| **OrientationCompass with solid fill** | **QR audio** |
| --- | --- |

Through the preceding activities, some questions arose regarding the Virgin Mary’s icon of the Museum....

1. Can we observe in greater detail elements of the 14th-century icon of Virgin Mary (eg clothing, facial expressions and posture, etc.)?

2. What were the main components of the materials used in the 14th-century icon of Virgin Mary?

3. Can these materials give us information about the artist's technique or socio-economic status?

4. Can we compare the materials and the technique used for this icon, with those used today for church icons? Are there similarities/differences?

*Discuss the above questions as a whole class*

**How can we answer these questions?**

**Record the results of the discussion**

| ***The students record the results of the discussion, concluding to the following***  **To answer the above questions, we should:**   * **Zoom in on the object to see details** * **Identify the ingredients from which it is made** * **Identify components that are an indication of maintenance** |
| --- |

| *Record the views heard  with a short video or audio recording.  Name it “1.a Problem and Solutions”* | | *QR audio* |
| --- | --- | --- |
| **ConceptualizationQuestions outline** | **QR audio** | | |

*Discuss as a whole class.*

**How can we see the details of the item?**

*Note or draw tools we can use   
to see details of an object*

| Instruments / Devices | Selection |
| --- | --- |
| **Magnifying glass** |  |
| **Binoculars** |  |
| **Telescope** |  |
| **Optical microscope** |  |
| **Close up eye vision** |  |
|  |  |
|  |  |

| ***The students fill in their ideas above or design in this space the above means/instruments.*** |
| --- |

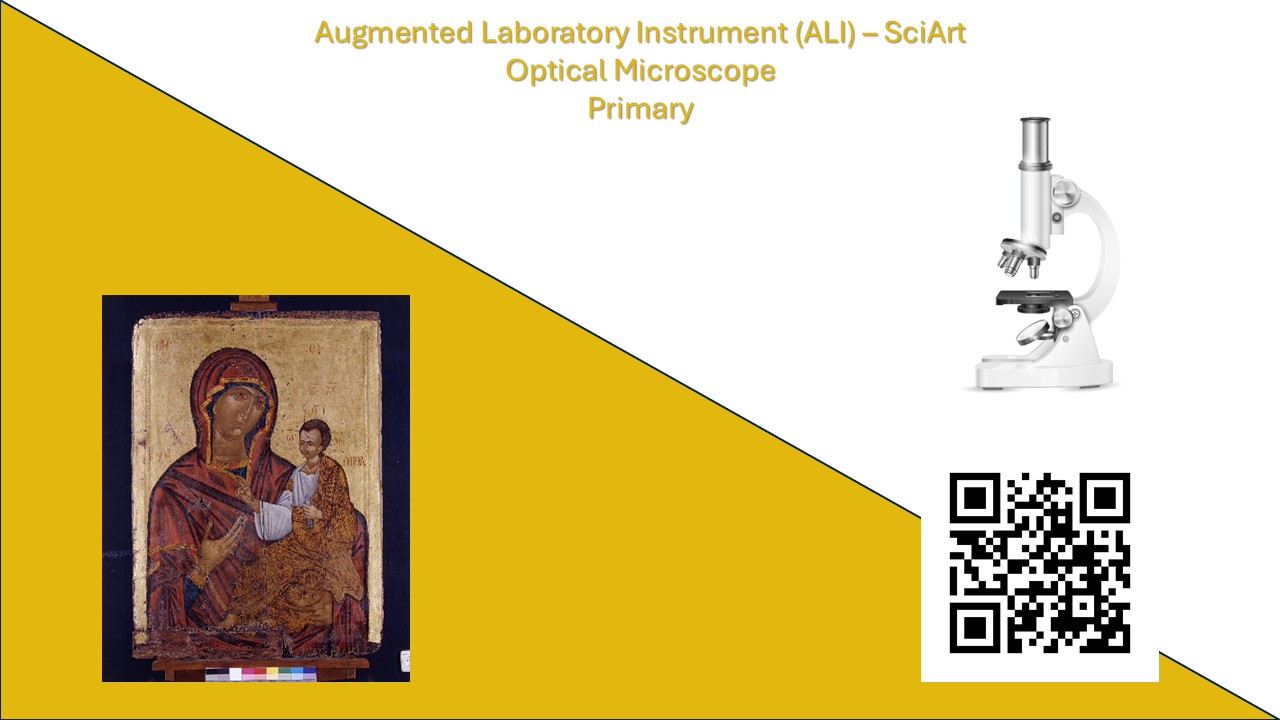
*Discuss as a whole class about the instrument that can give us the best results and choose it from the table above.*

***Through the discussion we end up to the optical microscope.***

| *Record the views heard  with a short video or audio recording.*  *Name it “1.b Conceptualization”* | | *QR audio* |
| --- | --- | --- |
| **ResearchResearch with solid fill** | **QR audio** | |

Use your mobile devices (tablets, mobiles, etc.) and scan the QR below.

Watch the video and download the results of the device you selected for the icon of Virgin Mary by clicking the **"Results"** button.

****

***Discuss with the whole class the results of this particular device***

* Can you describe the magnified images you took from the Optical Microscope for each point of interest?

What does the red layer look like?



Picture 1 Picture 2 Picture 3

***The discussion with the students concludes that we can identify points of interest with the Optical Microscope, such as the area of Virgin Mary's elbow (Picture 1). By zooming in on the area of interest (elbow) we observe evidence of wear, so we can take a sample without destroying the artifact (Picture 2). The cross-section of the sample (Picture 3) shows us the layer of red color above a darker one, maybe of brown colour. The level of magnification is not enough to be sure about that. There can be a discussion with students about how we intervene in an artifact for research or conservation purposes, without destroying/altering it.***

What does the golden layer look like?



