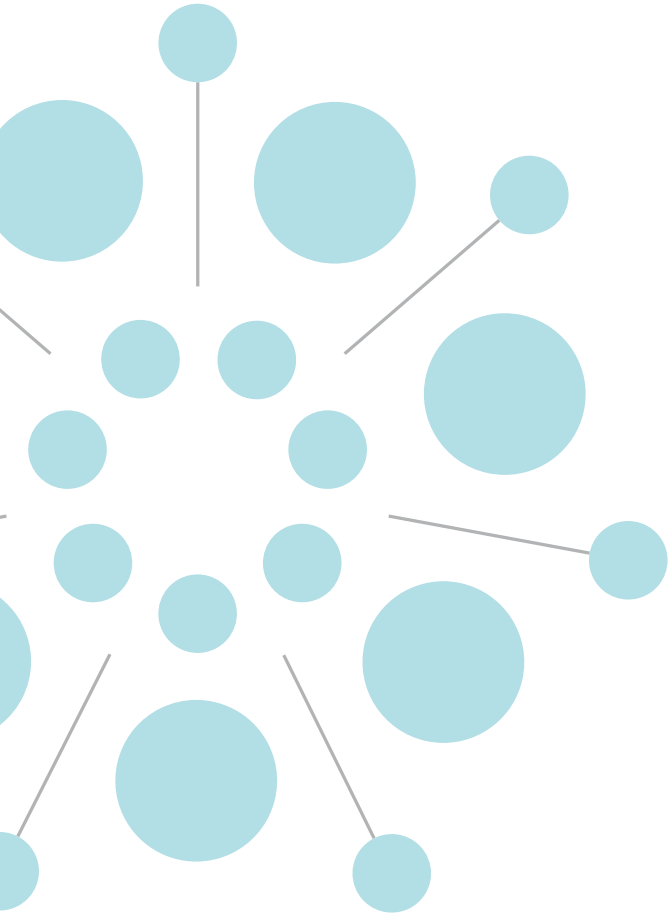
irresistible

The project bringing Responsible Research and Innovation into the classroom



irresistible

The goal of the project IRRESISTIBLE is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI).

To raise the awareness on RRI the project aims to increase students content knowledge about research by bringing cutting edge research into the program, and to foster the discussion among students about RRI issues by the introduction of relevant topics. By using formal (school) and informal (science center, museum or festival) teaching we familiarize schoolchildren with science.

topics

- Healthy ageing (Netherlands)
- Genomics and oceanography (Portugal)
- Oceanography and climate change (Germany)
- Climate change (Finland)
- Renewable energy sustainability (Israel)
- Solar energy and specific nanomaterial (Romania)
- Nanoscience (Turkey)
- Nanoscience applications (Greece)
- Nanotechnology (Italy)
- Nanotechnology (catalysis) (Poland)

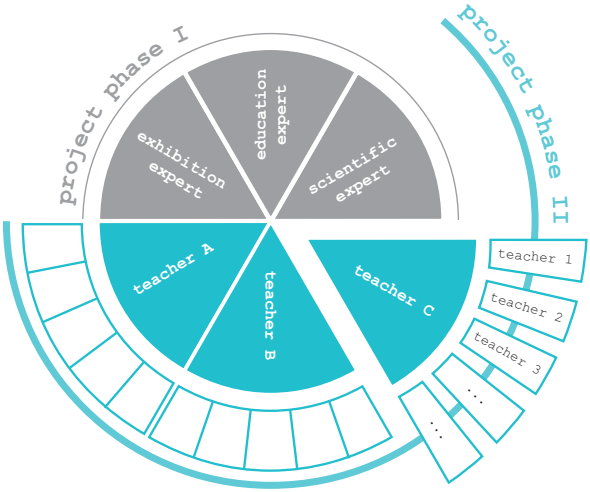
RRI: six key issues

- **Engagement:** joint participation of researchers, industry and civil society in the research and innovation process
- **Gender equality:** unlocking the full potential of society
- **Science education:** creative education to foster the future needs of society
- **Ethics:** Including societal relevance and acceptability of research and innovation outcomes
- **Open access:** free, online access to the results of publicly funded research
- **Governance:** the responsibility of policy makers to develop harmonious models for RRI

project course

In each of the ten countries a Community of Learners (CoL) will be formed to develop a thematic module. These groups comprise of school teachers, education experts from universities, exhibition experts from museums / science centers and researchers from the thematic field.

The material developed will be used by the CoLs teachers with their students. Additionally the students will visit relevant university labs and translate results from their programme into an exhibit, that sheds light on the relationship between research and society.



After phase I of the project there will be ten modules on various RRI-topics that have been tested in five to ten classes each. In phase II, the teachers from the first phase will each train five colleagues.

The teaching modules will also be available online in different languages. The best exhibits from the project will be presented to the European public during a special session at an international conference.

Ultimately, this project will teach almost ten thousand students to consider the social impact of scientific research.

partners

Netherlands	University of Groningen (coordination)
Finland	University of Helsinki
	University of Jyväskylä
Germany	IPN
	Deutsches Museum
Greece	University of Crete
	Eugenides Foundation
Israel	Weizmann Institute of Science
Italy	University of Bologna
	University of Palermo
Poland	Jagiellonian University
Portugal	Universidade de Lisboa
Romania	Valahia University Targoviste
Turkey	Bogazici University

irresistible

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

www.irresistible-project.eu

Coordinator: j.h.apotheker@rug.nl

SEVENTH FRAMEWORK PROGRAMME

irresistible

The Irresistible-project:

The goal of the projec t IRRESISTIBLE is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI).
In the project, partners from universities and science centers have worked together with teachers to develop teaching material about scientific subjects. All material is based on Inquiry-Based Science Education and combines formal and informal learning approaches.

Other modules in the Irresistible-project:

- Polar Science: Evaluate Earth Health trough Polar Regions
- Oceanography and Climate Change
- Geo-engineering and Climate Control
- Bane of the Oceans
- Atmosphere and Climate Change
- Nano for Health
- Nanotechnology for Solar Energy
- Nanotechnology for Information
- Nanoscience Applications
- The Catalytic Properties of Nanomaterials
- Perovskite-based Photovoltaic Cells

Visit our website for more information: www.irresistible-project.eu

www.irresistible-project.eu

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 5.2.1 Young people and science: Topic SiS.2013.2.2.1-1 Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

SEVENTH FRAMEWORK PROGRAMME

irresistible

The project bringing Responsible Research and Innovation into the classroom

Carbohydrates in (Breast) Milk

a better health with smart carbohydrates

"Why don't babies drink milk from the supermarket?"

This central question in this interdisciplinary teaching module is answered during biology and chemistry classes. The module comprises many topics from the curriculum of both subjects. The module is suitable for upper level high-school, but with adaptations it can also be used in different grades.

Why use this module in class?

- Interdisciplinary module combining biology and chemistry in a scientific context
- Combination of many active learning approaches
- Modules addresses many Academic Skills
- Module includes the relation of the scientific topic with societal issues by using Responsible Research and Innovation (RRI)
- Students make an exhibition on the science & the ethical issues as wind-up of the module

Module Carbohydrates in Breast Milk

In this module, students work on many different aspects of (breast)milk and its effect on babies.
The module combines biological topics like digestion, the importance of gut bacteria and their influence on the immune system and thus the health of adults and babies, and chemical topics like biochemistry and process chemistry in the context of milk and the production of baby formula. In addition, ethical issues are addressed like the marketing of breast milk substitutes, and the discussions between breast-feeding and bottle-feeding mums.

The project is closed by an exhibition at school, in which the students present what they have learned to their peers, combining scientfic and ethical issues.

The project takes about 12-16 lessons, depending on the topics and learning approaches used.

"Yes, it cost time to do this project, but it brought me a lot in return. The students acquire very necessary skills"
- Biology teacher, The Netherlands

Responsible Research and Innovation (RRI)

Responsible Research and Innovation is a term that is introduced by the EU to make science and society work better together. The goal is that all societal actors, including citizens, are more involved in the process of Research and Innovation.
The students of today are the scientists and the citizens of tomorrow, so it is necessary for them to see the relevance of science topics for society.
In the module, the six key issues of RRI are introduced (*Engagement, Open Access, Gender, Ethics, Science Education* and *Government*) and the students are motivated to work with this topics by actities like a game, role play or debate over propositions that relate to the scientific topics.

Inquiry-based Science Education (IBSE) and active learning

The module is based on the didactic model of IBSE and is divided into 6 chapters:
Engage – engage the student with the topic with a quiz and some background information
Explore – explore the scientific questions, perform experiments;
Explain – answer the scientific questions in groups;
Elaborate – elaborate on the ethical/RRI-issues;
Exchange – building an exhibition and pitching;
Evaluate – test and grading of the exhibitions.

The teaching module contains many opportunities for active learning approaches:
- Manuals for different experiments included in the module.
- Students learn the scientific content in groups, and present their findings to the rest of the class;
- Ethical/RRI-issues can be discussed in a role play game or a debate
- Students summarize their findings in an exhibition.

In this way, academic skills like summarizing, searching for information, presentating, argumentating and desiging are dealt with..

"Students are much more creative than I expected, it really exceeded my expectations"
- Chemistry teacher, The Neterlands

Student exhibitions in The Netherlands

irresistible

The Irresistible-project:

The Project IRRESISTIBLE is a European Commission funded project, whereby fourteen partners including academic institutions and science centers or museums from ten countries collaborate through a Science-in-Society activity of 7th Framework Program, (FP7).

The goal of the project IRRESISTIBLE is to bridge formal and informal education by developing a module introducing cutting-edge science through inquiry-based science education to raise the awareness of students and public in Responsible Research and Innovation (RRI).

