irresistible

Responsible Research and Innovation (RRI)

Applications of nanomaterials in museum research

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Universitatea Valahia din Targoviste

Applications of nanomaterials in museum research

An educational module for sciences lessons for secondary education, developed by researchers from Prahova Natural Science Museum and a Professor from Târgoviște, Romania.

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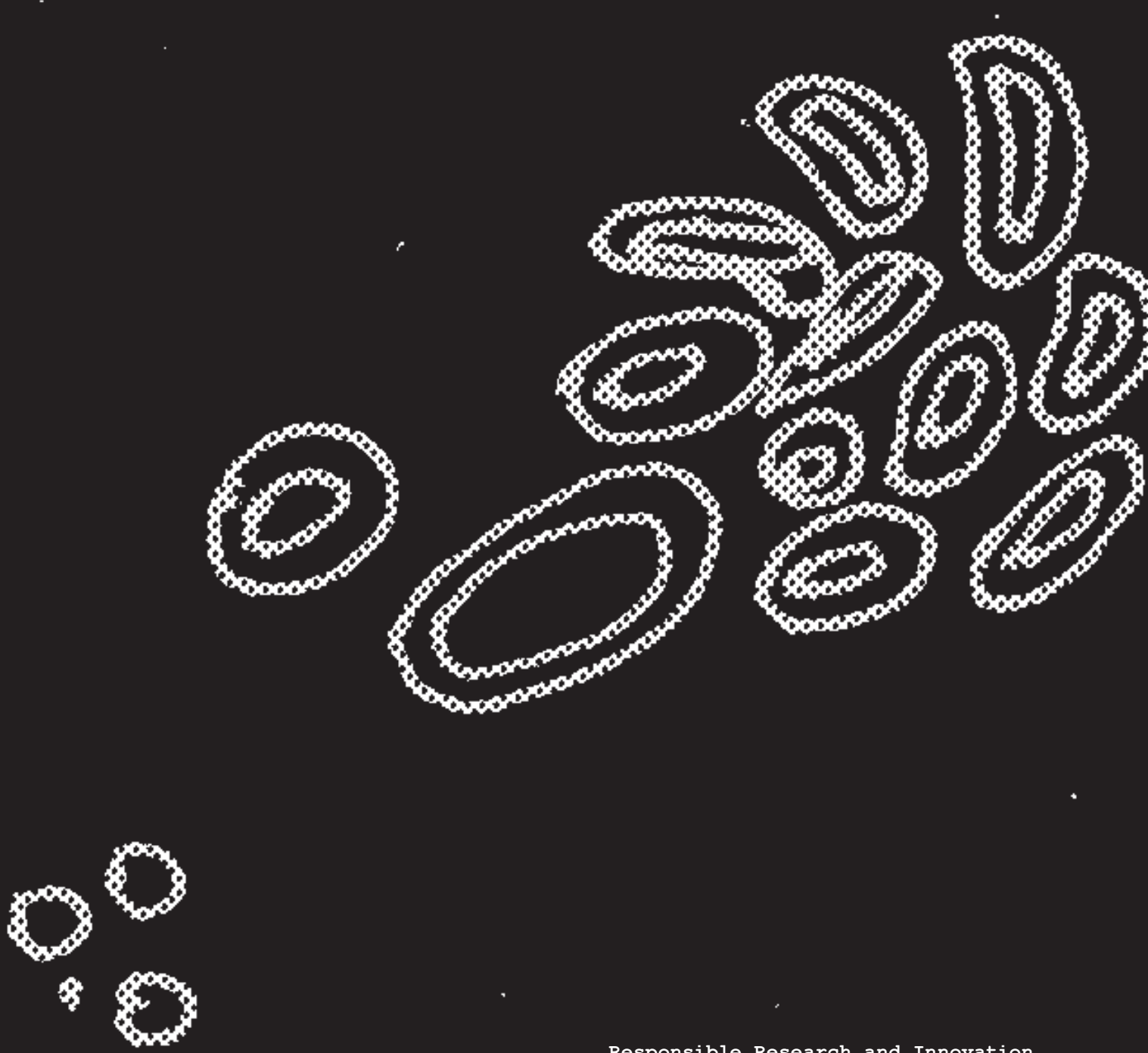


1 Overview

Applications of nanomaterials in museum research

The activities under this topic are designed to increase students' awareness regarding the existence of natural nanomaterials. This involves the development of experimental activities to distinguish the nanoparticles from the natural nanomaterials and to identify the correlation between their structure, functions and use at industrial level.

