for information boards they would like to work on.**

**These are presented to the whole class. Once all the groups have presented, the class decides together on which one item each team will develop an information board for, in order to put on an informative exhibition.**

**3. Individual tasks within each team, related to the preparation of the information boards, are identified and allotted to team members. Students are given instructions about what they need to prepare in advance for the task in phase 5.**

Phase 4.

Individuals research and prepare materials for their team’s information board. They are expected to bring these materials with them to the next lesson to make the creation of the information boards a relatively quick task.

**Phase 5.**

**1. Teams are given 20 minutes to use the materials they have brought with them and other resources to complete their information boards (one A3 or one A2 sheet).**

 **The information boards are combined into one display.**

**2. The class reflect on the factors needed for a successful collaboration and evaluate their individual roles within the collaborative work they have undertaken.**

***Activities for each of the five phases of learning***

Phases 1, 3 and 5 are classroom based; and *phases 2 and 4* can be completed either in the classroom or independently out of the classroom.

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| **Phase** | **Activity** | **Reason for it** | **Activity summary** | **Estimated time** |
| **Phase 1 - Explore****Introduction to the 79CE eruption of Vesuvius and its impact on Herculaneum and Pompeii. The final task that students will be working towards is described, which is to work in teams to curate a small exhibition in which several pieces of art are selected from the sites, and for which information boards are created to inform the general public about each artwork, about its conservation, about why it should be conserved, and about the methods used to unearth its secrets.**  **Teams are organised for the task based on students’ individual skills and expertise. The class is invited to work together to create a set of teams, which each have all the necessary attributes to produce a piece of work of the best quality for the final joint exhibition. It is the exhibition as a whole on which the students will judge themselves and not the output of the sub-group they are working in.** **Introduce tasks for phase 2** | **1 Introduction** | **Stimulus material is used to introduce the archaeological sites of Herculaneum and Pompeii.** | **Images of the sites are used to prompt students’ reflections on their experiences or understanding of the sites.** **An animation of the 79CE eruption of Vesuvius illustrates what happened to create the sites.** | **30 minutes** |
| **2 Project task** | **Students are introduced to the exhibition task that they will be working towards and organise themselves into project teams.** | **Students consider the attributes necessary within each team working on the task.****They decide on how to organise the class and who will work on each team to ensure the best overall outcome for the whole class.** | **20 minutes** |
| *Phase 2 – Explore**Students explore online videos – documentaries, virtual tours and so on, to find out about Herculaneum and Pompeii. They can record their observations and thoughts using a recording proforma, that is provided, which can help them focus on developing ideas for the overall task.* | *3 Research task* | *Students find out more about Herculaneum and/or Pompeii in order to develop potential ideas for the information boards they have been asked to develop.* | *Each team decides what each member should look for.**Individuals find and watch an online video/documentary and record findings on a proforma research summary sheet.* | *10 minutes introduction,**then 1 hour or more* |
| **Phase 3 – Explore and Explain****Members of each team investigate one ‘technique’ used at Herculaneum or Pompeii with a view to explaining it to the rest of their team. There are five tasks to be completed to find out about:*** **Conservation of mosaics**
* **Conservation of frescos**
* **Use of 3D Laser scanning**
* **Use of UV-C radiation to destroy biofilms on paintings**
* **Herculaneum scrolls, and how modern physics may enable them to be read.**