Other modules in the Irresistible-project:

- Polar Science: Evaluate Earth Health trough Polar Regions
- Oceanography and Climate Change
- Geo-engineering and Climate Control
- Bane of the Oceans
- Atmosphere and Climate Change
- Perovskite-based Photovoltaic Cells
- Nano and Health
- Nanotechnology for Solar Energy
- Nanotechnology for Information
- Nanoscience Applications
- The Catalytic Properties of Nanomaterials

Visit our website for more information:
www.irresistible-project.eu

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. This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612[illegible]

irresistible

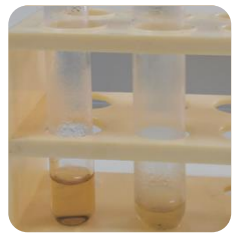
The project bringing Responsible Research and Innovation into the classroom

Nano and Health

How does nanotechnology contribute to health sciences?

Where do we encounter with nanoscience in our daily lives?

What are the benefits and risks of using products containing nanoparticles?



This module was developed around the central theme of applications of nanotechnology in health sciences integrating chemistry, physics, biology and mathematics. It addresses the central questions above and many more.

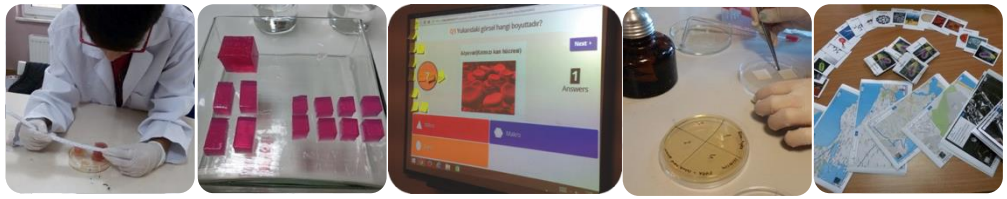
Why use this module in class?

- It addresses a cutting-edge science topic integrating chemistry, physics, biology, and mathematics.
- It was developed around approach of the inquiry-based science education, which requires students active involvement in learning as they practice certain science process skills
- It introduces students some Web 2.0 tools (Kahoot, Mindomo, Glogster, Aurasma and etc.) as learning-aid.
- It provides students with discussions of scientific topics through the critical perspective of Responsible Research and Innovation (RRI)
- It gives students the opportunity to develop and present an exhibition product.

Short Description of the Module

Using the method of inquiry-based science education, the module aims to teach the fundamental ideas of nanoscience (e.g., size and scale, size dependent properties, tools and instruments) and the use of nanoparticles in health sciences, in particular antibacterial effect of silver nanoparticles, by integrating the dimensions of Responsible Research and Innovation (RRI).

The module includes 8 coherently related lessons, and also a month-long period, at which students develop and exhibit interactive exhibition products. It involves various alternative activities, which are suitable for grade 7-11 (Age: 13-17).



Inquiry-Based Science Education (IBSE)

This module is developed based on 6E Learning Cycle:

- *engagement:* Students are engaged in topic with a local news about cross infections in hospitals, examination of a brochure including nano-based suggestions for prevention of cross infections and several activities on size and scale concept, size dependent properties and instruments (AFM, SEM) used in nanoscience.
- *exploration:* Students synthesize silver nanoparticles, test its antibacterial effect and test the durability of the antibacterial effect of a textile nano-product against washing.
- *explanation:* Students share and discuss the results of experiments they conduct, and discuss on the mechanism behind the antibacterial effect of silver nanoparticles and results of washing analysis.
- *elaboration:* Students examine the properties and usage areas of other nanoparticles such as gold nanoparticles and zinc oxide nanoparticles.
- *exchange:* Students develop an exhibit product related to content of the module in groups. They display these products first in their schools, then at a science center.

Reference:
European Commission. (2012). Responsible Research and Innovation: Europe's ability to respond to societal challenges. *European Union Publication Office*

- *evaluation:* Students discuss and share the results of experiments they conduct with each other, they argue about many controversial RRI issues, and upload their journal entries on Edmodo. Finally, students' exhibition products are evaluated.

Responsible Research and Innovation (RRI)

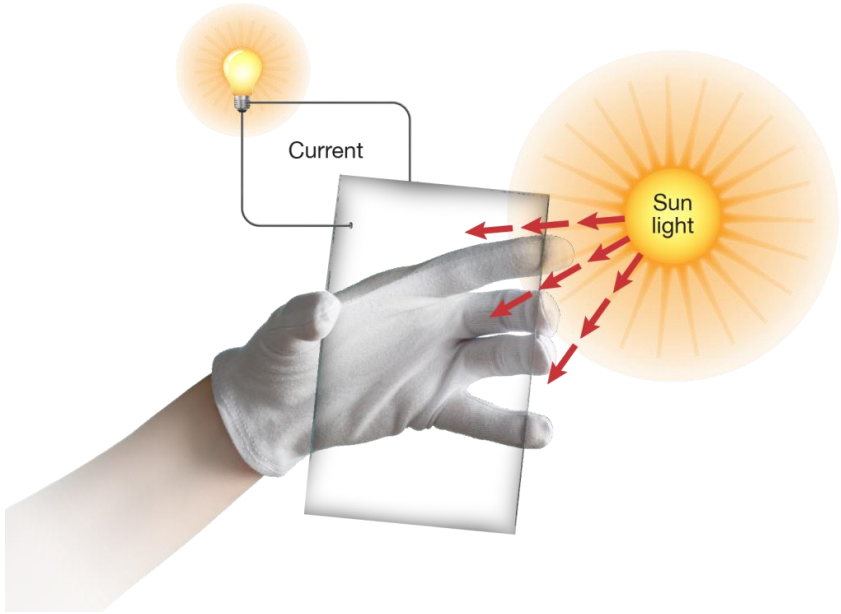
RRI is a term introduced by European Commission (EC, 2012) to describe a process, which meets all societal actors including citizens, scientists, politicians, and governmental and non-governmental organizations at a common ground, revealing their responsibilities for each other so as to improve the cooperation of science and society. EU has defined 6 key aspects of RRI (EC, 2012):

- *engagement* of all societal actors in the research and innovation process to develop joint solutions to societal problems and opportunities,
- *gender equality* is integration of gender dimension in research and innovation content with joint participation of women and men,
- *science education* should be focused for enhancement of the current education process for better equipped future researchers and other societal actors with the necessary knowledge,
- *ethics* implies that research and innovation must respect fundamental rights and the highest ethical standards,
- *open access* is free online access to the results of researches to enhance use of scientific results by all societal actors,
- *governance* implies the responsibility of policymakers to prevent harmful or unethical developments and promote improvements in research and innovation.

Student-Curated Exhibitions

Student-curated exhibition is the exchange phase of this module in a broad sense. During these exhibitions, students meet with many visitors from peers at other schools to academicians.

At the end of the 8 lessons of the module, students start t
interactive exhib
integrate a scienti
applications with

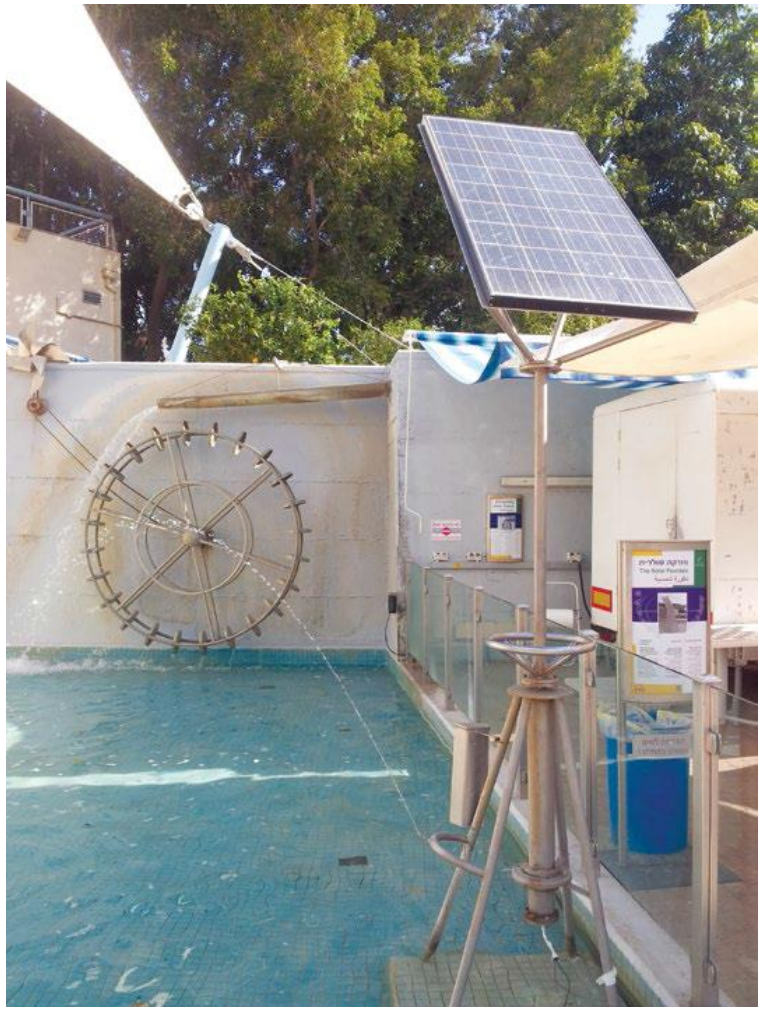


The RRI of Perovskite-Based Photovoltaic Cells (Weizmann Institute of Science)

This module was developed around the leading question: ***Under what conditions, if any, would we (the students) agree to have perovskite-based photovoltaic cells installed on the windows of our school?"***

Why use this module in class

- ✓ It addresses a cutting-edge science topic integrating chemistry, physics, energy and environment
- ✓ It was developed around approach of the inquiry-based science education, which requires students active involvement in learning as they practice certain science process skills
- ✓ It includes lab activities and a visit in a science museum
- ✓ It provides students with discussions of scientific topics through the critical perspective of Responsible Research and Innovation (RRI)
- ✓ It gives students the opportunity to develop and present an exhibition product.