Overview

Grade/Educational level	Secondary education
Domain	Science
Theme / themes of non-formal activity:	**Applications of Nanomaterials in Museum Research**
Educational objectives	**Educational objectives:** O1. Description and explanation of phenomena in the physics solids, respectively the science of nanomaterials. O2. The understanding of the theoretical aspects about nanomaterials. O3. The understanding and use of concepts in the science of nanomaterials. O4. The experimental investigation of the use of nanomaterials in the museum restoration and conservation practice. **Operational skills:** At the end of the activity the students will be able to: 1. Demonstrate the existence of natural nanomaterials; 1.1 Demonstrate experimentally the nano structure of nanomaterials. 2. Understand the correlation between the structure and the function of these natural nanomaterials; 2.1 Explain the changes from a structural point of view, 3. Understand the importance of natural nanomaterials; 3.1 Exemplify concrete situations in which nanomaterials have applicability (e.g. museum restoration and preservation) 4. Explain the physical mechanism of using nano solutions in the practice of museum research. 4.1 Show a responsible attitude towards environmental protection through the use of such materials.

Required preconditions		**Knowledge required:** Concepts, principles about the science of nanomaterials; Methods and techniques used in the experimental scientific investigation in the field of nanomaterials. The effects of the technological phenomena and processes derived from the science of nanomaterials on the beings and the environment. **Skills / Abilities:** The learning and use of the information by involving a multitude of mental and practical operations; Critical thinking; The use of intuition; Creative approach to specific problems of the science of nanomaterials; Teaching and working in modules; Solving scientific problems; The conduct of organized sets of mental and manual operations required for scientific investigation; Teamwork; The safe use of tools, instruments and devices in various contexts; The use of terms specific for the science of nanomaterials in a variety of communication contexts; The use of different methods of learning and presenting information; The use of ICT tools; Compliance with and application of protection and safety rules; Prediction of the effects of some specific actions on the beings and the environment. **Attitudes:** Respect for truth and rigor; Confidence in scientific truths and critical assessment of their limits; Interest, curiosity and personal initiative; Critical and self-critical spirit; Tolerance of others' opinions; Desire for information and assertion; Respect for scientific argumentation; Interest in exploring different means of communication, including those created by using ICT; Care for oneself, for the others and for the environment.
Procedural resources (teaching strategy)	Teaching-methods and procedures	**Methods:** the IBSE Method; the 6E -Method **Procedures:** Presentation; Presentation of ICT tools; Conversation; Problem solving; Practical work.
	Educational means	Coursebook and bibliography; Worksheets; Evaluation sheets; Presentation boards; ICT instruments; Materials and tools necessary for practical work
	Forms of non-formal work	Individual work; frontal work; teamwork
Estimated time		4 hours

Summary

The activity on the topic “The Use of Nanomaterials in Museum Research” is structured in the following sections:

A. Theoretical work entitled: “Uses of nanomaterials in museum restoration and preservation”, organised in three sections;

• Section I

Terms. Generalities.
Nanometric structures.
Properties of nanometric structures.
Examples of nanomaterials which are being studied at present.
Viewing of nanometric structures.
Risks of nanotechnologies.

• Section II

Strategic directions in the field of nanomaterials and nanotechnologies.
Fields of application.
Industrial potential.

• Section III: Nanomaterials for museum restoration and conservation.

Example: “Analytical analysis of the foundation and elevation mortars taken from the ditch on the north side of St. Vineri church in Târgoviște, Dâmbovița County”.

B. Experimental, practical work entitled: ”Uses of nanomaterials in museum research, with three experimental activities:

• The dosage of sulphates in a material which is to be restored by obtaining a nano substance.
• The dosage of chlorides in a material to be restored by obtaining a nano precipitate.
• The hydrophobic impregnation of lime with a nano solution of the SurfaPore®FX type.

C. The students’ creative activity during which they will use all the knowledge acquired during the other activities.

• The creation in groups of students of portfolios including theoretical aspects and different uses of nanomaterials.
• The creation of an informative material on all activities undertaken and whose purpose is the dissemination of the acquisitions in knowledge which is posted on various websites and in particular on the website of the institution organizing the activity, namely the Museum of Natural Sciences, Prahova.
• The creation of an exhibition with images, videos and samples (limestone blocks) obtained as a result of the activities of the project.
• The posting of all of the above on the website of the Museum of Natural Sciences and on other popularization or social networks.

