Integrating Responsible Research and Innovation to Nanoscience Applications as Extracurricular Activity in Secondary Science Education

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Introduction

Responsible Research and Innovation (RRI) is defined as 'a transparent, interactive process by which societal actors and innovators become mutually responsive to each other' (Von Schomberg, 2013). As RRI has becoming an integral part of science and technology, the need for understanding RRI and its key components by the society is rapidly increasing. One attempt to meet this need is to incorporate RRI into K-12 science education. To this end, a cutting edge science, nanoscience and its practical applications has been selected, and a RRI-integrated nanoscience module has been developed. This particular module was implemented as an extracurricular activity. The module included several inquiry-based activities, focusing on six key aspects of RRI; engagement, governance, gender equality, science education, open access, and ethics, in the context of nanoscience applications.

Settings of the Study

- The RRI-integrated nanoscience module was developed by a group of experts composed of science teachers, science educators, scientists, and museum experts, the so called Community of Learners (CoL).
- The content of the module was prepared in an inquiry-based format by integrating the 6E approach, i.e. engage, explore, explain, elaborate, evaluate and exchange, in various tasks and activities. The key aspects of RRI were integrated in specific tasks where the students analyzed and discussed the given scenario.
- Students learn the fundamental concepts of nanoscience, such as nanometer, size and scale, nanoparticle, antibacterial effect, as well as the key aspects of RRI such as engagement, while discussing why the committee included members from different societal actors.
- The module has been implemented to middle and high school students for 8 weeks, spending 11 contact hours in total. Then, students spent 3 weeks developing an exhibition on nanoscience applications integrating RRI.
- The lesson topics of the module are:
  - Hospital-Acquired Infections
  - Size and Scale
  - Modeling Drug Release or Absorption
  - Imaging Bacteria
  - Synthesizing AgNP and Testing Its Antibacterial Effect
  - Antibacterial Effect of Nanoproducts
  - Other Nanoparticles
  - Responsible Research and Innovation
  - Designing an Interactive Exhibition Product

Data Collection and Analysis

Design of the Study: A mixed methods design was adopted in the study and both quantitative and qualitativedata were collected.

Participants: In the study, participants were selected by purposeful sampling, because the module was implemented to the students whose teachers were a part of the CoL. The teachers of five different schools were recruited to work in the CoL through convenience sampling, considering their previous experience in nanoscience education.

Instruments & Data Collection:

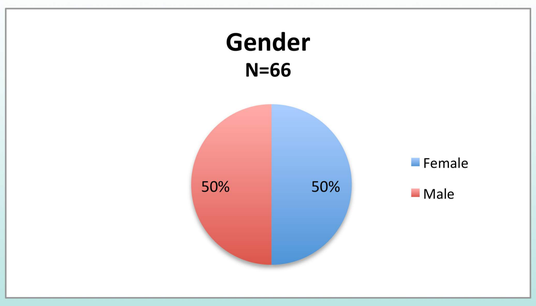
- For the quantitative aspect, students were given Nanoscience Content Questionnaire, Nanoscience Awareness Questionnaires, and Responsible Research and Innovation Questionnaire before and after they engaged in the module. The Nanoscience Content Questionnaire was composed of open-ended questions related to fundamental concepts of nanoscience. The other two questionnaires were of Likert-type.
- Qualitatively, selected students were interviewed in a semi-structured format in the beginning and at the end of the module. Additional data sources, including student created artifacts, teachers' observations, and field notes, were also collected.

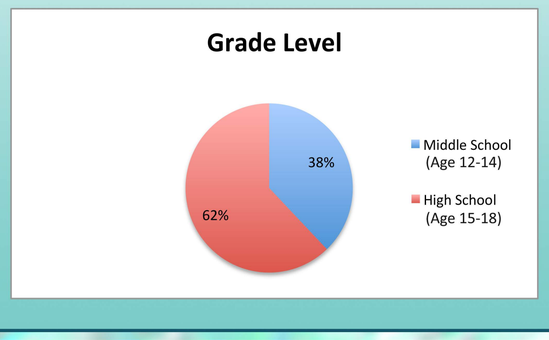
Data Analysis:

- For the quantitative data, the mean scores are compared statistically by Wilcoxon Signed Rank Test, for each participating school, and the whole group of participants. For the qualitative data, semi-structured interviews are coded by open coding. Results of the qualitative analysis are not reported in this paper. The emerging categories are determined and the resulting categories are explained in more detail.
- Similarly, students' artifacts and teachers' field notes will be coded and analyzed to investigate further effects of an RRI-integrated nanoscience module on students' attitudes towards RRI, conceptual understanding and awareness of nanoscience, to support quantitative data.