Short Description of the Module

The main goal of the module is to foster positive attitudes towards RRI by both teachers and students, by focusing on the use of perovskite-based photovoltaic cells within the context of using alternative energy. Perovskite-based photovoltaic cells are the research topic of a Weizmann Institute scientist. These photovoltaic cells have a relatively high efficiency but also have liabilities, such as the use small amounts of lead, a poisonous substance.

Target Group: 10th to 12th grade chemistry students

Duration of the Module: one 3-hour lesson on RRI (in the classroom), followed by a 6-hour visit (in the science museum and in the Weizmann Institute of Science) and a 3- to 4-hour session on building the exhibits (in the classroom).

- **open access** is free online access to the results of researches to enhance use of scientific results by all societal actors,

- **governance** implies the responsibility of policymakers to prevent harmful or unethical developments and promote improvements in research and innovation.

Student Curated Exhibitions

At the end of the module, students start to design and develop an interactive exhibition product at which they integrate the leading question of the module. The exhibition includes the scientific parts as well as the RRI dimension. Student-curated exhibition is the exchange phase of this module in a broad sense. During these exhibitions, students meet with many visitors from peers at other schools to academicians.

Responsible Research and Innovation (RRI)

RRI is a term introduced by European Commission (EC, 2012) to describe a process, which meets all societal actors including citizens, scientists, politicians, and governmental and non-governmental organizations at a common ground, revealing their responsibilities for each other so as to improve the cooperation of science and society. EU has defined 6 key aspects of RRI (EC, 2012):

engagement of all societal actors in the research and innovation process to develop joint solutions to societal problems and opportunities,

gender equality is integration of gender dimension in research and innovation content with joint participation of women and men,

science education should be focused for enhancement of the current education process for better equipped future researchers and other societal actors with the necessary knowledge,

ethics implies that research and innovation must respect fundamental rights and the highest ethical standards,

irresistible

The Irresistible-project:

The goal of the project IRRESISTIBLE is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI).
In the project, partners from universities and science centers have worked together with teachers to develop teaching material about scientific subjects. All material is based on Inquiry-Based Science Education and combines formal and informal learning approaches.

Other modules in the Irresistible-project:

- Atmosphere and Climate Change
- Polar Science: Evaluate Earth Health trough Polar Regions
- Oceanography and Climate Change
- Geoengineering: Climate Control
- Nanoscience Applications
- Nano for Health
- Nanotechnology for Solar Energy
- Perovskite-based Photovoltaic Cells
- Nanotechnology for Information
- Plastics - Bane of the Oceans
- Carbohydrates in (Breast) Milk

Visit our website for more information: www.irresistible-project.eu

www.irresistible-project.eu

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.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

irresistible

The project bringing Responsible Research and Innovation into the classroom

The Catalytic Properties of Nanomaterials

"Why is soot harmful and how we can get rid of it?"

It is one of the questions in this teaching module. The module comprises many topics from the school Chemistry curriculum such as absorption, catalysis, colloids, combustion processes. Students start their activities from the elements of the Nature of Science. The module is proposed for upper secondary schools, but with adaptations it can also be used for younger students.

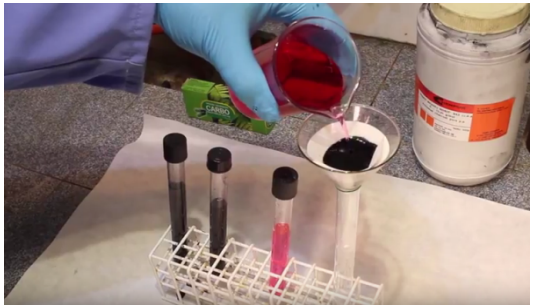
Why use this module in class?

- Module combining nanotechnology, environmental protection and catalysis
- Collection of many active learning approaches
- Modules addresses many Academic Skills
- Module includes the relation of the scientific topic with societal issues by using Responsible Research and Innovation (RRI)
- Students make an exhibition on the science & the ethical issues as wind-up of the module

the Catalytic Properties of Nanomaterials

In this module, students work on many different aspects of catalysis. They learn, obtain experimentally, investigate and model the effectiveness of various catalytic substances. Particular emphasis is placed on the catalytic removal of air pollutions. In parallel, the ethical aspects of innovations introduced are discussed, such as the disposal/recycling of the old automotive converter, illegal removal of particular matter exhaust converters from Diesel engines, or fraud when measuring the composition of exhaust gasses.
The project is closed by an exhibition at school, in which the students present what they have learned to their peers, combining scientific and ethical issues.
The project takes about 14-22 lessons, depending on chosen sub-modules and learning approaches used.

"We surely have learned to cooperate and rely on each other. When making the model and designing the exhibition we got really integrated and learned a lot" - student, Poland



Responsible Research and Innovation (RRI)

Responsible Research and Innovation is a term that is introduced by the EU to make science and society work better together. The goal is that all societal actors, including citizens, are more involved in the process of Research and Innovation.
The students of today are the scientists and the citizens of tomorrow, so it is necessary for them to see the relevance of science topics for society.
In the module, the six key issues of RRI are introduced (*Engagement, Open Access, Gender, Ethics, Science Education* and *Government*) and the students are motivated to work with this topics by activities like a game, role play or debate over propositions that relate to the scientific topics.

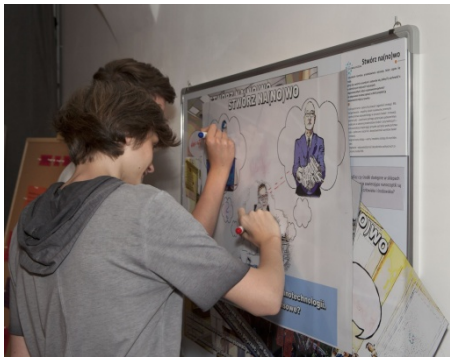
Inquiry-based Science Education (IBSE) and active learning

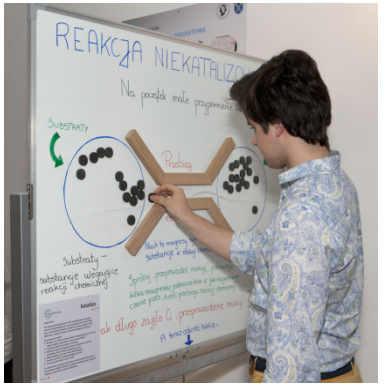
Each lesson consists of **6 phases** (6E –characteristic for IBSE):
Engage … the students with the topic by means of a quiz, videos, news,
Explore … the scientific questions, perform experiments;
Explain …in groups and in collaboration with the teacher;
Elaborate … by exploration new chemistry related fields and the RRI-issues
Exchange …between the groups of students as well as finally with wider audience by creating an open exhibition;
Evaluate … through self- and peer-assessment, tests, and tasks.

The module contains many opportunities for active learning approaches: students experiments, mindmaps, discussions: debate, brainstorming. In this s way students will:

- **Develop** their inquiry skills such as searching for information, analysing data, reasoning, argumentation, and such competencies as communication, cooperation.
- **Learn** about catalysis and catalysts, nanomaterials and nanotechnology
- **Increase their awareness** of the scientific method, RRI, and environmental protection.

"I underestimated the impact of the participation in the project on the students' soft skills, on building the sense of responsibility for the results of joint work. Now I think it was just as important as acuisition of new knowledge"
Chemistry teacher, Poland





Student exhibitions in Poland

irresistible

The Irresistible-project:

The goal of the projec t IRRESISTIBLE is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI).
In the project, partners from universities and science centers have worked together with teachers to develop teaching material about scientific subjects. All material is based on Inquiry-Based Science Education and combines formal and informal learning approaches.

Other modules in the Irresistible-project:

- Polar Science: Evaluate Earth Health trough Polar Regions
- Oceanography and Climate Change
- Geo-engineering and Climate Control
- Bane of the Oceans
- Atmosphere and Climate Change
- Nanotechnology in Health Sciences
- Nanotechnology for Solar Energy
- Nanotechnology for Information
- Nanoscience Applications
- The Catalytic Properties of Nanomaterials
- Perovskite-based Photovoltaic Cells

Visit our website for more information: www.irresistible-project.eu

www.irresistible-project.eu

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 5.2.1 Young people and science: Topic SiS.2013.2.2.1-1 Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

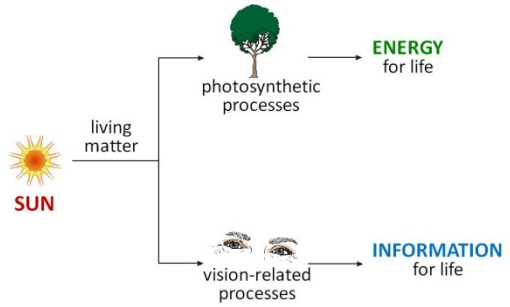
SEVENTH FRAMEWORK PROGRAMME

irresistible

The project bringing Responsible Research and Innovation into the classroom

Nanotechnology for information

"How can we use light to get information about the world?"



In nature photons are employed both as energy quanta and as information elements

This central question is answered in an educational module focused on the nanotechnology studies carried out to get information from the interaction light/matter and on the RRI aspects relevant to this specific research field. The module is suitable for upper level high-school and comprises many topics from the curriculum of both physics and chemistry.

Why use this module in class?

