RRI and Nanotechnology: Developing a Teaching Module and Exhibits for Primary and Secondary Students

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Introduction

Current literature indicates the need Science Education to render compatible with the latest scientific advances and social demands, to enhance students' interest in science and technology and to promote inquiry-based learning by familiarizing students with scientific methods and the communication of science (Osborne,2008). Nanoscience and Nanotechnology set up a scientific field appropriate to attain these objectives as they can initiate students to processes and nature of science and assist their moral and ethical development (Sadler, 2004; Jones et al. 2013). However, as teachers' quality is the most important factor influencing student achievement (Darling-Hammond, 2000), there is still a need for teacher training in cutting-edge science topics and for novel means of students' communication of their acquired knowledge.

Objectives

To this end, in the context of the IRRESISTIBLE project in Greece, primary and secondary school teachers supported by scientists, science education and science museum experts, developed and implemented a teaching module on Responsible Research and Innovation (RRI, European Commission 2012) using topics from the field of NST. The final outcome of the module was the construction of exhibits by the students to communicate the new knowledge to the wider public.

In the present study we investigate:

a) Teachers' abilities and difficulties in reconstructing the new scientific area of nanoscience and nanotechnology focused on RRI aspects into content for instruction

b) Primary and secondary school students' abilities and difficulties to construct exhibits on RRI aspects based on NST topics to communicate the knowledge acquired.

Methodology

Development and Implementation of the module

Five highly qualified and experienced in-service teachers (one primary teacher, two physics teachers and two chemistry teachers) participated as active members in a Community of Learners (fig.1)

Since the members of the CoL are located in different parts of Greece, teleconferences and face to face workshops were used in order to facilitate the collaboration and exchange of ideas and materials.

The development of the module was completed through a process 12 months long, as described in Fig.2

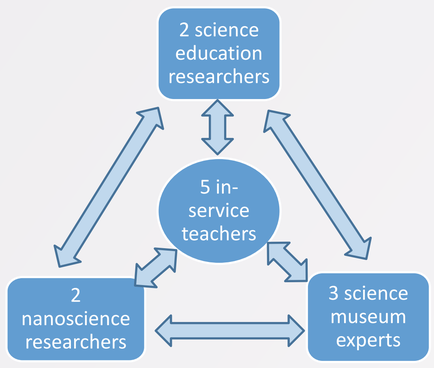

Fig.1 The greek CoL

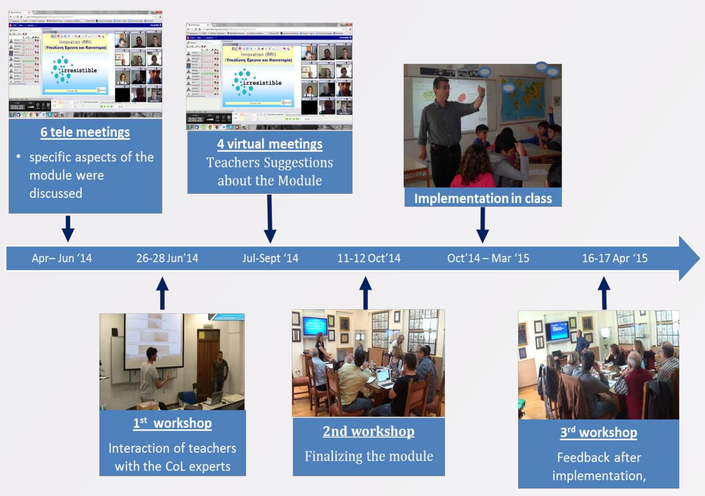

Fig.2 Module development timeline

Structure of the module

Lesson 1. Introduction
Lesson 2. Visiting the Science Museum
Lessons 3 & 4. Nanoscience Applications: Self-Cleaning Materials
- How small is Nano?
- Size-dependent properties

Lesson 5. RRI-Issues
- Newspaper articles
- Discussion with experts in school and the research center

Lesson 6. Visiting the Research Center
Lesson 7. Construction of Exhibits

Exhibits Development

During the exhibits development, students were supported by science museum experts (E.F.), science education researchers (UOC) and their teachers as shown in fig.3