**One member of each team can find out about one of these and report back to their group at the end of the exercise. If time allows, members of each team can complete more than one of these activities, each one takes 15-20 minutes.****Students share their findings from the previous task (activity 4) within their team. Using this information together with ideas gained from watching documentaries (the phase 2 task), each team decides on a short-list of two ideas for information boards they would like to work on.** **These are presented to the whole class. Once all the groups have presented, the class decides together on which one item each team will develop an information board for, in order to put on an informative exhibition.** **Individual tasks within each team, related to the preparation of the information boards, are identified and allotted to team members. Students are given instructions about what they need to prepare in advance for the task in phase 5.** | **4. Conservation and investigation techniques** | **Students find out about different techniques for conserving or investigating artefacts, three of which involve cutting edge science.** | **A circus of five activity stations. Three involve card sort activities and for the other two students extract information from magazine articles.****A member of each team completes one of the activities and reports back to their team in the next activity.**  | **20 minutes** |
| **5. Team planning** | **Information that students have found is shared within and between each team.** **Tasks relating to preparation of the exhibition are allocated to teams and to individuals in each team based on the interests and strengths of each, in order to achieve the best possible final outcome.** | **Students explain the information they each found while completing activities 3 and 4 (above) to their team. Each team identifies two ideas they would like to work on for an information board.** **Each team’s shortlist is presented to the class and, through discussion, the class decides which information board each group should create for the final exhibition.****Each team allocates members a specific task to do in preparation for creating their information board.** | **30-40 minutes** |
| *Phase 4 – Elaborate**Individuals research and prepare materials for their team’s information board. They are expected to bring these materials with them to the next lesson to make the creation of the information boards a relatively quick task.*  | *6. Content creation* | *Students individually prepare materials for information boards in advance of creating the finished products in teams.* | *Individuals research and prepare script, images, graphics for their team’s information board. Each individual works to their strengths.* | *1 hour or more* |
| **Phase 5 – Elaborate and Evaluate****Teams are given 20 minutes to use the materials they have brought with them and other resources to complete their information boards (one A3 or one A2 sheet).****The information boards are combined into one display.****The class reflect on the factors needed for a successful collaboration and evaluate their individual roles within the collaborative work they have undertaken.** | **7. Information board construction** | **The information boards are produced and combined to make a final exhibition.** | **Each team combined pre-prepared materials to construct their information board within a 20-minute limit.****The finished information boards could be added to a prepared display board in the classroom.** | **30 minutes** |
| **8. A successful collaboration?** | **Students reflect on what factors lead to a successful inter-disciplinary collaboration.** | **Each team reflects on the statements of a set of ‘collaboration’ cards, adds extra statements they think are relevant, sorts the cards into a rank order, and feeds back to the class.****Within each team, individuals are awarded two stars from the rest of the team, and identify a new strategy they could adopt to achieve a more successful outcome to collaborative work they are involved in.** | **30 minutes** |

**Guidance notes: pedagogical approaches**

In this unit students investigate examples of how scientists and experts from other fields have collaborated in order to achieve specified goals within a large project. As they do this, the students themselves work, as far as is possible, in their own inter-disciplinary teams towards an end goal that forms part of a larger project. The intention is to provide students with an immediate and personal experience on which to reflect in thinking about the nature of inter-disciplinary collaborative work in general, and the benefits of such work.

**Key information**

**Background information on Herculaneum and Pompeii**

Herculaneum and Pompeii are Roman towns that were buried during the eruption of Mount Vesuvius in 79 CE. Pompeii was a large town on the south-eastern side of Vesuvius and Herculaneum was a smaller resort town between the western side of Vesuvius and the coast. They are close to, and a little south of, the modern-day city of Naples in Italy.

Pompeii was rediscovered in late 1500s and Herculaneum in the early 1700s, with systematic excavation starting in 1738. Work in Pompeii started a little later in 1748, but the initial digging on both sites was often haphazard and damaging and was frequently carried out by untrained treasure seekers.

The first systematic studies of these sites, that perhaps marked the start of the modern science of archaeology, were funded by Don Carlos, King of Naples in the mid-18th Century. However, it was only in 1860 that haphazard digging was brought under control and archaeologists were given full control of the excavations.

**Volcanic eruption**

The eruption of Vesuvius in 79 CE was witnessed and described by the Roman historian Pliny the Younger. He described a cloud rising from a mountain, but because he was so far away he could not tell which mountain. What he described is the most violent type of volcanic eruption, now called a Plinian eruption, in which columns of gas and ash can be blasted up to 50 km into the air, forming a mushroom shaped cloud. In these eruptions, the whole top of a volcano can be obliterated and ash, volcanic rock and lava bombs can fall miles from the volcano. In addition, hot gases and volcanic material (at about 1000oC) are blasted down the slopes of the volcano at speeds that are typically about 60 miles per hour, but which can be up to seven or eight times faster. These pyroclastic flows have the power to destroy forests, strip soil from the bedrock and obliterate everything in their path.

The eruption of Vesuvius in 79 CE is thought to have lasted for two days. For about 18 hours a rain of pumice fell on Pompeii. During this time most of the inhabitants were able to escape. Then came a sudden pyroclastic flow that incinerated or suffocated all those still in the town. The heat from the pyroclastic flow was probably hot enough to cause instant death, even of people sheltering inside buildings. After the eruption was over Pompeii was buried to a depth of up to 6 m (20 ft).