Picture 1 Picture 2 Picture 3

***Another point of interest is the gold background of the image (Picture 1). By magnifying the point of interest (gold background) we observe evidence of wear and can take a sample (Picture 2). The cross-section of the sample (Picture 3) confirms the layer of gold between the other layers. The level of magnification is not enough to distinguish the layer of golden colour, apart from a very thin shiny layer, that is highlighted with the black arrow. There can be a discussion with students about how we intervene in an artifact for research or conservation purposes, without destroying/altering it.***

How does the fabric look magnified?



Picture 1 Picture 2: close up Picture 3: 10x magnification Picture 4: 50x magnification

***In the bottom left corner of the Virgin Mary’s icon (Picture 1), the students observe a spot that has worn away and reveals the existence of a textile, so we can take a sample (Picture 2) to study it. At higher magnification of the Optical Microscope (Picture 3) students can observe that the textile is composed of textile threads, which in turn are composed of fibers. Picture 4 shows a higher magnification of the textile fibers, but it is not enough to get more information about the origin of the fiber.***

| *Discuss and record the device functions with a short video or audio recording.*  *Why do we use it and what results can we get?  Name it “1.c Research”* | *QR audio* |
| --- | --- |

| **ConclusionThought outline** | **QR audio** |
| --- | --- |

* **Why do we see three different images for the same point of interest? Can you sort them from lowest to highest magnification?**

**The three images give us an increasingly higher magnification of the same point.**

**The higher the magnification, the greater the detail we can observe.**

* **Do you observe anything different in the images of the different points of the object we focused on?**

*Write down your observations or draw the pictures below with arrows for the points of special interest.*

| **In the images taken by the Optical Microscope, the points of interest are the red area on the elbow of Virgin Mary, the area with the gold background and the worn area revealing the textile, in the bottom left corner of the icon. So, it would be interesting to get more information about these points.** |
| --- |

| *Record your answers  in three different short videos or recordings.*  *Name them "1.d Conclusion A", "1.d Conclusion B"* | | *QR audio* |
| --- | --- | --- |
| **ConceptualizationQuestions outline** | **QR audio** | | |

*Discuss as a whole class.*

**What do we need to do to get more information   
about these points of interest?**

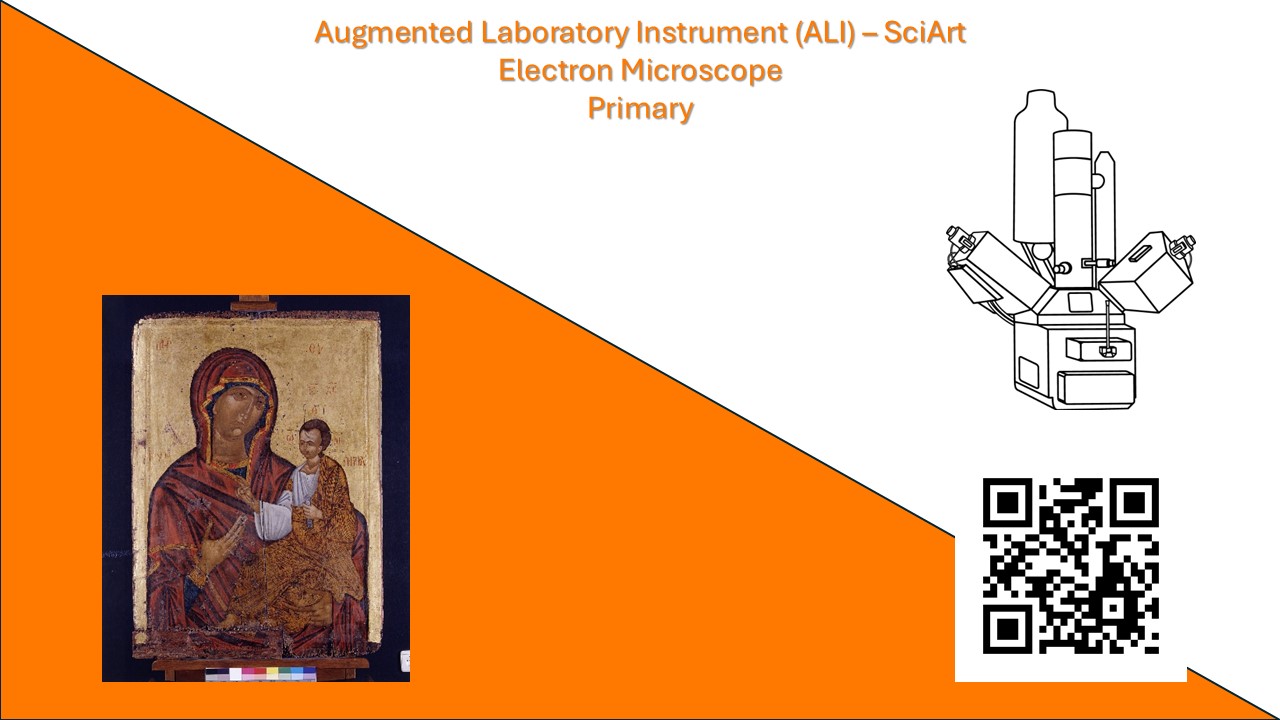
***A discussion is provoked in the class, in which we guide the students to focus on the need for further magnification.***

***The teacher introduces the Electronic Microscope as a solution for extra magnification.***

| *Record the views heard  with a short video or audio recording.*  *Name it “2.b Conceptualization”* | | *QR audio* |
| --- | --- | --- |
| **ResearchResearch with solid fill** | **QR audio** | | |

Use your mobile devices (tablets, mobiles, etc.) and scan the QR below.

Watch the video and download the results given by the device for the icon of Virgin Mary by clicking the **"Results"** button.