Sections	
1. The plan of the non-formal activity	The activity / planned operation is described; the spatio-temporal landmarks used and the learning results are indicated; procedural resources (methods, processes, resources) used are specified; the methods, techniques and evaluation tools applied are mentioned.
2. The teacher's guide	The non-formal training strategy pursued by the proponent is described. A minimum theoretical pocket summary is created and the appropriate investigation framework is described for the topic under discussion.
3. Evaluation	**The methods, techniques and tools used in the context of the formative evaluation are detailed, e.g.: feedback questionnaire, self-evaluation essay, peer tests, systematic observation sheets of the students' behaviour and work, portfolio etc.**

This activity promotes the students' scientific education through non-formal education strategies. It also includes research and responsible innovation (RRI) connected with the proposed topics. In this regard, the students (together with their trainers) create / design specific exhibits in accordance with the topic / topics proposed and the principles of RRI. These exhibits will be presented at the Science Centres, Museums, Libraries, etc.

The uniqueness of the activities included in the IRRESISTIBLE Module lies in using non-formal learning experiences dedicated to Science in a format which involves a 6-step Model. To ensure that the proposed objectives are achieved, this research starts from a real-life situation, developing further the connection between this one and the specific content of Sciences, so as to satisfy the learning needs of the students.

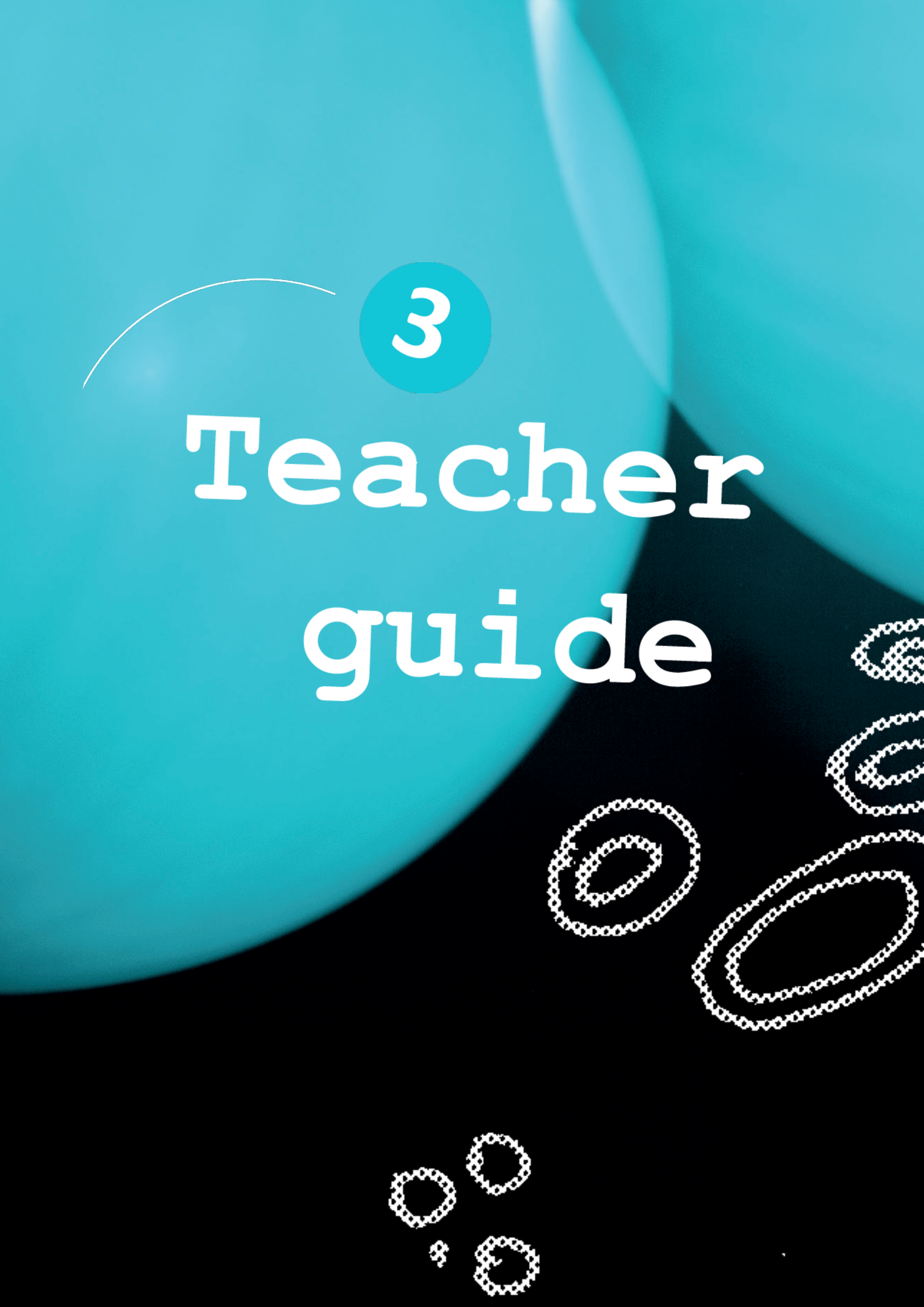
The uniqueness of the activities included in the IRRESISTIBLE Module is also ensured through:

- The motivational title – aimed at a problem taken from reality, likely to generate a socio-scientific approach;
- teaching subtasks cantered on IBSE and RRI – whose aim is to facilitate the learning of the scientific knowledge by students;
- Student-centred approach aimed at solving a problematic situation, providing student training / skill development, in line with the needs of society and the principles of responsible citizenship;
- Appropriate use of scientific knowledge, skills, in general in the context of an investigative approach centred on the 6E model;
- The use of Web 2.0 technologies in the investigative (exploratory) approach, but also for communication and presentation of results.

Educational scenario

Steps of non-formal activity/ time management	Educational objectives	Proposed activities	Non-formal Learning activities
1. Engage 1 h	O1	The trainer presents a theoretical content and discuss with the students about the content	The students listen to the trainer presentation, discuss about it and carry out the work asked by the trainer
2. Explore 1 h	O4	The trainer presents the materials necessary for the experiments and the stages of the experimental work and monitors the students' activity.	The students carry out the experiments and take pictures during and after the experiments.
3. Explain 40 min	O2	The trainer answers the questions which have been asked by the students and placed on the presentation board	The students listen to the trainer's answers and ask for further clarification and complete the portfolio plan, in groups.
4. Elaborate 40 min	O3	The trainer asks the students to design the portfolios according to the plan made and provides information and support to the students to create an information sheet.	The groups of students create the portfolios according to the plans proposed during previous work and draw up an information sheet on the portfolio
5. Disseminate / Share / Present / Expose 45 min	O3	The trainer asks the students to make a model exhibition. Together with the curators of the museum helps the students to create the exhibition.	Each group of students makes a model exhibition. The students create the exhibition and take pictures and make videos about the exhibition.
6. Evaluate 20 min	O1, O2, O3, O4	The trainer asks the students to present all their products.	The students answer the questions presented in the evaluation sheet and in the satisfaction questionnaires

The results of non-formal learning	Non-formal activity strategy			Evaluation
	Teaching methods and procedures	Means of education	Forms of organisation	
- personalized written material for each student. - the post-it notes presentation	- the IBSE method - the 6 E method - the RRI principles	coursebook. ITC tools; PC and beamer, white board, presentation board	individual, frontal	presentation board evaluation activity evaluation made by students (interest and evaluation sheet)
A set of video documents and photographs relating to the results of the practical work A samples of limestone block	- the IBSE method - the 6E method - the RRI principles - experiment - observation	Laboratory equipment 5% barium chloride solution; 1%Calcium sulfate solution, cover glass (equal in number to the number of students), 5 ml pipettes, 2% silver nitrate solution, 1%sodium chloride solution, camera, stereomicroscope, samples of limestone block equal (in number to that of the students), magnifying glass, atomiser, broad brushes, wash bottle, carpentry pencil, ruler	frontal, individual	evaliation by questionnaire
portofolio plan	- the IBSE method - the 6E method - the RRI principles - dialogue, conversation	- presentation board - ICT tools; PC with internet connection - writing paper - students' notes regarding previous activity	individual, in groups	Portfolio plan evaluation (satisfactory, good, very good).
Portofolio and information sheet	- the IBSE method - the 6E method - dialogue, conversation	- the portfolio plan made during the previous activity - writing paper - ICT tools to post the information material.	individual, in groups	Portfolio and the information sheet evaluation (satisfactory, good, very good).
Exhibition, pictures and video of the exhibition	the IBSE method method - explanation, dialogue, conversation, explanation	- writing paper - videos, photos and samples - Exhibition boards and showcases - ICT tools	individual, in groups	Exhibition evaluation
The students answers	- the IBSE method - the 6E method - individual work - experiment - practical work	- writing paper - camera - ICT tools - equipment necessary to create the exhibition - display boards	- individual - in groups - frontal	Summative assessment of each student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Teacher guide