- It is an interdisciplinary module combining physics and chemistry in a scientific context, but also technological application in everyday life
- It combines many active learning approaches
- It evolves many academic skills
- It includes the relation of the scientific topic with societal issues by using Responsible Research and Innovation (RRI)
- It involves students in making an exhibition on the science & the ethical issues as wind-up of the module

Module Nanotechnology for Information

The module is composed of a basic core dealing with nanotechnology and nanosensors: the fundamental laws of chemistry underpinning the development of nanotechnology; what nanosensors are, in particular the luminescent ones, and what they can be used for; the involvement of chemistry to design, prepare and use nanosensors; the importance of nanotechnology and nanosensors in our society for the human beings and the environment; the different types of natural and artificial nanosensors. The module is implemented by experimental activities concerning the use of luminol emission in forensic test to reveal blood stains and the identification of the compound responsible of the blue emission shown by Schweppes irradiated with UV-light. Ethical issues, like advantages and hazards connected to the use of nanosensors both for human beings and environment, the involvement of different actors in the development and use of nanosensors, the importance to design nanosensors for and with society, are also addressed.
At the end of the module the students are engaged in the creation of exhibits in which scientific and ethical issues are combined.

The module takes about 14-18 hours spanned in 8-10 lessons.

"The RRI invites to make reflections that were never made before at school, at least not in such a structured manner"

Chemistry teacher, Italy

Luminol at work in crime scenes, Italy

Responsible Research and Innovation (RRI)

Responsible Research and Innovation is a term that is introduced by the EU to make science and society work better together. The goal is that all societal actors, including citizens, are more involved in the process of Research and Innovation.
The students of today are the scientists and the citizens of tomorrow, so it is necessary for them to see the relevance of science topics for society.
In the module, the six key issues of RRI are introduced (*Engagement, Open Access, Gender, Ethics, Science Education* and *Government*) and the students are motivated to work with this topics by actities like a game, role play or debate over propositions that relate to the scientific topics.

Inquiry-based Science Education (IBSE) and active learning

The module is based on the didactic model of IBSE and is divided into 6 chapters:
Engage – engage the student with the topic with a quiz and some background information
Explore – explore the scientific questions, perform experiments;
Explain – answer the scientific questions in groups;
Elaborate – elaborate on the ethical/RRI-issues;
Exchange – building an exhibition and pitching;
Evaluate – test and grading of the exhibitions.

The teaching module contains many opportunities for active learning approaches:

- Manuals for different experiments included in the module.
- Students learn the scientific content in groups, and present their findings to the rest of the class;
- Ethical/RRI-issues can be discussed in a role play game or a debate
- Students summarize their findings in an exhibition.

In this way, academic skills, like summarizing, searching for information, discussing, experimenting and designing , are dealt with.

"it was the first time we did a project to convey our ideas to other people. For me the exhibit creation has been a stimulus to study"

A 15 year old student, Italy

Student exhibitions at the Museum of Balì in Italy

irresistible

The Irresistible-project:

The goal of the projec t IRRESISTIBLE is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI).
In the project, partners from universities and science centers have worked together with teachers to develop teaching material about scientific subjects. All material is based on Inquiry-Based Science Education and combines formal and informal learning approaches.

Other modules in the Irresistible-project:

- Polar Science: Evaluate Earth Health trough Polar Regions
- Oceanography and Climate Change
- Geo-engineering and Climate Control
- Bane of the Oceans
- Atmosphere and Climate Change
- Nanotechnology in Health Sciences
- Nanotechnology for Solar Energy
- Nanotechnology for Information
- Nanoscience Applications
- The Catalytic Properties of Nanomaterials
- Perovskite-based Photovoltaic Cells

Visit our website for more information: www.irresistible-project.eu

www.irresistible-project.eu

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 5.2.1 Young people and science: Topic SiS.2013.2.2.1-1 Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

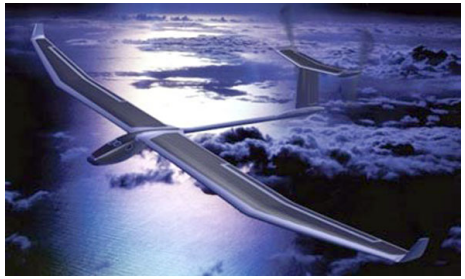
SEVENTH FRAMEWORK PROGRAMME

irresistible

The project bringing Responsible Research and Innovation into the classroom

Nanotechnology for solar energy

"Why do we have to use renewable energy sources, in particular solar energy?"



The solar-powered aircraft Solar Impulse

This central question is answered in an educational module focused on the nanotechnology studies carried out to convert sunlight into electric energy and on the RRI aspects relevant to this specific research field. The module is suitable for upper level high-school and comprises many topics from the curriculum of both physics and chemistry.

Why use this module in class?

- It is an interdisciplinary module combining physics and chemistry in a scientific context, but also economic and technological aspects
- It combines many active learning approaches
- It evolves many academic skills
- It includes the relation of the scientific topic with societal issues by using Responsible Research and Innovation (RRI)
- It involves students in making an exhibition on the science & the ethical issues as wind-up of the module

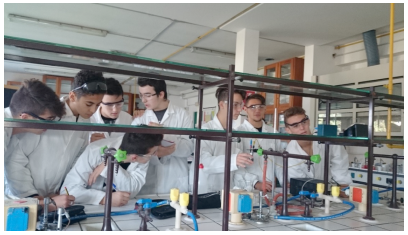
Module Nanotechnology for Solar Energy

The module is composed of a basic core dealing with the need of using renewable energy sources, in particular solar energy, the description of natural and artificial ways of exploiting and storing solar energy, the importance of nanotechnology to address the problem of energy supply and the production of photovoltaic energy, pros and cons concerning the different materials used to develop photovoltaic cells, i.e. perovskite. The module is implemented by experimental activities concerning the construction of a Graetzel cell with natural dyes and the analysis of the photoanode with an atomic force microscope.
Ethical issues, like social implications raised by the development of renewable energy sources, the importance of engaging different actors to face the energy problem, the choices made by the governments of different world regions and countries to address the problem of energy supply, are also tackled.
At the end of the module the students are engaged in the creation of exhibits in which scientific and ethical issues are combined.

The module takes about 20-25 hours spanned in 12-14 lessons.

"It is a very interesting and valuable project. It was very engaging for me because it provided knowledge of what we can find in the everyday life"

A 16 year old student, Italy



Students in laboratory, Italy

Responsible Research and Innovation (RRI)

Responsible Research and Innovation is a term that is introduced by the EU to make science and society work better together. The goal is that all societal actors, including citizens, are more involved in the process of Research and Innovation.
The students of today are the scientists and the citizens of tomorrow, so it is necessary for them to see the relevance of science topics for society.
In the module, the six key issues of RRI are introduced (*Engagement, Open Access, Gender, Ethics, Science Education* and *Government*) and the students are motivated to work with this topics by actities like a game, role play or debate over propositions that relate to the scientific topics.

Inquiry-based Science Education (IBSE) and active learning

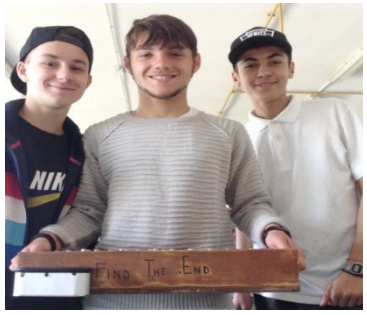
The module is based on the didactic model of IBSE and is divided into 6 chapters:
Engage – engage the student with the topic with a quiz and some background information
Explore – explore the scientific questions, perform experiments;
Explain – answer the scientific questions in groups;
Elaborate – elaborate on the ethical/RRI-issues;
Exchange – building an exhibition and pitching;
Evaluate – test and grading of the exhibitions.

The teaching module contains many opportunities for active learning approaches:
- Manuals for different experiments included in the module.
- Students learn the scientific content in groups, and present their findings to the rest of the class;
- Ethical/RRI-issues can be discussed in a role play game or a debate
- Students summarize their findings in an exhibition.

In this way, academic skills, like summarizing, searching for information, discussing, experimenting and designing , are dealt with.

"To create the exhibit the students worked in complete autonomy. Everyone had the opportunity to choose what to do and how to do it following his inclination. This was highly motivating for them"

Chemistry and Physics teachers, Italy



Student exhibitions in Italy

irresistible

The Irresistible-project:

The goal of the projec t IRRESISTIBLE is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI).
In the project, partners from universities and science centers have worked together with teachers to develop teaching material about scientific subjects. All material is based on Inquiry-Based Science Education and combines formal and informal learning approaches.

Other modules in the Irresistible-project:

- Atmosphere and Climate Change
- Polar Science: Evaluate Earth Health trough Polar Regions
- Oceanography and Climate Change
- Geo-engineering and Climate Control
- Nano for Health
- Perovskite-based Photovoltaic Cells
- Nanotechnology for Information
- Nanoscience Applications
- The Catalytic Properties of Nanomaterials
- Plastics - Bane of the Oceans
- Carbohydrates in (Breast) Milk

Visit our website for more information: www.irresistible-project.eu

www.irresistible-project.eu

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 5.2.1 Young people and science: Topic SiS.2013.2.2.1-1 Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

SEVENTH FRAMEWORK PROGRAMME

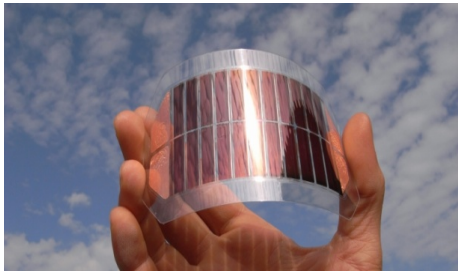
irresistible

The project bringing Responsible Research and Innovation into the classroom

Nanotechnology for solar energy

RRI aspects of environment friendly energy production

"Could we use natural pigments to exploit solar radiation?"



This central question in this interdisciplinary teaching module is answered during physics and chemistry classes. The module includes many topics from the curriculum of both subjects. The module is suitable for upper level high-school, but with adaptations it can also be used in other grades.

Why use this module in class?