****

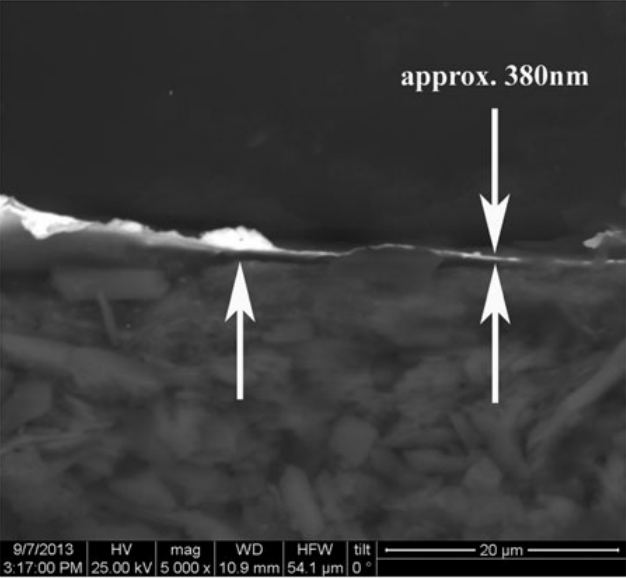
***Discuss with the whole class the results of this particular device***

* In the first point of interest, the sample taken below from the elbow of the Virgin Mary, what do you observe in the SEM image? What does the red layer look like? Can you measure its thickness? How are pigment grains visualized?



***The different black-and-white gradation from the SEM image on the left, depicts the red painting layer (yellow arrow), among the other layers on the Virgin's elbow. We can identify the red pigment grains of the layer (optionally we can measure the width of each painting layer) and we can choose some spots on the layer of interest to continue our research.***

* In the second point of interest, the sample taken from the golden background of the Virgin Mary’s icon, what do you observe in the SEM image? What does the golden layer look like? Can you measure its thickness?



***The SEM image on the left shows the cross-section of the sample from the golden background of the Virgin Mary’s icon (optionally we can measure the width of this layer). We can now locate the layer of golden colour, which is highlighted with the arrows.***

* In the third point of interest, the sample taken from the textile fibers of the worn area in the bottom left corner of the icon, what do you observe in the SEM image? What do textile fibers look like with SEM? What material are the textile fibers made of?

***The SEM image on the left shows the textile fibers in the worn area. The material can be identified from their morphological characteristics. The threads show us that its fibers present a ribbon-like form that seems to be slightly twisted. We compare the SEM image we collected to SEM images from various threads that are used for textiles, and we observe that its features match with those of cotton fibers.***Εικόνα που περιέχει στιγμιότυπο οθόνης, ασπρόμαυρο, μονοχρωματικό, μονοχρωματική φωτογραφία

Περιγραφή που δημιουργήθηκε αυτόματα

| *Describe how the device works and what we use it for with a short video or audio recording.*  *Name it “1.c Research”* | | *QR audio* |
| --- | --- | --- |
| **ConclusionThought outline** | **QR audio** | | |

* **Which one of the three different points of interest, scanned with the SEM method, has the highest magnification? How can we find it?**

**Image 2 has a higher magnification of 5000x. We can directly read the magnification from the information at the image's bottom. We can also calculate the magnification from the given scale.**

***The three images have a magnification of 100x (Image 1), 5000x (Image 2) and 400x (Image 3). We can see the magnification in the information at the image’s bottom. We can also calculate the magnification from the given scale.***

* **Why do we get black and white images?**

**We get black and white images because SEM does not use natural light but electrons.**

***We help the students reach the above conclusion by mentioning the video's information.***

* **Comparing the SEM image of the textile and the data from the table, what do you conclude about the material of the textile?**

**By comparing the SEM image of the icon we are studying with the data from the reference image, we conclude that the textile is cotton.**

***The students conclude that the textile is made of cotton.***

* **What do we observe in the images? Can we make inferences about the ingredients in the points of interest (red color, gold, and textile fibers)?**
* **No matter how high the magnification of the artifact is, it cannot give us clear answers about the ingredients that the red color, the gold background, and the textile fibers consist of.**
* **We assume from the points of different black-white gradation the existence of different materials. So, it would be interesting to use a new technique to determine the components of materials.**
* **So, we select the points where the magnification from SEM shows us that there are different materials to find their components with a new method, EDS.**

| *Record your answers  in three different short videos or recordings.*  *Name them "2.d Conclusion A", "2.d Conclusion B",  "2.d Conclusion C"* | | *QR audio* |
| --- | --- | --- |
| **ConceptualizationQuestions outline** | **QR audio** | |