Teacher guide

This non-formal activity allows the students to acquire / and to form new knowledge, skills, attitudes, etc. related to:

a) the demonstration of the existence of natural nanomaterials, to experimentally outline the nano-structure of nanomaterials;

b) the understanding of the correlation between structure and function for these natural nanomaterials, to explain the changes from a structural point of view;

c) the understanding of the importance of natural nanomaterials, to exemplify the concrete situations in which nanomaterials can be used (e.g., museum restoration and preservation);

d) the explanation of the physical mechanism of using nano-solutions in the practice of museum research, to show a responsible attitude towards environment protection through the use of such materials.

1. Engage

Trainer

The trainer presents the topic 'Uses of nanomaterials in museum restoration and preservation' in PowerPoint format with the following content:

Section I: 1. General Terminology. 2. Nanometric structures 3. Properties of nanometric structures 4. Examples of nanomaterials 5. Viewing of the structures 6. Risks.

Section II: 1. Strategic directions in the field of nanomaterials and nanotechnologies 2. Applicability fields 3. Industrial potential.

The trainer asks the students to propose questions about the contents presented, at least one question per student note it/them on post-it notes and to propose criteria to place the post-it notes containing questions about the lesson contents on the model presentation board.

The trainer asks the students to negotiate, by using arguments, the most effective criterion to create the presentation board.

A PowerPoint (ppt.) presentation about the materials used in museum conservation and restoration is shown.

Section III:

1. Nanomaterials used in museum restoration and conservation

2. Example: practical study: ''Analytical analysis of the foundation and elevation mortars taken from the ditch on the north side of St. Vineri Church'' in Târgoviște, Dâmbovița County''.

Atudents are invited to ask questions about the contents presented.

The students are asked to propose criteria for the classification of the questions in order for these to be placed to a presentation board and to negotiate the choice of an efficient classification criterion for the questions (e.g. general issues on nanomaterials used in analytical investigations necessary for conservation and restoration, issues related to the practical example)

The post-it notes with questions regarding Section III are placed on the presentation board.

The trainer proposes the students an experimental activity, telling them that they will better understand the contents presented through the experimental example and presents the theoretical and material resources necessary for the experiment

Theoretical resources:

- Museum restoration knowledge
- knowledge of chemistry on sulphates, chlorides, limestone and its forms

Experimental Resources:

- knowledge about the experimental operations of dosing and impregnation;
- knowledge about tools and laboratory equipment;

Students

The students listen to the presentation, write down the key concepts and issues they consider important. They also write down on the post-it notes their questions about the contents presented. The students propose criteria to place their questions on the presentation board (for example, according to the theoretical issues criterion or the problem solving criterion).

They negotiate, by using arguments, on the most effective criterion used in order to create the

presentation board. They choose the most effective criterion to design the presentation board and complete the presentation board according to the criterion they have chosen.
The students write down the information that they consider important and write on a post-it note questions about the contents presented, at least one question per student. The students propose criteria for the classification of their suggested questions.
The students give arguments and negotiate on choosing an effective criterion for the presentation of the post-it notes containing questions and their placement on the presentation board. The students place the post-it notes containing their proposed questions on Section III on the presentation board. The students listen to the trainer and write down the new knowledge

At the end of the activity, each student will have personalized written material on the contents presented by the trainer. The students will make a presentation of the post-it notes where they wrote questions and issues and which are placed on a presentation board.

At the end of the activity, the trainer will evaluate the presentation board rating the questions suggested by the students. The trainers will ask the students to evaluate the activity through filling in answers on a student interest and evaluation sheet. This evaluation sheet will include the following questions: '' Have you found the contents presented interesting?''; '' Was the presentation clear enough?''; '' How do you evaluate the trainer's work?'';
The students will answer the questions by giving marks on a scale from 1 to 10.

2. Explore

Trainer

- The trainer proposes the students the experimental work having the title: "The uses of nano-materials in museum research" and presents the sections of the practical work:
I. The dosage of sulphates from a material which is due to be restored by obtaining a nano substance;
II. The dosage of chlorides from a material to be restored by getting a nano precipitate;
III. The hydrophobic permeation of limestone with a SulfaPore® type nano solution;

- The trainer presents the students the materials needed for the first practical work: the dosage of sulphates from a material to be restored by obtaining a nano substance;
The materials required are:

- 5% barium chloride solution,
- 1% calcium solution sulphate,
- cover glass,
- 5 ml pipette,
- stereo microscope with a camera

The stages of the experimental work:
1. with a pipette, the students take a drop of 1% calcium sulphate solution and put it on the cover glass.
2. it is viewed through the stereomicroscope.