Findings

Demographics





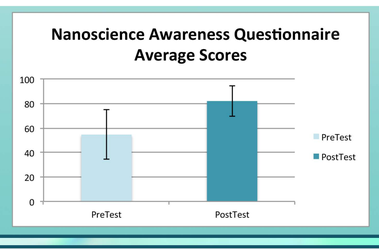
Nanoscience Awareness Questionnaire

Descriptive Statistics				Test Statistics[a]	
	N	Mean	Std. Deviation	Z	Asymp. Sig. (2-tailed)
PreTest	63	54.6032	20.32045	-6.580[b]	.000
PostTest	63	82.0317	12.39793		

a. Wilcoxon Signed Ranks Test b. Based on Negative Ranks

Wilcoxon Signed Rank Test				
Ranks				
		N	Mean Rank	Sum of Ranks
Post Test- Pre Test	Negative Ranks	1[a]	29.50	29.50
	Positive Ranks	60[b]	31.03	1861.50
	Ties	2[c]		
	Total	63		

a. PostTest<PreTest b. PostTest>PreTest c. PostTest=PreTest



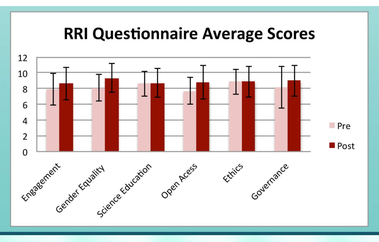
Responsible Research and Innovation Questionnaire

Descriptive Statistics				Test Statistics[a]	
	N	Mean	Std. Deviation	Z	Asymp. Sig. (2-tailed)
PreTest	21	163.5714	22.63531	-2.034[b]	.042
PostTest	21	173.3333	21.44139		

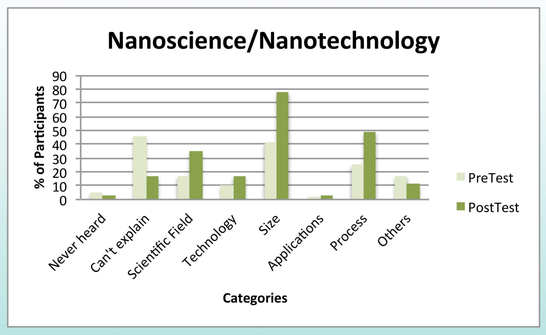
a. Wilcoxon Signed Ranks Test b. Based on Negative Ranks

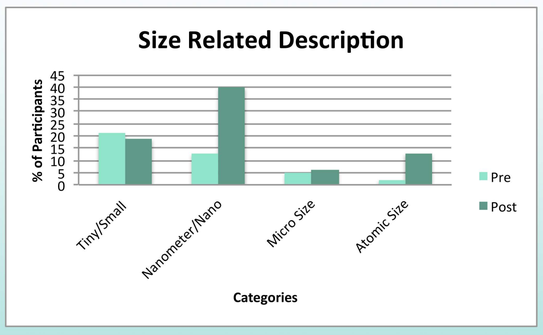
Wilcoxon Signed Rank Test				
Ranks				
		N	Mean Rank	Sum of Ranks
Post Test- Pre Test	Negative Ranks	4[a]	14.25	57.00
	Positive Ranks	17[b]	10.24	174.00
	Ties	0[c]		
	Total	21		

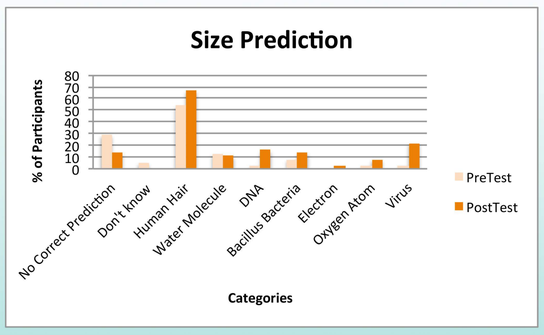
a. PostTest<PreTest b. PostTest>PreTest c. PostTest=PreTest