*Discuss as a whole class.*

**What do we need to do to find the components   
of the points of interest of the object we are studying?**

**What should we recognize?**

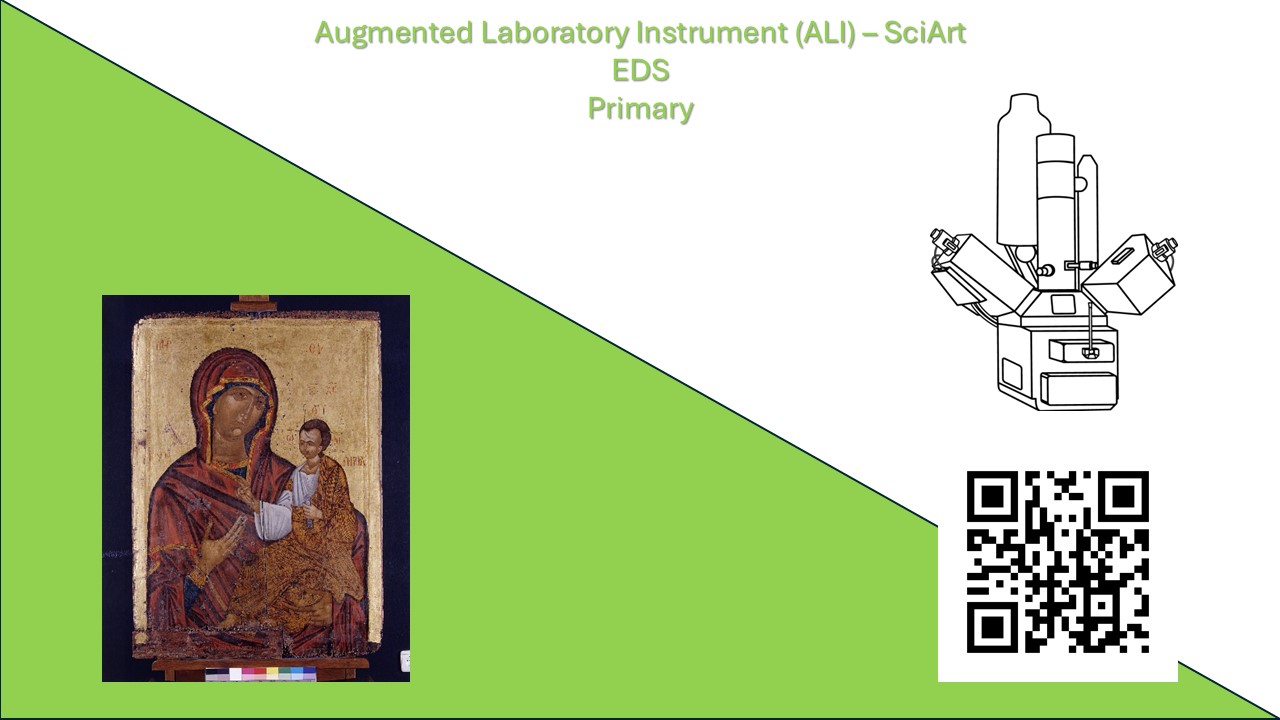
***A class discussion is provoked which leads to the conclusion that the elements from which the materials in the points of interest (red color, golden background, textile) are composed must be identified.***

***The teacher introduces the EDS method for the elemental analysis of the selected points. "EDS is an analytical method used to identify the elements found in a sample."***

| *Record the views heard  with a short video or audio recording.*  *Name it “1.b Conceptualization”* | | *QR audio* |
| --- | --- | --- |
| **ResearchResearch with solid fill** | **QR audio** | | |

Use your mobile devices (tablets, mobiles, etc.) and scan the QR below.

Watch the video and download the results of the method for the icon of Virgin Mary by clicking the **"Results"** button.

****

***Study in your group and then discuss with the whole class   
the results of this particular method***

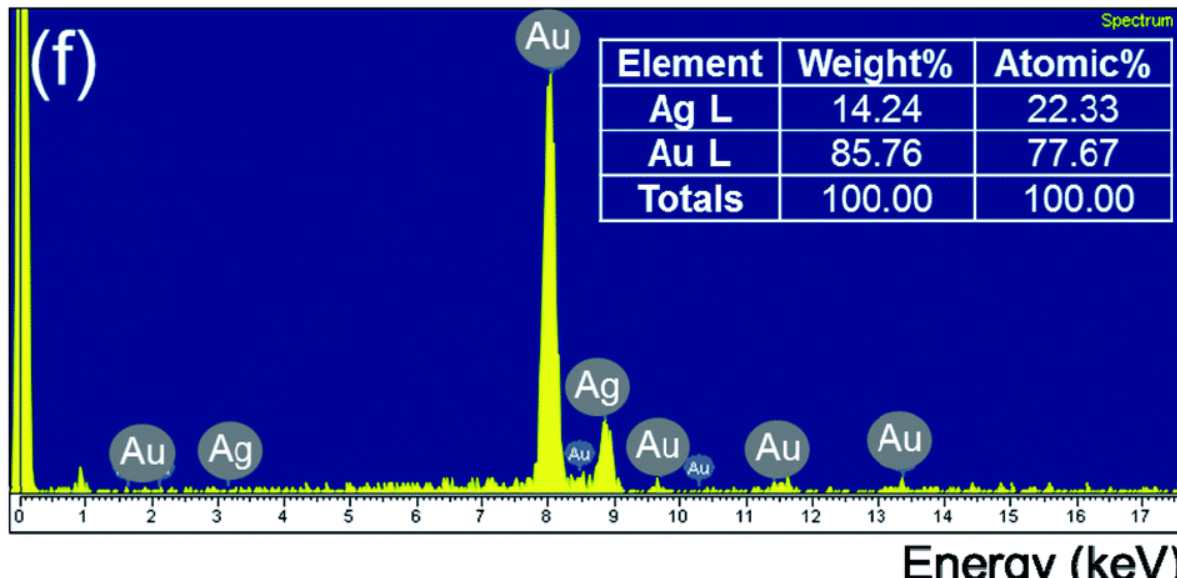
* In the first point of interest, the cross-section taken from the red color layer sample, what do you observe in the EDS spectrum? What elements does it consist of?
* In the second point of interest, the cross-section taken from the gold layer sample, what do you observe in the EDS spectrum? What elements does it consist of?
* In the third point of interest, the cross-section taken from the textile fibers sample in the worn area in the bottom left corner of the icon, what do you observe in the EDS spectrum? What elements does cotton consist of, as it is an organic material?