- Interdisciplinary module combining chemistry and physics in a scientific context
- Combination of many active learning approaches
- Modules addresses many Academic Skills
- Module includes the relation of the scientific topic with societal issues by using Responsible Research and Innovation (RRI)
- Students make an exhibition on the science & the ethical issues as outcome of the module

Module Nanotechnology for Solar Energy

In this module, students work on many different aspects dealing with the conversion of solar radiation in usable energy by organic photovoltaic cells.
The module combines chemical topics such as redox reactions and the operation principles of electrochemical cells, and physics topics such as semiconductors and photovoltaic and photoelectric effects. In addition, ethical issues are addressed like renewable energy sources, and the possibility of exploiting solar radiation, a freely accessible and widely available energy source.

The classroom work ends with an exhibit, at school or at a science fear, in which the students present what they have learned to their peers, combining scientific and ethical issues.

The module lasts 12-14 1h lessons, depending on the classroom level and learning approaches used.

One of the teachers claimed that, by attending this module, "Students familiarized themselves with the methods of research investigation by critically observing phenomena and solving problems"

Responsible Research and Innovation (RRI)

Responsible Research and Innovation is a term that is introduced by the EU to make science and society work better together. The goal is that all societal actors, including citizens, are more involved in the process of Research and Innovation.
The students of today are the scientists and the citizens of tomorrow, so it is necessary for them to see the relevance of science topics for society.
In the module, the six key issues of RRI are introduced (*Engagement, Open Access, Gender, Ethics, Science Education* and *Government*) and the students are motivated to work with this topics by actities like a game, role play or debate over propositions that relate to the scientific topics.

Inquiry-based Science Education (IBSE) and active learning

The module is based on the didactic model of IBSE and is divided into 6 chapters:
Engage – engage the student with the topic with a quiz and some background information
Explore – explore the scientific questions, perform experiments;
Explain – answer the scientific questions in groups;
Elaborate – elaborate on the ethical/RRI-issues;
Exchange – building an exhibition and pitching;
Evaluate – test and grading of the exhibitions.

The teaching module contains many opportunities for active learning approaches:
- Manuals for different experiments included in the module.
- Students learn the scientific content in groups, and present their findings to the rest of the class;
- Ethical/RRI-issues can be discussed in a role play game or a debate
- Students summarize their findings in an exhibition.

In this way, academic skills like summarizing, searching for information, presentating, argumentating and desiging are dealt with.

"Students have positively experienced the interaction with their peers both from their own class and from other schools"
- Chemistry teacher, Palermo, Italy

Student exhibitions in Palermo (Italy)

irresistible

The Irresistible-project:

The goal of the project IRRESISTIBLE is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI).
In the project, partners from universities and science centers have worked together with teachers to develop teaching material about scientific subjects. All material is based on Inquiry-Based Science Education and combines formal and informal learning approaches.

Other modules in the Irresistible-project:

- Atmosphere and Climate Change
- Polar Science: Evaluate Earth Health trough Polar Regions
- Oceanography and Climate Change
- Geoengineering: Climate Control
- Nano for Health
- Nanotechnology for Solar Energy
- Perovskite-based Photovoltaic Cells
- Nanotechnology for Information
- Nanoscience Applications
- The Catalytic Properties of Nanomaterials
- Plastics - Bane of the Oceans
- Carbohydrates in (Breast) Milk

Visit our website for more information: www.irresistible-project.eu

www.irresistible-project.eu

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.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

irresistible

The project bringing Responsible Research and Innovation into the classroom

Nanoscience Applications

How nanotechnology applications affect our everyday lives?

The **Nanoscience Applications** module focuses on technologies related to improve quality of life. Students will come in touch with state of the art (photocatalytic) nanomaterials and their use for a healthy environment (air and water quality control). Through this module it is intended that students get acquainted with fundamental nanoscience concepts, boost their environmental awareness and involvement with prime societal problems and realize the role of nanomaterials and technology and their impact and risks to human health. In a second phase, students are motivated to to reflect on the 6 dimensions of RRI via discussions with scientists and to present their knowledge and concerns through scientific exhibits.

Why use this module in class?

- Combination of formal and informal learning environments
- Students come in contact and discuss with scientists
- Detailed lessons' descriptions & students' worksheets
- Propositions for adjustments for grades 6-12
- Broad range of hands-on activities
- Interconnection of the scientific topic with societal issues by using Responsible Research and Innovation (RRI)
- Students make an exhibition on nanotechnology & its ethical issues

Module: Nanoscience Applications

Nanoscale Science and Technology constitutes an interdisciplinary field that attracts students' interest through its impressive innovative and yet controversial applications. Nowadays, as many nano-applications are already at the market shelves it is highly important that students gain fundamental scientific knowledge to be able to make informed choices. In the same time Nanotechnology sets up a fertile field to practice students' critical thinking through conversations about the arising ethical issues.

This module, appropriately adjusted, can be implemented in primary school classes (aged 11-12), in lower secondary classes (aged 14-15) and upper secondary classes (aged 16-17). In the detailed description of the module the activities appropriate for each age are pointed out. The module can be completed in 8-9 lessons, depending on the learning approaches used. To be able to follow this module students should be able to estimate the size of an object using a unit or another object as reference, to know what properties of a material are, to be familiarized with analyzing newspaper articles.

"It was the first time that we were called to build something on our own. We felt free to design what we wanted and then construct it. It was nice presenting our work to others. We never imagined we could know more about something so innovative and explain it to others!" (Student, Greece)

Responsible Research and Innovation (RRI)

Responsible Research and Innovation is a term that is introduced by the EU to make science and society work better together. The goal is that all societal actors, including citizens, are more involved in the process of Research and Innovation. In the module, the six key issues of RRI are introduced (*Engagement, Open Access, Gender, Ethics, Science Education* and *Government*) and the students are motivated to work with this topics by activities like analysing cartoons and newspaper articles, and discussions over propositions that relate to the scientific topics.

Inquiry-based Science Education (IBSE) and active learning

The module is oriented to the inquiry based approach in Science Education and is divided into 5 chapters:

Engage – students are engaged to the topic through a) videos with current nano-applications and self-cleaning materials and b) a visit to the science and research center.

Explore & Explain – students explore various aspects of nanoscience through their involvement in a series of hands-on activities based on nanomaterials. They collect, analyze data and draw conclusions while dealing with experimental activities.

Elaborate – students elaborate their findings and discuss RRI issues: a) by visiting a research institute and discussing with experts, b) through newspaper articles.

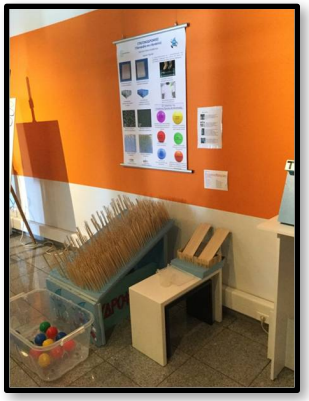
Exchange – students (with the support of museum experts and their teachers) develop exhibits which are hosted at science centres and presented to the public.

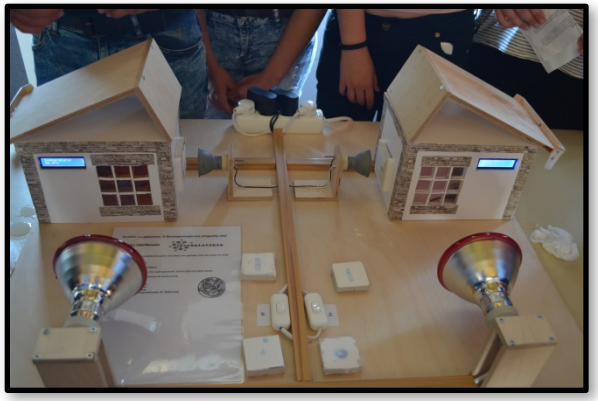
Evaluate – students assess their knowledge through a final questionnaire and the exhibits development and presentation.

Through the module's activities, students are expected to:

- Develop substantive knowledge concerning Nanoscale science & technology
- Develop a critical attitude towards the use of derivatives of current research
- Develop communicational skills by presenting their knowledge through exhibits
- Become familiarized with the scientific method
- Cooperate effectively to build a scientific exhibit

"The most important outcome of procedure was the fact that students worked with team spirit, bonded with each other and improved their relations with me. The exhibits development motivated students and helped them improve their self-image" (Teacher, Greece)





Student exhibitions in Greece

irresistible

The Irresistible-project:

The goal of the project IRRESISTIBLE is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI).
In the project, partners from universities and science centers have worked together with teachers to develop teaching material about scientific subjects. All material is based on Inquiry-Based Science Education and combines formal and informal learning approaches.

Other modules in the Irresistible-project:

- Atmosphere and Climate Change
- Polar Science: Evaluate Earth Health trough Polar Regions
- Oceanography and Climate Change
- Geoengineering: Climate Control
- Nano for Health
- Nanotechnology for Solar Energy
- Perovskite-based Photovoltaic Cells
- Nanotechnology for Information
- Nanoscience Applications
- The Catalytic Properties of Nanomaterials
- Plastics - Bane of the Oceans
- Carbohydrates in (Breast) Milk

Visit our website for more information: www.irresistible-project.eu

www.irresistible-project.eu

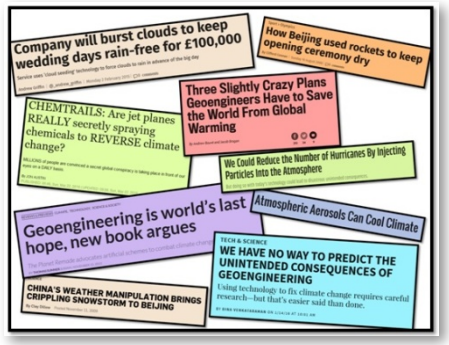
IRRESISTIBLE is a project on teacher training, combining formal and informal learning focused on Responsible Research and Innovation.
It is a coordination and support action under FP7-SCIENCE-IN-SOCIETY-2013-1, ACTIVITY 5.2.2 Young people and science: Topic SiS.2013.2.2.1-1 Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

irresistible

The project bringing Responsible Research and Innovation into the classroom

Geoengineering: Climate Control

"Climate Geoengineering: is it real or just another conspiracy theory?