3. the photograph is taken.
4. two drops of 5% barium chloride are added.
5. it is viewed through the stereomicroscope and the occurrence of a light (nanomaterial) white precipitate is remarked. This is the barium sulfate.

The trainer gives the students the required materials, namely one cover glass for each student, and puts the containers with barium chloride 1% and calcium sulfate 5% on the tables. The trainer introduces the stereomicroscope to the students and invites students to carry out the experiment shown, individually, while monitoring them. He asks the students to take pictures both during the experiment and also at the end of it, focusing on the results. The trainer shows the students how to interpret the results of the experiment: the presence of sulphites is proven by the occurrence of a light (nanomaterial) white precipitate, which is barium sulfate.
The trainer continues with the preparation of the 2nd section of the practical work, namely ''The dosage of chlorides from a material to be restored by obtaining a nano precipitate''.
The materials required are:

- 2% silver nitrate solution
- 1% sodium chloride solution
- cover glass
- 5 ml pipettes
- camera stereomicroscope

The stages of the experimental work:
1. a drop of 1% sodium chloride solution is taken with the pipette and it is put on the cover glass
2. it is observed under the stereomicroscope
3. the photograph is taken
4. 2 drops of 2% silver nitrate solution are added
5. the result is observed under the microscope and the appearance of a voluminous white precipitate (nanomaterial) is noticed , which is in fact the silver chloride
The trainer monitors the students during the practical work and asks the students to take pictures during each step of the experiment and also at the end of it when the results are shown. The trainer shows the students how to interpret the result; the presence of chlorides is proven by this milky white precipitate which appeared together with the formation of the nanomaterial
The trainer presents the students Section III of the practical work, more precisely, ”The hydrophobic permeation of limestone with a SulfaPore® type nano solution for effective protection of historical monuments”.
The materials required are:

- a 2l bottle of SurfaPorex® FX
- polished limestone plates (one per student)
- broad brushes
- atomizer
- wash bottle

- carpentry pencil
- ruler
- magnifying glass
- camera

The stages of the experimental work:
1. a plate of limestone is taken
2. a line is drawn in the middle of the limestone block
3. the SurfaPore®FX solution is sprayed with the atomiser on the left half of the block
4. it is put aside for about 30 minutes to polymerize
5. tap water is sprayed on both parts of the limestone plate. (left / right)
6. It is noticed that water forms liquid beads and slides on the left treated side, while the right side is wet.

The trainer monitors the students during the practical work and asks the students to take pictures during each step of the experiment and also at the end of it.
The trainer shows the students how to interpret the results of the practical work: the nanoparticles have the ability to self-polymerize and create a waterproof 3D network that permanently binds with the pores of the surface on which they have been applied to prevent water permeation.
The trainer asks the students to make questions about the practical work they have performed and write them down on some post-it notes.
The trainer asks the students to place the post-it notes with the questions about the practical work on the presentation boards.

Students

The students listen to the trainer's presentation and note down the steps of the experiments than carry out the actual experiments, under the supervision of the trainer and following the steps presented by the trainer. The students get the result indicated by the trainer and take picures and make videos of the experimental results also obtained during the experiment.

At the end of the experimental work the students will have a set of video documents and pictures relating to the results of the practical work of each section during the experiments. The students will have also samples of limestone block on which they carried out section III of the practical work.
At the end of the practical work the trainer will ask students to fill in a questionnaire on their satisfaction level, which will include the following questions: ''What problems did you encounterduring the practical work?'' ''What stage of the practical work was the most interesting? ''

3. Explain

Trainer

The trainer proposes the students to return to the presentation boards on which are placed the

post-it notes containing the students' questions regarding both the theoretical presentation of nanomaterials as well as the practical work. The trainer suggests the students to think about possible answers to the questions they have asked. He answers the questions which have been asked by the students and placed on the presentation board. The students organize themselves into groups, the criterion for grouping being the common topic of the questions placed on the presentation board.

The groups are asked to make a plan of a portfolio containing the following information:

- the topic of the questions
- the questions subsumed to the topic placed on the presentation board.
- the answers given by the trainer
- questions which possibility extend to other topics
- suggestions for new issues unexplored yet
- suggestions for new practical work

The trainer suggests the students to use ICT for information.