***Students observe the spectrum and table of elements and identify the elements of the sample.***

***The teacher explains to the students that an EDS spectrum is only obtained by selecting points or points of interest from the SEM images.***



***This is the spectrum from the EDS method for the red paint layer of the point of interest on the Virgin's elbow. It consists mainly of mercury (Hg) and sulfur (S). However, other elements also appear in smaller concentrations, among which iron (Fe) shows the highest, with 5%.***



***This is the elemental analysis conducted on the gold layer of the cross-section of the sample collected from Point of Interest 2. It is a gold-silver alloy, consisting of 80% gold and 20% silver.***

***This is the spectrum we get from the EDS method for the point of interest of the textile in the bottom left corner of the Virgin Mary’s icon. The elemental analysis shows that it consists of carbon and oxygen. This is typical of organic materials. The identification of cotton fibers was already completed by their morphological characteristics with SEM. Here the connection is made that cotton, as an organic material, is composed of O and C.***

Look for materials containing the elements found in our artifact in the source given to you below (QR) and record possible materials that our artifact consists of.

**QR link to the database**

***Students open the database and search for the materials in which the chemical elements (focusing on the ratio of the elements) identified through the method are found.***

***Discuss with your class the results of your investigation from the database.***

| **Name** | **Chemical type** | **Image** |
| --- | --- | --- |
| Cinnabar | HgS |  |
| Corderoite | Hg3S2Cl2 |  |
| Hematite | Fe2O3 |  |

| *Discuss and record how the method works with a short video or audio recording.*  *What results did it give us? What else did we have to do?*  *Name it “3.c Research”* | | *QR audio* |
| --- | --- | --- |
| **ConclusionThought outline** | **QR audio** | | |

List the materials in which the elements are found in our sample in the table below.

| **Points of interest** | **Chemical Compounds** |
| --- | --- |
| The red color on the elbow of the Virgin Mary | **Cinnabar (HgS) or Corderoite (Hg3S2Cl2 )** |
| Golden background on the icon of the Virgin Mary | **Alloy with Gold and Silver** |
| Textile fibers in the bottom left corner of the Virgin Mary’s icon | **Organic compound that confirms in conjunction with SEM results that the textile is made of cotton fibers** |

| *Record your answers  in a short video or audio recording.*  *Explain how you got there.*  *Name them "3.d Conclusion"* | | *QR audio* |
| --- | --- | --- |
| **ConceptualizationQuestions outline** | **QR audio** | | |

*Discuss as a whole class.*

**Is the evidence found in more than one material?   
If so, is there any difference between the materials you can observe in the database?**

***The teacher asks the students to focus on the information given by the database to notice that the materials, containing the elements we are looking for, are located in more than one chemical compound that is different from each other.***

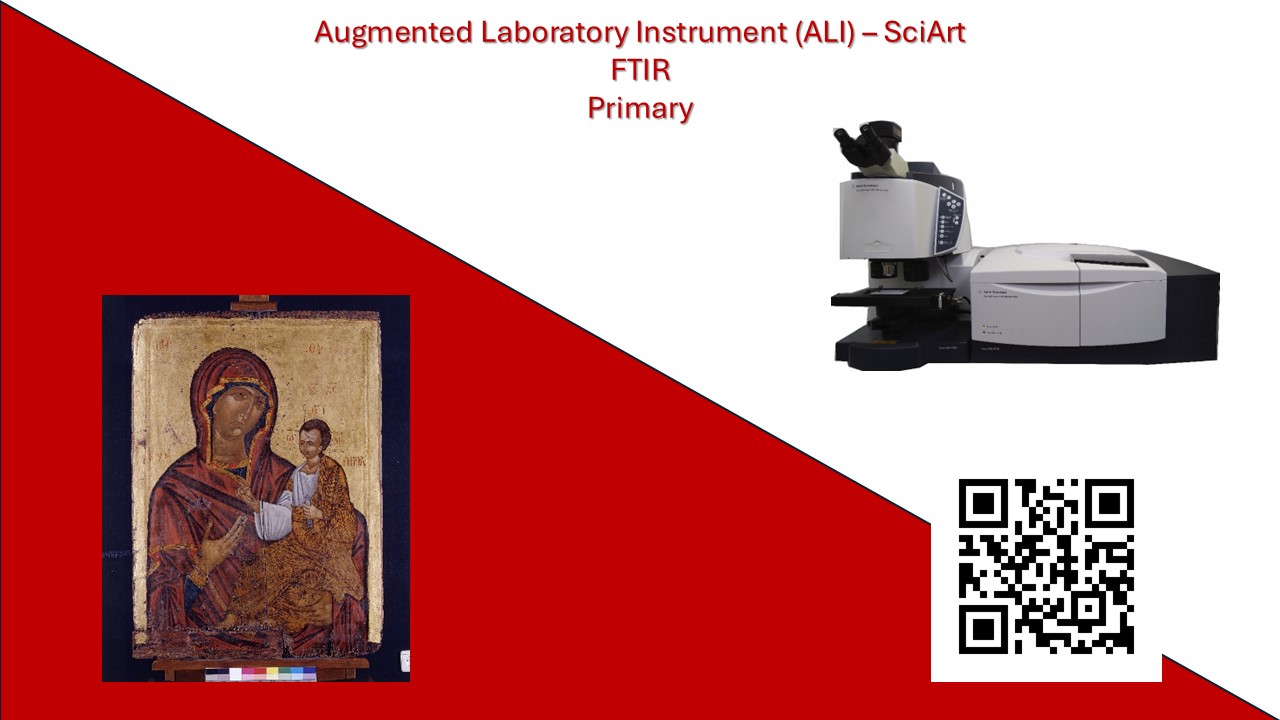
**What do you notice different and what should we identify   
to limit the materials?**

***The above observation makes it necessary to narrow down the possible compounds present in our sample. The discussion highlights the need for further analysis to identify a specific chemical compound. The students will use the FTIR method and discover that this technique provides results only for the textile, not the red color and the gold.***

| *Record the views heard  with a short video or audio recording.*  *Name it “4.b Conceptualization”* | | *QR audio* |
| --- | --- | --- |
| **ResearchResearch with solid fill** | **QR audio** | | |

Use your mobile devices (tablets, mobiles, etc.) and scan the QR below.