Students, will research about Geoengineering — which is presented to them as "maybe another conspiracy theory?" – more precisely about its strategies in mitigation of Global Warming. It is intended that students understand the Biological/Physical/Chemical principles behind each strategy and, also, its advantages and disadvantages. In a second phase, students need to reflect about the 6 dimensions of RRI and conceive situations that relate each dimension with Geoengineering with the purpose of conceiving a Manifest Pro-Responsible Geoengineering that will be presented in the final exhibition, intended to be developed and presented by students as a way to educate the community about this topic.

Why use this module in class?

- Interdisciplinary module combining biology, physics and chemistry in a scientific context
- Combination of many active learning approaches
- Modules addresses many Academic Skills
- Module includes the relation of the scientific topic with societal issues by using Responsible Research and Innovation (RRI)
- Students make an exhibition on the science & the ethical issues as wind-up of the module

Module Geoengineering: Climate Control

The fantastic idea of Geoengineering — the intentional large scale manipulation of the environment to counter act the negative impacts of global climate change — is starting to be taken seriously in science and policy circles. For some scientists and policymakers, concern about the efficacy of political efforts to avoid dangerous climate change is beginning to make these schemes look less fantastic. So far, the disadvantages of Geoengineering approaches have tended to outweigh the advantages in most minds that have turned to the issue. However, in recent years such proposals have received more support from a number of prominent scientists and economists, with calls for more research into their feasibility, costs, side effects and frameworks for implementation.

This module is aimed at students from 12 to 18 years old, and it takes about 12-18 lessons, depending on the learning approaches used. Climate Change, its causes and consequences should be a topic already addressed by students and such concepts must be clear so that students can understand not only the potential of Geoengineering but also the risks associated with this scientific field and, as such, the importance of Responsible Research and Innovation.

"We've learned a lot about Geoengineering and its advantages and disadvantages. But the most important was the feeling of being useful. Through the exhibition we felt that we were really being useful to the community because we were able to teach them something new!"(Student, Portugal)

Responsible Research and Innovation (RRI)

Responsible Research and Innovation is a term that is introduced by the EU to make science and society work better together. The goal is that all societal actors, including citizens, are more involved in the process of Research and Innovation. In the module, the six key issues of RRI are introduced (*Engagement, Open Access, Gender, Ethics, Science Education* and *Government*) and the students are motivated to work with this topics by activities like analysing cartoons and newspaper articles, and discussions over propositions that relate to the scientific topics.

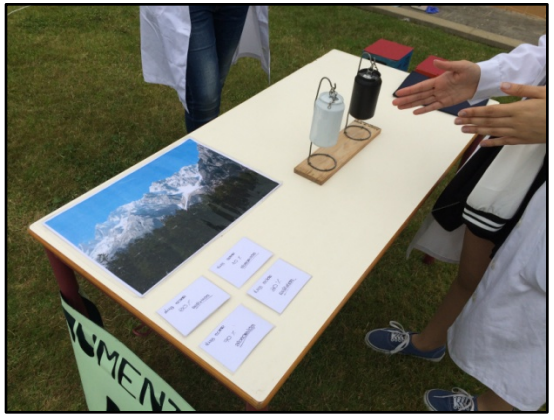
Inquiry-based Science Education (IBSE) and active learning

The module is based on the didactic model of IBSE and is divided into 7 chapters:
Engage – engage the student with the topic with cartoons, videos and newspaper article analysis;
Explore – explore Geoengineering strategies (the science behind them but also their advantages and disadvantages); perform an experiment;
Explain – develop a colaborative presentation about the issues explored and present it to the class;
Elaborate – elaborate on the ethical/RRI-issues;
Exchange & Empowerment – develop a final exhibition to be presented to the community – it serves as a platform for students to share with others what they've learned and also share their own opinions and concerns about the topic;
Evaluate – students assess their peers through online questionnaires; self and hetero-asessment of the objects and final exhibition.

Through the set of tasks of the module, students will:

- Develop substantive knowledge concerning Climate Geoengineerning
- Develop reasoning competencies;
- Develop communicational competencies;
- Construct a reflexive and critical attitude in relation to Responsible Research and Innovation regarding Climate Geoengineering.

"This module exceeded my expectations: students have certainly learned but, what suprised me the most was that they felt that this topic was so important that they wanted to spread the word to everyone! They developed an amazing exhibition!"(Teacher, Portugal)



Student exhibitions in Portugal

irresistible

The Irresistible-project:

The goal of the project IRRESISTIBLE is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI).
In the project, partners from universities and science centers have worked together with teachers to develop teaching material about scientific subjects. All material is based on Inquiry-Based Science Education and combines formal and informal learning approaches.

Other modules in the Irresistible-project:

- Atmosphere and Climate Change
- Polar Science: Evaluate Earth Health trough Polar Regions
- Oceanography and Climate Change
- Geoengineering: Climate Control
- Nano for Health
- Nanotechnology for Solar Energy
- Perovskite-based Photovoltaic Cells
- Nanotechnology for Information
- Nanoscience Applications
- The Catalytic Properties of Nanomaterials
- Plastics - Bane of the Oceans
- Carbohydrates in (Breast) Milk

Visit our website for more information: www.irresistible-project.eu

www.irresistible-project.eu

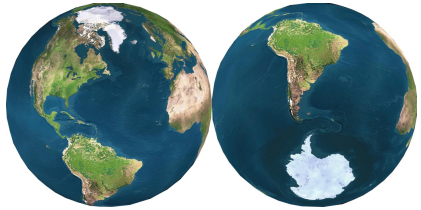
IRRESISTIBLE is a project on teacher training, combining formal and informal learning focused on Responsible Research and Innovation.
It is a coordination and support action under FP7-SCIENCE-IN-SOCIETY-2013-1, ACTIVITY 5.2.2 Young people and science: Topic SiS.2013.2.2.1-1 Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

irresistible

The project bringing Responsible Research and Innovation into the classroom

Polar Science: Evaluate Earth Health trough Polar Regions

"Polar Science: an imperative part of understanding how climate change affects our planet."



Students, will research about Polar Science as a multidisciplinary scientific domain that contributes to a better understanding of our planet's health. It is intended that students know the importance of Polar Science and understand how it contributes to our changing world trough the analysis of scientific papers. In a second phase, students need to reflect about the 6 dimensions of RRI and identify RRI practices in the papers and also suggest other, having the opportunity to explore some examples of good RRI practices in Polar Science. Finally, students will build an interactive exhibition as a way to educate the community about this topic.

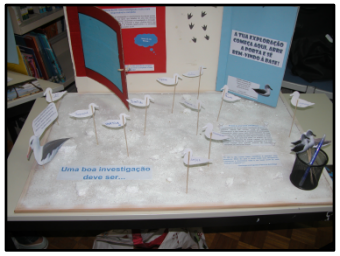
Why use this module in class?

- Interdisciplinary module combining biology, physics, chemistry, geology and geography in a scientific context
- Combination of many active learning approaches
- Modules addresses many Academic Skills
- Module includes the relation of the scientific topic with societal issues by using Responsible Research and Innovation (RRI)
- Students make an exhibition on the science & the ethical issues as wind-up of the module

Module Polar Science: Evaluate Earth Health trough Polar Regions

Few people know the importance of Polar Science and how it contributes to our changing world. The Polar Science aim is understanding how climate changes affect our planet. Polar scientists have participated in multidisciplinary international projects, with the objective of evaluating environmental and sociological processes in the Arctic and in Antarctica, studying the relationship between the polar regions and the rest of the Planet. These multidisciplinary projects have the major purpose of improving our ability to detect regional and global changes, allowing an evaluation of the consequences for humanity and for the planet.

This module is aimed at students from 15 to 18 years old, and it takes about 10 lessons with extra classroom work, depending on the learning approaches used. Change, its causes and consequences should be a topic already addressed by students and such concepts should be clear so students can understand the polar science study objet. Being familiarized with the scientific method and having a level of knowledge and language that allow students to analyse a scientific paper it is also required.



"We've learned a lot about various features of the poles that I had no idea! As well as I had no notion that Portugal was so involved , like other countries in the Polar Science"(Student, Portugal)

Responsible Research and Innovation (RRI)

Responsible Research and Innovation is a term that is introduced by the EU to make science and society work better together. The goal is that all societal actors, including citizens, are more involved in the process of Research and Innovation. In the module, the six key issues of RRI are introduced (*Engagement, Open Access, Gender, Ethics, Science Education* and *Government*) and the students are motivated to work with this topics by exploring real examples of RRI practices related to polar science and discussions on RRI practices present in the analysed scientific papers.

Inquiry-based Science Education (IBSE) and active learning

The module is based on the didactic model of IBSE and is divided into 7 chapters:
Engage – engage the student with the topic with reflexive tasks, videos and texts. Having a national polar scientist talking with students will lead to greater engagement;
Explore – explore Polar Regions characteristics regarding some relevant aspects as their climate, biology, geology…;
Explain –analysis of different research papers ;
Elaborate – identify the presence (or absence) of RRI practices in the research paper; suggest ways of improving RRI regarding the investigation;
Exchange & Empowerment – develop a final exhibition to be presented to the community – it serves as a platform for students to share with others what they've learned and also share their own opinions and concerns about the topic;
Evaluate – students assess their peers through online questionnaires; self and hetero-assessment of the presentations, objects and final exhibition.