Herculaneum by contrast was not affected by the falling pumice on the first day of the eruption. Again, most people were able to flee and on the second day when several pyroclastic flows engulfed the town, very few inhabitants remained. The flows buried Herculaneum to a depth of about 20 m (65 ft) and significantly changed the coastline around the town.

**Early discoveries and changing nature of excavations**

In 1860 a director of excavations was appointed for Pompeii and a systematic approach began. New systems for recording work were introduced and focus turned to the overall history rather than individual objects, buildings or artworks. At each stage, new processes and techniques were devised, such as taking plaster casts of cavities to reveal human figures and other organic objects. At this time a school of archaeology was established and the site was opened up to visitors. In 1865, the director of excavations was also given control of the site at Herculaneum. By this time the tunnelling in Herculaneum had given way to open excavation. This was causing conflict because it was taking land from residents of Resina that had been rebuilt on the land above the ancient city.

Excavations of Herculaneum stopped in 1877 and only started again in 1927 when, under the Fascist government of Mussolini, the residents of Resina were forcibly relocated. Work stopped again during World War II and did not start again until 1958.

An inventory made of murals in Pompeii in 1957 found that a third of those uncovered by earlier excavations had completely faded through exposure to light and neglect. By the late 1970s, the majority of those remaining had been lost too.

Weather also affects both sites, with damage caused by acid rain and water damage. Weeds, algae, lichen, bird droppings and wear and tear from tourists are also a problem, and the area is prone to earthquakes.

In 1977 fourteen frescoes were cut from walls of the House of Gladiators and stolen and over the years smaller ‘souvenirs’ have been taken by visitors.

**Conservation and reconstruction**

Some of the early restoration and conservation has also caused later problems. For example, iron that had been used to reinforce original concrete in buildings has rusted and caused further damage; and some modern materials used to repair frescoes caused further deterioration.

Since 1977 little new excavation has taken place and the focus of archaeological work has been the conservation and analysis of what has already been excavated. Scientific experimentation is now used to identify the most appropriate materials, methods and strategies in conservation and reconstruction techniques, e.g. De Vita, Smeti and Volta (2013) and Rainer et al. (2017).

Scientific methods are also being employed to record and monitor all aspects of the site and play a key role in planning and scheduling conservation work, e.g. Brizzi et al. (2006).

Two useful websites for finding out more about conservation and reconstruction techniques are:

* The Getty Conservation Institute: <https://www.getty.edu/conservation/>
* The British School at Rome: <https://www.bsr.ac.uk/research/archaeology/completed-projects/herculaneum>

**New research and technologies**

Some new technologies now being used in research and conservation at Herculaneum and Pompeii have been included in the teaching resources for this unit.

*3D Laser Scanning*

Since the early 2000s, 3D laser scanners originally designed to accurately map and record crime scenes (Brizzi et al., 2006) have been used to make accurate records of the site. Advances in computer software allow the generation of 3D models to be built from multiple scans. These models can be used for multiple purposes, including virtual tours and reconstructions that represent what the buildings could have looked like two thousand years ago. Geographical information systems (GIS) allow extra detailed information to be added and accessed at any point in a 3D model. This information can be measurements (e.g. humidity levels) over time; conservation work planned or carried out; and so on. GIS information within 3D models is increasingly being used to record and plan conservation work across the two sites, and is particularly valuable in facilitating problem solving discussions between experts from different fields.

*UV-C Irradiation*

Damage to the surface of wall paintings can be caused by algae, lichens and other biological contamination. Experimentation on chemically accurate copies of fragments of paintings and pigments found on site (Cennamo et al., 2020) has enabled a process of UV-C irradiation to be developed that can destroy biological contamination completely, without affecting the colours of the pigments in the painting. This method is non-invasive and can be completed quickly on site at times of day (night time) when there are no tourists visiting. The previous method involved the application of toxic chemicals that could leach into drainage water.