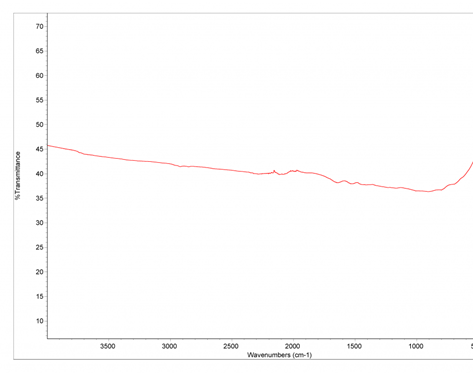
Watch the video and download the results of the method for the image of the Virgin by clicking the **"Results"** button.

****

***Discuss in the whole class the results of this particular method***

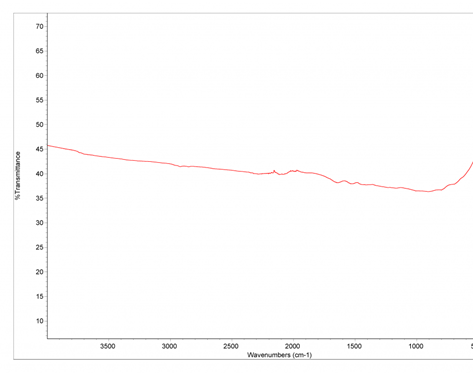
***The teacher informs the students that the FTIR method does not yield results for all materials. Based on the results, only the textile shows a spectrum.***

* In the first point of interest, the sample of the red paint layer, what do you observe in the FTIR spectrum? Does it deliver results?



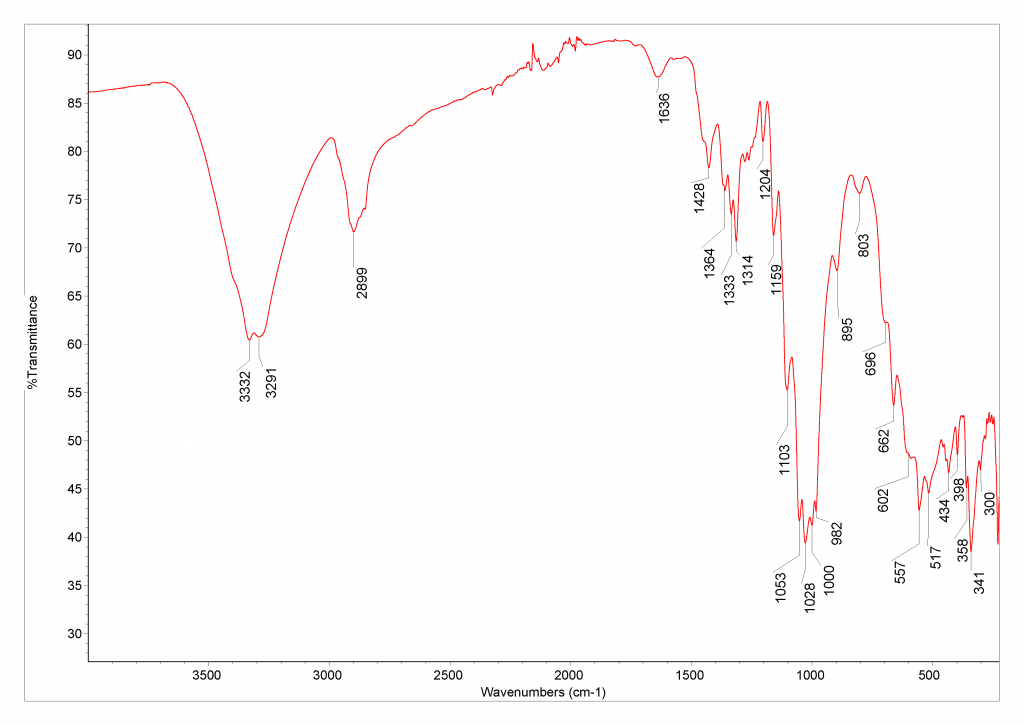
***The FTIR method is not suitable for providing any results. Probably, it is not compatible with the materials present in this specific layer of paint.***

* In the second point of interest, the sample of the gold layer, what do you observe in the FTIR spectrum? Does it deliver results?



***The FTIR method is not suitable for providing any results. Probably, it is not compatible with the materials found in this specific layer of gold.***

* In the third point of interest, the sample of the textile fibers of the worn area in the bottom left corner of the icon, what do you observe in the FTIR spectrum? What type of fiber is cotton textile?



***The FTIR method gives a spectrum with inverted peaks for the textile area of the bottom left corner of the Virgin Mary’s icon indicating that the material is composed of plant fibers. It matches cellulose completely, which is characteristic of plant-based fibers.***

| *Discuss and record how the method works  with a short video or audio recording. What results did we get?*  *Name it “4.c Research”* | | *QR audio* |
| --- | --- | --- |
| **ConclusionThought outline** | **QR audio** | | |

* **Does the FTIR method yield results for all materials? If not, record in the table below the materials for which it did not yield results.**

| **Red color** |
| --- |
| **Gold background** |

* **Which compound was identified in the textile by FTIR?**

| **Cellulose (C6H10O5)** |
| --- |

| *Record your answers  in a short video or audio recording.*  *Explain how you got there.*  *Name them "4.d Conclusion"* | | *QR audio* |
| --- | --- | --- |
| **ConceptualizationQuestions outline** | **QR audio** | | |