Students

The students listen to the trainer’s answers and ask for further clarification. They form groups and complete the portfolio plan.

The students propose new topics to be researched and new questions that can become research topics.

The students will present the group portfolio plan; one portfolio for each group. This will be evaluated by the trainer by rating it (satisfactory, good, very good).

4. Elaborate

Trainer

The students are asked to design the portfolios according to the plan made during previous work. They have to create an information sheet to be presented to the other groups.

The trainer asks the students to make observations and suggestions with regard to these information sheets. He provides information and support to the students to achieve this information sheet. The groups of students discuss these materials, the aim of the discussions being their improvement so as to be posted on the website of the organizing institution.

Students

The groups of students create the portfolios according to the plans proposed during previous work and draw up an information sheet on the portfolio and the acquisition in knowledge they have gained during their activities. The students communicate both within their group and with the other groups.

The student groups will present their portfolios and will post the material containing information about their knowledge acquisitions from the activities in which they have been involved. The trainer will assess the portfolio and the information sheet by rating them (satisfactory, good, very good).

5. Expose

Trainer

The trainer proposes the students to make an exhibition which will include images, comments and samples of practical work. The trainer asks each group of students to make a model exhibition and to make the display boards according to the model proposed using all the material they have obtained during the activity.
The trainer together with the curators of the museum helps the students to create the exhibition. The students are asked to take pictures and create video documents to be posted on the website of the institution.

Students

Each group of students makes an model exhibition using pictures, comments and samples resulting from their participation in all activities. They create the display boards. Under the guidance of the trainer and the museum curators, the students create the exhibition.
The students take pictures and make videos about the exhibition to be posted both on the website of the institution and on the social networks.

The exhibition organized by the students will be assessed by ratings (less interesting, interesting, very interesting by the other guests who will see the exhibition and who participate in the project. They will complete a questionnaire with the questions; ,, How do you assess display board no. 1? ', '' How do you assess display board No.2?", etc.

6. Evaluate

Trainer

The trainer asks the students to present: evaluation sheets, satisfaction questionnaires, the portfolio of the whole activity (made in groups), the model exhibition, the information sheets necessary for the dissemination of the results of the activity by posting them on the organizing institution's website and on other sites, the exhibition at the end of the activities

Students

The students answer the questions presented in the evaluation sheet and in the satisfaction questionnaires. The groups students create one portfolio for each group which will include all the knowledge the students have acquired during activities and an information sheet to be posted on various websites. The students will make an exhibition using all their acquisitions during the activities.

At the end of the whole activity the trainer will make a summative assessment of each student and will give a final mark (satisfactory, good, very good, excellent).

The results of non-formal learning

1. customized written material for each student on the theory and applications of nanomaterials and nanotechnologies.
2. proposed questions and issues that will be presented on post-it notes and made available to all participants in the project, their content being the theoretical and practical aspects of nanomaterials.
3. At the end of the experimental activity the students will have learnt laboratory techniques and have a set of video documents and photos on the stages and results of each section of the practical activity.
4. a portfolio containing theoretical and applied topics in the field of nanomaterials.
5. experience in communication and formulation of scientific problems.
6. informative material on aspects of nanoscience and its application in museum research, which is required to disseminate the information about the activities carried out.
7. exhibition of pictures and reviews of the project activities.
8. communication and interaction with experts, peers and the general public through the exhibition and the web pages where students involved in the project post the materials.

Recommended training methods

The strategies of the formal activities used are:

- the IBSE strategy
- the 6E model
- the RRI principles.

During the theoretical and experimental activities, the IBSE strategy, the 6E model and the RRI principles will be put together in the following way:

- The theoretical work entitled 'Uses of nanomaterials in museum conservation and restoration` responds to the involvement stage in the 6E model and covers stages 1,2,3,4 in the IBSE strategy; theoretical issues related to the science of nanomaterials are presented, the problem of these applications is raised and presented, especially related to museum research, and questions are asked.
- The experimental activity is related to the exploration stage within the 6E model and to stages 5,6,7,8 of the IBSE strategy; the theoretical and material resources necessary for the experiments are presented and discussed; the experiments are conducted and new questions are raised about the topic.
- The activity during which a portfolio, information sheets and an exhibition are created is related to the Explanation, Development and Dissemination stage within the 6E model and stages 8,9,10 and 11 of the IBSE strategy; the students review the questions they have proposed to be solved and offer solutions using the results of experimental work, the trainer’s guidance and the information they have gathered while using the ICT tools. Also the dialogue and interaction with experts, colleagues and the public is beneficial for training skills related to the scientific research activity.