Through the set of tasks of the module, students will:

- Develop substantive knowledge concerning Polar Science
- Develop reasoning competencies;
- Develop communicational competencies;
- Construct a reflexive and critical attitude in relation to Responsible Research and Innovation regarding Polar Science

"Along the way the students learned many things, mostly about RRI and Polar Science. I figured out in the products presented in the exhibition and the way they presented them."
"(Teacher, Portugal)

Student exhibitions in Portugal

irresistible

The Irresistible-project:

The goal of the IRRESISTIBLE project is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI).
In the project, partners from universities and science centers have worked together with teachers to develop teaching material about scientific subjects. All material is based on Inquiry-Based Science Education and combines formal and informal learning approaches.

Other modules in the Irresistible-project:

- Polar Science: Evaluate Earth Health trough Polar Regions
- Business Game Offshore Wind Energy
- Geo-engineering and Climate Control
- Carbohydrates in (Breast) Milk
- Atmosphere and Climate Change
- Nanotechnology in Health Sciences
- Nanotechnology for Solar Energy
- Nanotechnology for Information
- Nanoscience Applications
- The Catalytic Properties of Nanomaterials
- Perovskite-based Photovoltaic Cells

Visit our website for more information:

www.irresistible-project.eu

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.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

irresistible

The project bringing Responsible Research and Innovation into the classroom

Plastic – Bane of the Ocean

Oceanography and Climate Change

The module explores the influence of plastics on the ocean such as the different ways of contamination, the behavior of plastics in the ocean, the adsorption of pollutants on micro-plastic particles, as well as their intrusion in the food chain. The module has a global as well as local level and includes experimental and group work.

Why use this module in class?

- Interdisciplinary module combining chemistry, biology, and physics in a scientific context
- Combination of many active learning approaches
- Modules addresses many academic skills
- Module includes the relation of the scientific topic with societal issues by using Responsible Research and Innovation (RRI)
- Students develop an exhibition on the science as well as ethical issues to reflect on the module's topic

Module: Plastic – Bane of the Ocean

In this interdisciplinary module, students explore different types of plastic, their lifetime and way of decomposition as well as the effects on the ocean and marine life. Next to oceanographic content, the module combines biological, chemical and physical aspects. It starts with macro-plastic and its decomposition to micro-plastic, the problem of plasticizers dissolved from it and its threat to flora, fauna and humans. Different factors influencing the process are highlighted, like sea currents and the food chain, including experiments like investigating local water bodies. Within the module, a red line is drawn from useful (everyday) products to products with a high risk potential – e.g. containing micro-plastic particles. In addition, ethical issues like the use of micro-plastic particles in cosmetics are addressed. The project is closed by an exhibition at school, in which the students present their topic to their peers and/or parents, combining scientfic and ethical issues.

The project takes about 15-20 lessons, depending on the topics and learning approaches used. It can be taught in lower as well as in upper level high-school.



Responsible Research and Innovation (RRI)

Responsible Research and Innovation is a term that is introduced by the EU to make science and society work better together. The goal is that all societal actors, including citizens, are more involved in the process of Research and Innovation.
The students of today are the scientists and the citizens of tomorrow, so it is necessary for them to see the relevance of science topics for society.
In the module, the six key issues of RRI are introduced (*Engagement, Open Access, Gender, Ethics, Science Education* and *Government*) and the students are motivated to work with this topics by actities like a game, role play or debate over propositions that relate to the scientific topics.

Structure of the module following the 6E approach

Engage: Starting with a trailer showing flora and fauna of the ocean in fascinating pictures, followed by a PowerPoint slideshow, which gradually shifts from great pictures to touching photographs showing the impact of plastic on marine creatures.
Explore: Mystery: “Why is the health of the Larsson family in Greenland possibly in danger because they don’t want to give up their traditional diet?” Students get ~16 fact cards with different arguments. In groups of 4 they analyze the arguments and try to create a path to solve the question. The game should give an idea of the complex relations playing together in the ocean.
Explain: As a result of the mystery, students describe a possible way how the Larsson’s family is connected to the global problem of plastic waste in the ocean.
Elaborate: Pupils deal with further research questions about the local observation of the plastic problem. In this phase, pupils perform their own experiments, read scientific publications on the subject and confront extracurricular learning partners with questions. In the second part of the elaborate phase, the aspects of RRI are discussed in class, looking back and highlighting them in the module performed so far.
Exchange: An exhibition is developed to exchange the gained knowledge with peer students and/or parents.
Evaluate: At this stage, the expertise of the students is checked with a test. This includes questions about both the global and the local view of the problem.



Student exhibitions in Germany

irresistible

The Irresistible-project:

The goal of the IRRESISTIBLE project is to design activities that foster the involvement of students and the public in the process of Responsible Research and Innovation (RRI).
In the project, partners from universities and science centers have worked together with teachers to develop teaching material about scientific subjects. All material is based on Inquiry-Based Science Education and combines formal and informal learning approaches.

Other modules in the Irresistible-project:

- Polar Science: Evaluate Earth Health trough Polar Regions
- Carbohydrates in (Breast) Milk
- Geo-engineering and Climate Control
- Plastic - Bane of the Oceans
- Atmosphere and Climate Change
- Nanotechnology in Health Sciences
- Nanotechnology for Solar Energy
- Nanotechnology for Information
- Nanoscience Applications
- The Catalytic Properties of Nanomaterials
- Perovskite-based Photovoltaic Cells

Visit our website for more information:

www.irresistible-project.eu

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.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

irresistible

The project bringing Responsible Research and Innovation into the classroom

Business Game Offshore Wind Energy

Oceanography and Climate Change

The module is a simulation game in which students discuss the possible investment of a municipality into an offshore wind park. They research and adopt the roles of different stakeholders and debate the risks and benefits of the investment in the light of local (municipal) and global (ocean) aspects.

Why use this module in class?

- Interdisciplinary module combining biology, physics, and economics in a scientific context
- Combination of several active learning approaches
- Modules addresses many academic skills
- Module includes the relation of the scientific topic with societal issues by using Responsible Research and Innovation (RRI)
- Students develop an exhibition on the science as well as ethical issues to reflect on the module's topic

Module: Offshore Wind Energy

In this interdisciplinary module, topics from the curriculum of biology and physics are addressed. Students independently develop structures for risks and benefits of an offshore wind park. By stepping into the role of a stakeholder, they analyze the information from this point of view and develop a suitable line of argumentation. Meanwhile they have to evaluate alternative sources of energy supply (like other forms of conventional or regenerative energy) and take into account environmental legislations as well as principles of sustainability. During the final discussion ethical and political aspects are addressed – like the consequences for the marine life and the financial situation of the municipality. The project is closed by an exhibition at school, in which the students present their topic to their peers and/or parents, combining scientfic and ethical issues.

The project takes about 5-12 lessons, depending on the topics and learning approaches used. It can be taught in lower as well as in upper level high-school.

Responsible Research and Innovation (RRI)

Responsible Research and Innovation is a term that is introduced by the EU to make science and society work better together. The goal is that all societal actors, including citizens, are more involved in the process of Research and Innovation.
The students of today are the scientists and the citizens of tomorrow, so it is necessary for them to see the relevance of science topics for society.
In the module, the six key issues of RRI are introduced (*Engagement, Open Access, Gender, Ethics, Science Education* and *Government*) and the students are motivated to work with this topics by actities like a game, role play or debate over propositions that relate to the scientific topics.

Structure of the module following the 6E approach

Engage: The module starts with a description of the scenario: in order to secure the future energy supply, the local community would like to invest in an offshore wind park and invites a number of stakeholders to a council meeting .
Explore: Students choose a stakeholder role and explore relevant facts and arguments in order to present and defend their position on the issue.
Explain: In the municipal debate pupils have to present and explain their viewpoints and arguments as a specific stakeholder within their role (including technical, scientific, social, ethical and personal points of view).
Elaborate: After the initial viewpoints have been given in the municipal debate, the pupils have to react to the statements of the other stakeholders and elaborate on their previous presentations. This phase also requires pupils to reflect on their initial views in light of the emerging complex problem, thus challenging them to develop and propose a responsible decision.
Exchange: An exchange takes place at different levels throughout the simulation game: usually, an identical stakeholder role is assigned to two or three pupils. In the research phase these have to work together, exchanging findings on facts and arguments. The main exchange then occurs in the 'municipal conference', where the various stakeholders debate the issue of whether the municipality should invest in offshore wind energy. Finally, additional exchange is necessary to develop an exhibition with a coherent picture of the topic.
Evaluate: The simulation game ends with a communal debriefing session, in which the pupils reflect on the simulation game

Student exhibitions in Germany

Exhibitions

- **Local Exhibitions (in schools) - starting with March 2015** (schools involved in IRRESISTIBLE Project)
- **Exhibition 1: "The World of Nanomaterials and Solar Energy" - August - November 2015** - at *History Museum of Dambovita County*
- **Exhibition 2: "The Sun & The <Nano> World" - March - July 2016** - at *Prahova Natural Science Museum*
- **European Researcher's Night - September 2015** - at *History Museum of Dambovita County*
- **European Researcher's Night - September 2016** - at *History Museum of Dambovita County / Museum of the Romanian Police Targoviste*
- **European Researcher's Night - September 2016** - special event in *Kiel, Germany*

IRRESISTIBLE Project

IRRESISTIBLE is a European Commission funded project, whereby fourteen partners including academic institutions and science centers / museums from ten different European countries collaborate through a Science-in-Society activity, in the frame of 7th Framework Program (FP7).

The goal of the IRRESISTIBLE project is to bridge formal and informal/non-formal education by developing Training Modules introducing actual and cutting-edge science topics through inquiry-based science education, in order to raise the awareness of students and public in *Responsible Research and Innovation* (*RRI*).