*Discuss as a whole class.*

**What can the inability to determine a chemical compound with the FTIR method mean for some materials?**

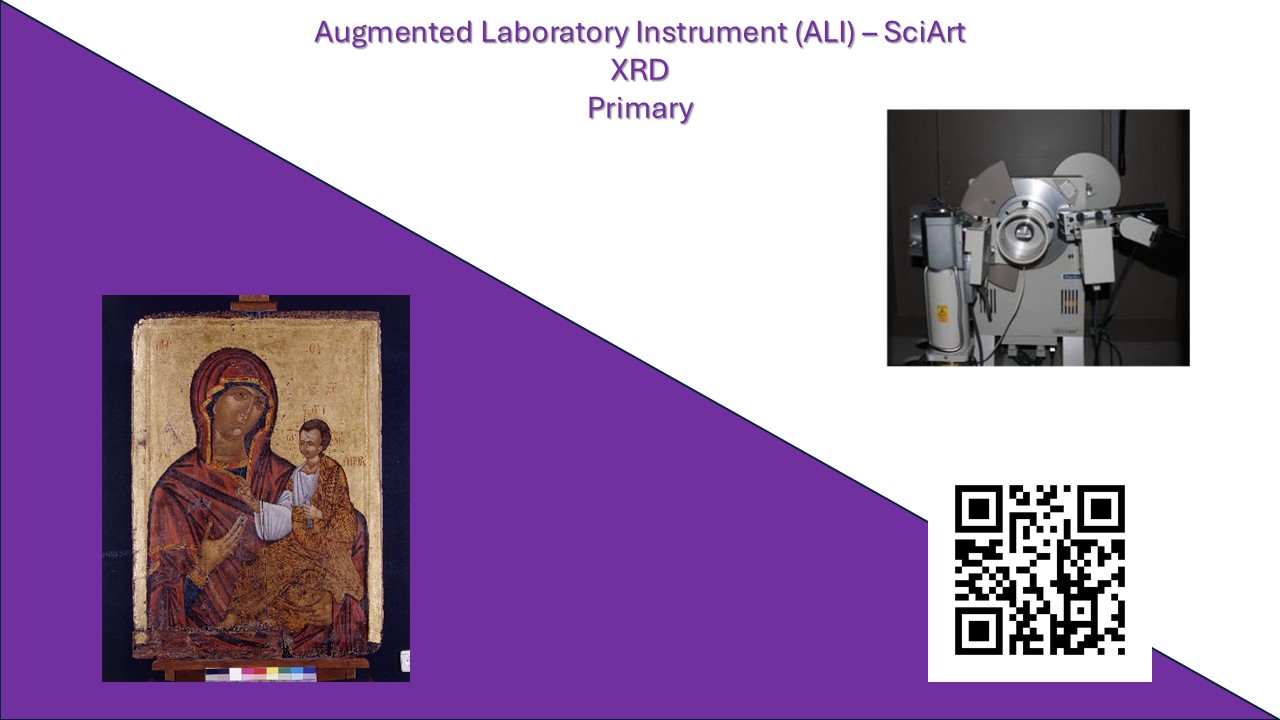
***A discussion is provoked in the whole class to show that each method has its limitations.***

***For this reason, we use more than one method when analysing a sample. There are chemical compounds for which the FTIR method cannot provide results, which is why some of the elements we originally found, using the EDS method, did not appear in our results. In this way, the teacher introduces the need to use another method to accurately determine the composition of materials, namely the XRD method.***

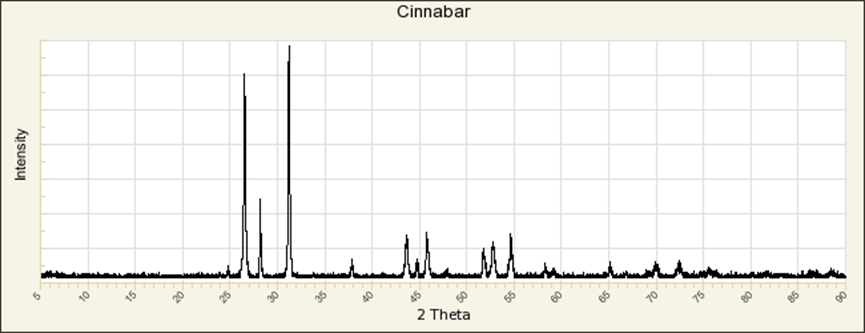
| *Record the views heard  with a short video or audio recording.*  *Name it “5.b Conceptualization”* | | *QR audio* |
| --- | --- | --- |
| **ResearchResearch with solid fill** | **QR audio** | | |

Use your mobile devices (tablets, mobiles, etc.) and scan the QR below.

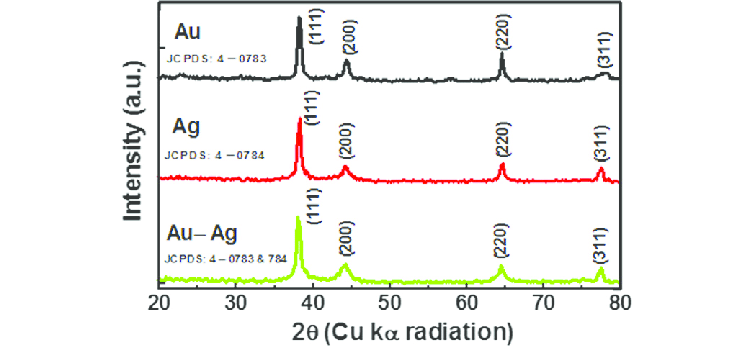
Watch the video and download the results of the method for the icon of the Virgin by clicking the **"Results"** button.