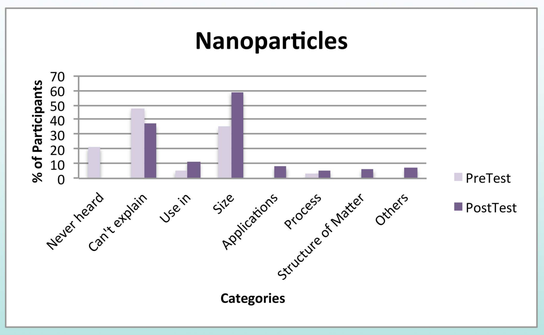


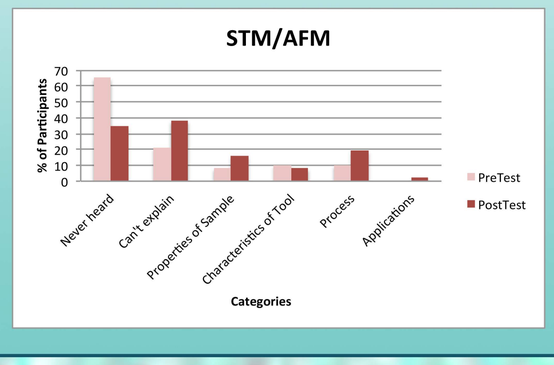
Nanoscience Content Questionnaire

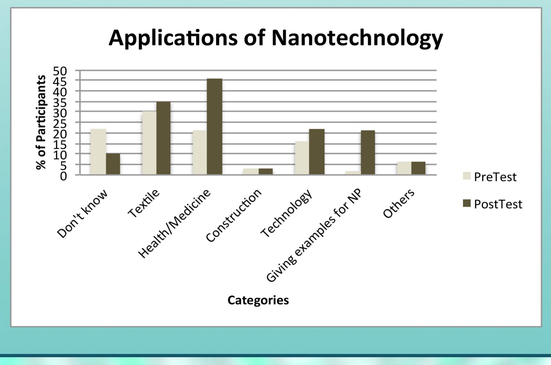


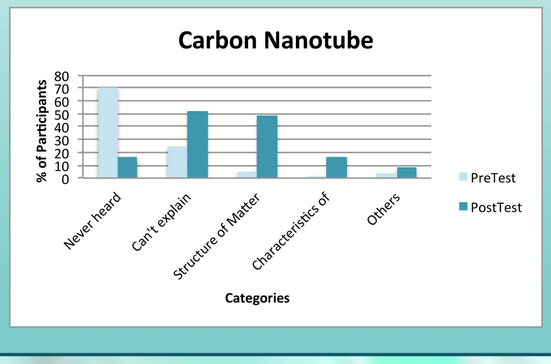


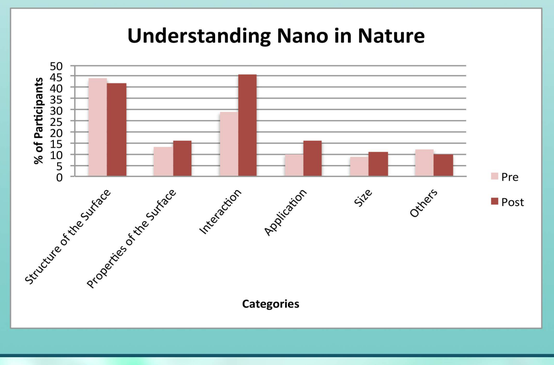












Conclusion and Discussion

- In this study, a Nanotechnology Applications in Health Sciences Module was developed by Community of Learners, and implemented to 65 secondary school students as an extracurricular activity for 12 weeks. When the students' Nanoscience Awareness, Understanding of RRI and Conceptual Understanding of Nanoscience were compared in the beginning and at the end of the implementation, specific improvements we're observed.
- After completing the module, students reached to a significantly higher level of Nanoscience Awareness ($p=0.000$) and Understanding of RRI ($p<0.05$) in total and specifically in the aspects of 'gender' ($p<0.05$) and 'open access' ($p<0.05$). For the conceptual understanding, they started to describe Nanoscience and Nanotechnology by emphasizing sizes, scale and applications. They reached a deeper understanding of nanoscience in nature, nanoparticles and related applications. In conclusion, the module helped students improve their conceptions in Nanoscience as well as Responsible Research and Innovation.
- All in all, the module can be suggested to other secondary students as a good practice.

References:

Von Schomberg, Rene (2013). A vision of responsible innovation. In R. Owen, M. Heintz and J Bessant (eds.) Responsible Innovation. London: John Wiley.

http://www.irresistible-project.eu/index.php/en/

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.

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http://www.irresistible-turkiye.com/index.html