RRI implies that *societal actors* (researchers, citizens, policy makers, business, third sector organizations etc.) *work together during the whole research and innovation process in order to better align both the process and its outcomes with the values, needs and expectations of society*.

SEVENTH FRAMEWORK PROGRAMME

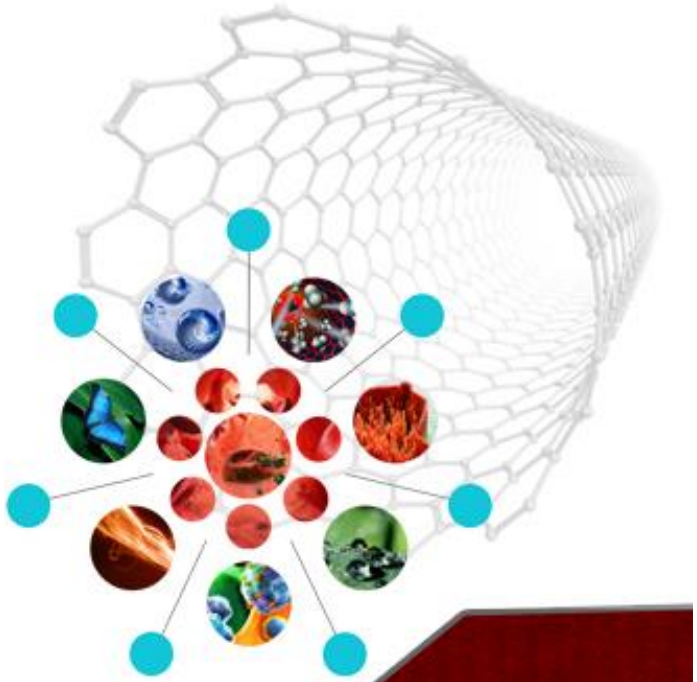
IRRESISTIBLE is a project on teacher training, combining formal and informal/non-formal learning focused on Responsible Research and Innovation.
It is a coordination and support action under FP7-SCIENCE-IN-SOCIETY-2013-1 ACTIVITY 5.2.2 Young People and Science - Topic SiS.2013.2.2.1-1: Raising youth awareness to Responsible Research and Innovation through Inquiry Based Science Education.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under Grant Agreement no. 612367.

irresistible

UNIVERSITATEA VALAHIA din TÂRGOVIȘTE 1992

Romanian IRRESISTIBLE Teaching Module

Applications of Nanomaterials



IRRESISTIBLE - Including *Responsible Research and Innovation* in Cutting Edge Science and Inquiry-based Science Education to Improve Teacher's Ability of Bridging Learning Environments

http://www.irresistible-project.eu/
http://irresistible.ssai.valahia.ro/

Applications of Nanomaterials - Content

(1) Natural Nanomaterials - The experiments proposed in this unit direct students to acknowledge the nanoparticles in natural nanomaterials. The activities are planned to make students think about maintaining people's health and responsible use of food-related nanotechnology.

(2) Lotus Effect - The students approach the effect from a nanoscience innovation perspective. The purpose is to form a responsible attitude towards using nanomaterials in various industries. The experimental activities highlight the structural and functional properties of super-hydrophobic nanomaterials.

(3) Nanoscience - A Facilitator Background for a United Group - The students are introduced to the concept of nano-metals and learn green methods for obtaining colloidal nanoparticles (Au and Ag) from plant extracts, with a responsible attitude concerning the use of nanoparticles in practice.

(4) Magnetic Liquids Technology - Ferrofluids - Ferrofluids are a special class of nanomaterials that combines the usual properties of a liquid and a magnet. This unit involves students to study the properties of such unusual materials before proceeding to search and design several applications. The unit claims some previous knowledge related to magnets.

(5) Applications of nanomaterials in Medicine - The activities designed in this unit aim to the formation of a conscious and responsible attitude towards the importance of using the properties of nanomaterials - either natural or synthesized - in the medical laboratory.

(6) Applications of nanomaterials in Solar Energy Systems - The envisaged activities target to enrich the students' knowledge concerning the renewable energy, but also to specific Responsible Research and Innovation issues related to solar energy technologies.

(7) Industrial applications of nanomaterials - The activities proposed to be carried out by the students lead to know general notions about nanomaterials and their applications in industry.

(8) Applications of nanomaterials in Museum Research - The envisaged unit activities - strengthening the whole knowledge gained till this moment - propose to carry out also a series of experimental / practical work specific to museums.

(9) The World of Nanomaterials and ***(10) Biomimicry / Nanobiomimicry*** - Those two multimedia units are designed in order to fundament the concepts and notions learnt by the students during the entire Module. In this respect, a movie (in the first activity) and many images (in the last one) are used to explain - in details - various applications of nanomaterials and introduce also the concept of biomimicry.

Examples of Workshops organized with teachers & students

- "*Nanosciences and responsible research*" - History Museum of Dambovita County
- "*Multimedia Instruments for Promoting the Concept of Responsible Research and Innovation in Museum Practices*" - Prahova Natural Science Museum
- "*Responsible Research and Innovation in the Area of Nanotechnology*" – "Ion Heliade Rădulescu" Dambovita County Library
- "*Nanobiomimicry and Responsible Research*" - National College "Constantin Cantacuzino" Targoviste
- "*Applications of nanomaterials in industry*" - Valahia University Targoviste
- "*Applications of nanomaterials in renewable energy technologies*" - Multidisciplinary Scientific & Technological Research Institute of Valahia University Targoviste
- "*History of nanomaterials. Applications of nanomaterials in practice*" - "Ion Heliade Rădulescu" Dambovita County Library
- "*Applications of nanomaterials in museum research*" - Prahova Natural Science Museum
- "*World of Tomorrow and the Future Energy*" - Technical College "Elie Radu" Ploiesti

The IRRESISTIBLE project

The goal of the project IRRESISTIBLE is to design activities that foster the involment of students and the public in the process of Responsible Research and Innovation (RRI). In the project, partners from universities and science centers have worked together with teachers to develop teaching material about scientific subjects. All material is based on Inquiry-Based Science Education and combines formal and informal learning approaches.

Other modules in the IRRESISTIBLE project:

- Polar Science: Evaluate Earth Health through Polar Regions
- Oceanography and Climate Change
- Geoengineering and Climate Control
- Nano for Health
- Perovskite-based Photovoltaic Cells
- Nanotechnology for Information
- Nanoscience Applications
- The Catalytic Properties of Nanomaterials
- Plastics – Bane of the Oceans
- Carbohydrates in (Breast) Milk

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.
This project has received funding from the European Union's Seventh Framework Programme for research, technological development and demonstration under grant agreement no 612367.

SEVENTH FRAMEWORK PROGRAMME

irresistible

The project bringing Responsible Research and Innovation into the classroom

Climate change – effects and adaptation

"Ocean temperatures on the rise. Glaciers melting. Droughts and floods becoming more common.

What is it all about?
What can we do about it?"

As the climate conversation affects all members of society and policy makers, education is key to meaningful correspondence between decision makers and citizens. This module includes chemistry, physics, biology, geography, and social sciences topics important to the study of climate change such as acidity, CO_2 –cycle, greenhouse effect and policy-making. The module is proposed for students aged 11-13. It includes additional tasks for use with older students.

Why use this module?

- Module is interdisciplinary combining earth sciences, chemistry, physics and social sciences in the context of a global grand challenge
- Module addresses many academic skills
- Module combines diverse active learning approaches
- Module bridges science with societal issues by addressing Responsible Research and Innovation (RRI) dimensions
- Students make an exhibition on science and society as outcome of the module

About the teaching module

The goal in this module is to educate students about the numerous phenomena that are associated with climate change. During the learning sequence, students will familiarize themselves with several effects of climate change, the adaptation of different fauna to changing environments, and the role of local governance in climate change prevention.

This is accomplished by the students doing scientific experiments, investigating related topics and interacting, relating and corresponding with the parties affected by climate change.

The module culminates on a student-made exhibition, in which the students' present their peers with what they want them to know about climate change and help ensure their responsible future decision-making.

Students' studying greenhouse effect in theory and in practice

Responsible Research and Innovation (RRI)

Resonsible Research and Innovation is a term that is introduced by the EU to make science and society work better together. The goal is that all societal actors, including citizens, are more involved in the process of Research and Innovation. The students of today are scientists and the citizens of tomorrow, so it is necessary for them to see the relevance of science topics for society.

In the module, the six key issues of RRI are introduced (Engagement, Open Access, Gender, Ethics, Science Education and Governance) and the students are motivated to work with this topic with games, roleplay, or debates over propositions that relate to the science topics.

Inquiry-Based Science Education (IBSE) and active learning

The teaching module utilizes inquiry-based teaching methods, which emphasize learning by using similar methods as researchers. The lessons comprise six activities (6E – characteristic for IBSE)

Engage - Arousing students' curiosity and generating interest (video, news, story, etc.)

Explore - Acquiring a common set of experiences within which students can begin to construct their understanding

Explain - Connecting students' previous experiences with current learning and making sense of the main concepts. Introducing formal language, scientific terms, and content information relevant to the subject

Elaborate – Applying previously introduced concepts and experiences to new situations

Exchange - Sharing of knowledge between students', peers and other audiences via different medias (exhibition, blogs, videos)

Evaluate - Evaluation of students' conceptual understanding and skills (also self- and peer-assessment)

This teaching module offers plenty of opportunities to include engaging and active learning opportunities. This is done in the module by motivating student activities such as experimental work and online assignments. In the end of the teaching period students' also prepare presentations and exhibition as a group effort. In the end of the teaching period this will:

- Increase students' awareness of consequences of climate change
- Give students valid **tools** for inquiry activities, such as controlling variables, or designing experiments
- Improve students' understanding of **scientific inquiry**, **RRI aspects**, and **science communication** skills

Students working together on a museum visit