*Diamond Light Source synchrotron science facility, University of Oxford*

The largest library in antiquity was found in Herculaneum in the mid-nineteenth century. It consisted of hundreds of carbonised scrolls that include potentially many ancient works that have been lost to civilisation. About half of the scrolls have been destroyed by attempts to unroll them in order to access the text. The recently built Diamond Light Source synchrotron generates an extremely high brilliance, high intensity, sharply focused x-rays. It has been shown that this light can be used to penetrate and read characters from the scrolls found in Herculaneum, without the need to unroll them (Merchant, 2018).

**AS/A level specification links**

**AQA A-level physics**

Nature of electromagnetic waves.

Representation of electric fields by electric field lines.

Electric field strength.

E as force per unit charge defined by E = F/Q

Magnitude of E in a uniform field given by E = V/d

Derivation from work done moving charge between plates: Fd = QΔV

Trajectory of moving charged particle entering a uniform electric field initially at right angles.

Magnitude of E in a radial field given by E = Q/4πε0r2

Magnetic fields.

Force on a current-carrying wire in a magnetic field: F = BIl when field is perpendicular to current.

Fleming’s left-hand rule.

Magnetic flux density B and definition of the tesla.

Force on charged particles moving in a magnetic field,

F = BQv when the field is perpendicular to velocity.

Direction of force on positive and negative charged particles.

Circular path of particles; application in devices such as the cyclotron.

**AQA A-level chemistry**

Acids and bases are important in domestic, environmental and industrial contexts. Acidity in aqueous

solutions is caused by hydrogen ions and a logarithmic scale, pH, has been devised to measure acidity.

An acid is a proton donor.

A base is a proton acceptor.

Acid–base equilibria involve the transfer of protons.

**AQA A-Level biology, chemistry and physics shared content:**

Comment on experimental design and evaluate scientific methods.

Present data in appropriate ways.

Know and understand how to use a wide range of experimental and practical instruments, equipment and techniques appropriate to the knowledge and understanding included in the specification.

**AQA A-Level environmental science**

Ozone layer: Ozone was produced by chemical reactions involving oxygen and ultraviolet light in the stratosphere.

Students should understand how new technologies improve the validity of ecological research by allowing the collection of more representative data and new information.

**OCR A-level classical civilisation**

Content of Greek art

The 6th–4th centuries BC was a period of great change in the Greek world, and this is reflected in the art which was produced. In this component learners will gain a thorough knowledge of the selected aspects of Greek art, but they will also gain some understanding of, and insight into, the context in which it was created, particularly the areas of religion, society, values and history/politics.

Learners will have the opportunity to explore and engage with a range of the visual arts produced by the Greeks in 6th–4th centuries BC, including free-standing sculpture, architectural sculpture and vase-painting.

Having undertaken this study, learners will appreciate the profound effect Greek art has had on the art of later periods. This component will hone learners’ visual and analytical skills, develop their ability to offer critical analyses, and enable them to articulate an informed personal response to the works under consideration.

**Pearson Edexcel history of art A-level**

As part of this course, students complete two out of three option from: nature in art and architecture; identities in art and architecture; or war in art and architecture. For each they must analyse pieces of work whilst considering: cultural, social, technological and political factors; developments in materials, techniques and processes; and ways in which art has been used and interpreted by past and present societies.

**AQA A-Level geography**

The nature of vulcanicity and its relation to plate tectonics: forms of volcanic hazard: nuées ardentes, lava flows, mudflows, pyroclastic and ash fallout, gases/acid rain, tephra. Spatial distribution, magnitude, frequency, regularity and predictability of hazard events.

Impacts: primary/secondary, environmental, social, economic, political. Short and long-term responses: risk management designed to reduce the impacts of the hazard through preparedness, mitigation, prevention and adaptation.

Impacts and human responses as evidenced by a recent volcanic event.

**AQA A-Level art and design: graphic communication**

Students are required to work in one or more area(s) of graphic communication, such as: design for print; illustration; communication graphics.

Students will be required to demonstrate skills in all of the following:

* understanding of meaning, function, style, scale, colour and content in relation to the chosen area(s) of graphic communication
* awareness of intended audience or purpose for their chosen area(s) of graphic communication
* ability to respond to an issue, concept or idea, working to a brief or answering a need in the chosen area(s) of graphic communication
* appreciation of the relationship of form and function and, where applicable, the constraints of working to a brief
* appreciation of the appropriate use of typography (which could include hand lettering and calligraphy)

**References**

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