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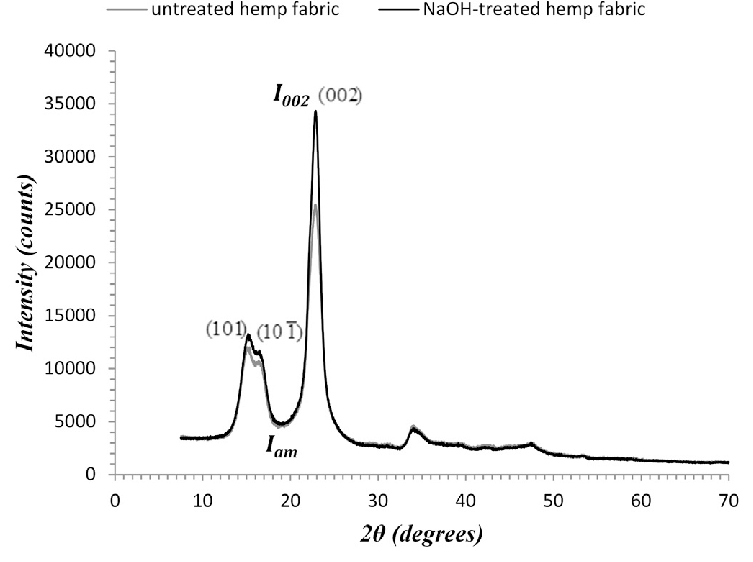
***Discuss in the whole class the results of this particular method***

***Students observe the diffractogram graph. The teacher initiates a discussion about the necessity of researching data from known materials and correlating them with the chemical compounds identified, to determine the specific materials present in our sample.***

***The red pigment used for this paint layer is cinnabar (HgS).***



***The XRD diffraction pattern for the gold layer of the sample confirms the EDS results that we have gold-silver alloy (80% gold and 20% silver).***



***The XRD pattern for the textile confirms that we have cellulose.***

| *Discuss and record how the method works  with a short video or audio recording.*  *What results did we get?*  *Name it “4.c Research”* | | *QR audio* |
| --- | --- | --- |
| **ConclusionThought outline** | **QR audio** | | |

* **Note the material/chemical compound you identified using the XRD method.**

| **Points of interest** | **Chemical Compounds** |
| --- | --- |
| Red paint color on the elbow of the Virgin Mary | **Cinnabar (HgS)** |
| Golden background on the icon of the Virgin Mary | **Alloy with 80% Gold and 20% Silver** |
| Cloth in the bottom left corner of the Virgin Mary’s icon | **Organic compound that confirms, in combination with FTIR results, that the textile is composed of cellulose** |

| *Record your answers  in a short video or audio recording.*  *Explain how you got there.*  *Name them "4.d Conclusion"* | *QR audio* |
| --- | --- |

**Back to the initial questions…**

1. Can we observe in greater detail elements of the 14th-century icon of Virgin Mary (eg clothing, facial expressions and posture, etc.)?

2. What were the main components of the materials used in the 14th-century icon of Virgin Mary?

3. Can these materials give us information about the artist's technique or socio-economic status?

4. Can we compare the materials and the technique used for this icon, with those used today for church icons? Are there similarities/differences?

| **ConceptualizationQuestions outline** | **QR audio** |
| --- | --- |

*Discuss as a whole class.*

**How can we use the conclusions drawn from archaeometric methods to answer the initial questions?**

*Please provide questions that you can ask an AI engine. The answers it gives you, combined with the results you already have, will help address the initial questions.*

| ***The teacher facilitates a class discussion to formulate the questions that students need to address the above questions. Such questions may be:***   * **What is the value of the particular materials and how rare were they?** * **Where are these materials located?** * **With what materials and pigments are church icons made today?**   ***The questions in ChatGPT must be in English because it does not give correct answers in Greek.*** |
| --- |

| *Record the questions you will ask in ChatGPT  with a short video or audio recording.*  *Name it “6.b Conceptualization”* | *QR audio* |
| --- | --- |
| **ResearchResearch with solid fill** | **QR audio** |

Use ChatGPT to get information about the above questions. Record the information you need to answer the questions.

***Searches in ChatGPT must be conducted in English because it does not produce accurate answers in Greek.***

| **Question** | **Main ChatGpt Answer Points** |
| --- | --- |
| What materials and pigments are used for church icons today? | **………** |
| In which geographical areas do we find the mineral cinnabar? |  |
| What is the difference between artificial and mineral cinnabar? |  |
|  |  |
|  |  |
|  |  |

*Discuss as a whole class the answers   
to the specific questions you asked in ChatGPT.*

| *Note the main points of the answers for each question.  Did it help you find the answer?  How;*  *Name it “4.c Research”* | | *QR audio* |
| --- | --- | --- |
| **ConclusionThought outline** | **QR audio** | | |

*Record the answers to the initial research questions.*

| **1. Can we observe in greater detail elements of the 14th-century icon of Virgin Mary (eg clothing, facial expressions and posture, etc.)?** |
| --- |
| ***…….*** |
| **2. What were the main components of the materials used in the 14th-century icon of Virgin Mary?** |
| ***From the samples taken of the points of interest of the church icon, we identified that the red pigment cinnabar was used, that an alloy of 80% gold and 20% silver was used in the background of the icon, and that cotton textile was used.*** |
| **3. Can these materials give us information about the artist's technique or socio-economic status?** |
| ***Since textile was found on the icon of the Virgin Mary, we conclude that it is of high artistic value.***  ***The presence of a Gold-Silver alloy, as well as cinnabar, indicates the use of expensive materials. Therefore, we can conclude that the artist was skilled and that the creation of the image of the Virgin Mary was commissioned by someone of high socio-economic status.*** |
| **4. Can we compare the materials and the technique used for this icon, with those used today for church icons? Are there similarities/differences?** |
| ***Comparison of results from the archaeometric methods applied to the icon with those obtained by the students from the ChatGPT search.*** |

|  | *QR audio* |
| --- | --- |

**Create a video of your answer to each   
interview question.**

**One or the other of you will ask the question**

**and one or the other will answer!!!**

*Name the videos "Final Answer 1", "Final Answer 2", etc.*