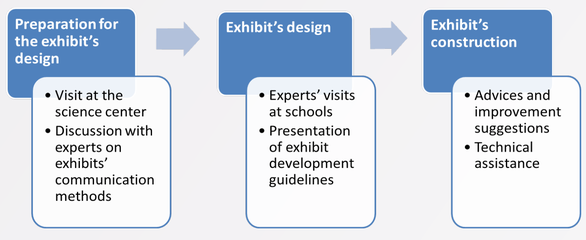

Fig.3 Support provided during each exhibit development phase

Examples of students' exhibits

Data collection

On Module development	On exhibits development
Pre- and post- teachers training questionnaire (NST and RRI)	Pre- and post exhibits development questionnaire
Questionnaire on module development suggestions (teachers)	Semi constructed focus group interviews
Video-recordings of the CoL meetings	Field notes
Semi constructed individual interviews (teachers)	Students' exhibits
Developed modules at different phases of teachers training	Individual interviews (teachers)

Table1. Data collection methods we used

Results

Development and Implementation of the module

As far as it concerns the teachers, they take advantage of experts' participation in CoL, developing a module intergrating nodal NST and RRI issues that brings in balance formal and informal education features.

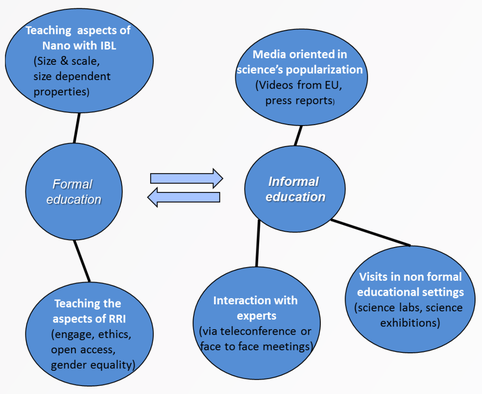

Fig.4 Aspects of formal & informal education in interaction

Exhibits Development

Students managed to develop several types of scientific exhibits addressing a wide range of NST aspects (Table2 & Table3).

Exhibits scientific content	Primary education	Lower secondary education	Upper secondary education	Total
SyperHydrophobic materials/ size dependent properties	1	1	1	**3**
Nano-medicine		2	1	**3**
Other nano-applications (ferrofluids, photocatalytic materials)		1	1	**2**
Size and scale	3			**3**
General nanotechnology knowledge	3	1		**4**
Nanostructures			1	**1**

Table2. Exhibits' scientific content

Exhibits type	Primary education	Lower secondary education	Upper secondary education	Total
Interactive posters	3	2	-	**5**
Informative posters	1	1	2	**4**
Playful activities (Board games, origami crafts etc.)	2	-	1	**3**
Digital/multimedia exhibits (digital interactive posters, digital game, quiz, video)	-	2	4	**6**
Experiments activities	1	1	2	**4**

Table3. Exhibits' Type

During the exhibit development process students are influenced by several factors both in the selection of the content and the type of the exhibit. The main factors are shown below in fig.5. Finally, in terms of RRI aspects presentation, students seem to face difficulty in integrating all RRI aspects in their exhibits and giving an overview of what comprises RRI as they focused mostly in science education (Table4).

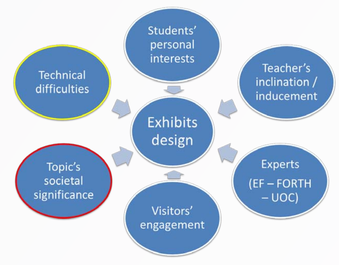

Fig.5 Factors that influenced students in exhibits development

RRI Aspects	Primary education	Lower secondary education	Upper secondary education	Total
Engagement	1	2	3	6
Science Education	6	5	4	15
Gender	_	2	1	3
Ethics	-	3	1	4
Open Access	-	3	1	4
Governance	-	2	-	2

Table4. RRI aspects presented in exhibits

Conclusion

Implementing the IRRESISTIBLE Project, teachers combine formal and informal learning tools for teaching RRI aspects through NST topics. The effectiveness of such a combination can be seen from the students gained ability to communicate the acquired knowledge by designing science exhibits .

References

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IRRESISTIBLE is a project on teacher training, combining formal and informal learning focused on Responsible Research and Innovation.

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