3- Teacher guide

The students will realize the importance of scientific education for research and the development of the society and, furthermore, the ethical implications, due to the ethical issues involved in research and innovation. The students will understand the need for everybody's access to the results of scientific research and thus will realize the role that policy makers have to ensure compliance with ethical principles of scientific research and also everybody's access to the discussion of these problems.

The students will participate in the project in mixed groups of boys and girls, thus understanding the need to enforce the principle of gender equality in research and innovation activities.

Aimed educational objectives

Aimed educational objectives	Non-formal learning activities
1. Description and explanation of some in physics and chemistry of solids phenomena, respectively the science of nanomaterials.	The presentation of theoretical content.
2. The understanding of the theoretical aspects of nanomaterials and nanotechnologies.	- Investigation through interrogation; proposal of theoretical and application questions and problems related to the field of nanomaterials. - The students' investigation, through documentation using ICT tools, of the answers to the questions and suggestions for solutions to the research problems also raised by the students. - The creation in groups of students of a portfolio on research topics proposed by the students.
3. The understanding and use of the concepts of the science of nanomaterials.	- the creation of an informative material by groups of students on the activities done during the project. - the creation by the students of an exhibition presenting all the activities related to the project.
4. Experimental investigation of some uses of nanomaterials in the practice of museum restoration and conservation.	The performance of the following experiments: • The dosage of sulphates from a material to be restored by obtaining a nano substance. • The dosage of chlorides from a material to be restored by obtaining a nano precipitate. • Hydrophobic lime impregnation with a nano solution of the SurfaPore®FX type.

For the learning activities proposed in this non-formal activity, it is assumed that students:

- Know the concepts of ''phenomenon'' and ''process'' in physics and chemistry
- Have basic knowledge of solid physics; crystal structure
- Have basic knowledge of salts in chemistry
- Have basic knowledge about laboratory utensils and chemical reactions
- Have basic knowledge about safety rules in the chemistry laboratory

Evaluation

The evaluation strategy can be designed for the subtasks of the non-formal approach being tailored to suit their needs.
The use of feedback questionnaires, self-evaluation essay, peer tests, systematic observation sheets of the behaviour and activity of students, portfolio etc. are recommended.
The evaluation of the students' work within the non-formal sub-tasks is aimed at (the aims of this approach are mentioned):
a) to assess the degree of specific skills acquired by students through the use of the 6E model and the IBSE method;
b) to assess the level of student interest in the proposed activities;
c) to assess the students' level of satisfaction after their participation in the proposed activities;
d) to assess the degree to which students have learned the RRI principles;

Evaluation strategies

- Formative
- Summative
- Self-evaluation

Tools used for evaluation

Examples: feedback questionnaire, self-evaluation essay, peer tests, systematic observation sheets of the students' behaviour and work, portfolio etc.
1. For the implementation stage; formative strategy, individual assessment of each student is done by assigning ratings (on a scale from least interesting / average interesting / very interesting / excellent) and by the ''Student interest and satisfaction assessment sheet", in which students are asked to answer to the following questions; "Was the information presented interesting?"', "Was the presentation clear enough?", "How do you evaluate the trainer's work?".
2. For the exploration stage; individual; through a satisfaction assessment questionnaire containing the following questions: "What problems did you encounter during practical work?', 'What stage of the practical work was the most interesting?".
3. For the explanation stage; portfolio plan assessed by the trainer by awarding ratings (satisfactory, good, very good).
4. For the development phase; portfolio and information material needed for the dissemination of the information about project activities evaluated through ratings (sufficient, good, very good).
5. For the dissemination stage; each display board of the exhibition will be evaluated by the other participants in the project through an evaluation questionnaire, containing the following questions; "How do you assess display board no.1?", "How do you assess display board No.2?", and so on, depending on the number of presentation boards.
6. For the evaluation stage the trainer will assign a final rating (satisfactory, good, very good, excellent) to each student at the end of the whole activity.

4 Sources

Sources

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The websites were consulted between August and November 2014

5 Colophon

Colophon

IRRESISTIBLE is a project on teacher training, combining formal and informal learning focused on Responsible Research and Innovation. It is a coordination and support action under FP7-SCIENCE-IN-SOCIETY-2013-1, ACTIVITY 5.2.2 Young people and science: Topic SiS.2013.2.2.1-1 Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education. The project IRRESISTIBLE is funded by the EU as FP-7 project number 612367

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