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PROMOTING NANOSCIENCE TOPICS IN FORMAL EDUCATION

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Abstract

In general, considering a reasonable and relative periodicity, the school curriculum has to pass a process of updating and/or reform - in many cases, in strong connection to the nature and extent of the changes that occurred in each educational system, but also linked with what is happening in the society. Nowadays, many opportunities for getting knowledge and developing personal and social affirmation of each individual are related to the spectacular advancement of science and technology. In the actual context, significant changes are noticed in the labor market, pushing the educational systems to anticipate the needs of the near-future society, not just to react to technological developments. In this respect, creativity, entrepreneurial and managerial skills, responsible use of technology, responsible research and innovation, are already present in the education of the 21st century. In this respect, nano-education has been introduced and developed in Romania, and recording an entire process of consolidation, especially at the level of higher education - promoting nano-area as one of the most dynamic big domains in the world of research since the beginning of the century. However, in secondary education, the preoccupations remain sporadic, several positive aspects being recorded especially in non-formal education. This paper tries to offer an answer related to how important nano-education is for the actual generation of youngsters, and what are the main problems that teachers face when trying to promote aspects linked with the nano-world.

Keywords: Nanoscience; nano-education; curriculum; formal education;



1. INTRODUCTION

The beginning of the 21st century has brought to humanity an important number of innovative solutions to a series of problems, solutions implemented - in many cases - with the help of new technologies. On the other hand, a fierce struggle between companies producing various equipment and software applications is recorded, with the view to have supremacy in the world market. At the same time, new technologies and materials have emerged (including nanotechnology and nanomaterials), which have led to manufacturing products with better properties and with smaller and smaller dimensions.

Related to nanotechnology, that is described as the defining technology of the 21st century and represents “the potential technology for defining the industrial revolution of the future” (Ho, Scheufele, & Corley, 2010). In this respect, Education for Nanoscience and Nanotechnology try to find a well-deserved place in the national education system, especially since the area of Nanotechnology has become one of the most dynamic in the world of research in the last two decades.

However, in higher education, bachelor and master degree programs have been introduced, with the aim for studying nanotechnology and nanomaterials, and as good and gladdening news, several specific disciplines are included in the curricula of few undergraduate programs, such: Introduction in Nanoscience (and/or Nanotechnology), or Basics of Nanotechnology, but also chapters dedicated to Nanoscience and Nanotechnology, found in the content of disciplines related to study programs in Engineering, Physics, Chemistry, and Biology (<https://www.imt.ro/nanoprospect/>).

In any case, in secondary education, attempts to introduce Nanoscience/Nanotechnology-specific content into school curricula and classroom-activities remain timid. There are recorded some, mostly related to disseminating achievements in the field, both in formal and in non-formal education, the last ones being introduced especially in the frame of one-week educational activities proposed in the national program entitled “School in Another Way”, or with the occasion of debates or scientific meetings with students and specialists in the field.

2. PROBLEM STATEMENT AND PARTICULAR QUESTIONS

If we take into discussion the national level, in the research field, at the beginning of the last funding cycle of European programs (2014-2020), the area of Nanotechnology was presented and disseminated as a promising and very successful domain for Romanian research, in accordance to what is happening in other European Union countries, especially when research is developed in partnerships, having in the teams, institutions with expertise in the nano-area. Unfortunately, Romania has managed to win only a few projects - within the “Horizon 2020” program - although significant investments have been made in the experimental infrastructure, with successful and important results (Dascălu, 2017). And yet, the research - even in the case of nanomaterials and nanotechnology - cannot be entirely delimited by education, being practically a continuous, deeply interdisciplinary, and - more often - even a complicated process, involving a large number of highly qualified scientists or researchers in the field.

Starting from the abovementioned facts, it is supposed to claim as necessary to find the answer to several particular questions (even though probably, the main question is generally addressed as follows: “What do we mean by nano and what is specific for nano-education?”):

- is the current Romanian education system able to train high-profile researchers and scientists, and - especially - ready to take on such important tasks as those that represent real challenges, specific to the nano-area?
- how can be increased the students’ motivation to be involved in and to learn Science, and how can be improved their participation in formal (but also in non-formal) educational activities, dedicated to learning and practicing Science?
- are teachers ready to be updated (in terms of knowledge), to present, discuss, and explain to their students, what is new in the area of Science, what are the ultimate scientific discoveries, what are the applications of new technologies, but especially, are they prepared to make appropriate connections with the contents proposed by the actual school curricula?
- how can we manage and - especially - how can we limit the major decline, recorded in students’ interest in Science? That fact has become obvious in recent decades, and also reported in many documents published by the European Commission, starting with 2007, when the Report entitled “Science Education NOW: A Renewed Pedagogy for the Future of Europe” (published by Rocard and his

collaborators), sounded a serious alarm about the decline of young generation interest in Science. Of course, it is supposed that nanotechnology, together with its applications in actual life, can revive the students' attention for Science, coming practically in response to the technological development of society, and requiring a series of efforts from educators and trainers to inspire and arouse the curiosity of young people to learn as much as possible about what is around us, but especially about what will surely occupy the market of modern products in the future. (Ghattas, & Carver, 2012).

3. DISCUSSION

For secondary teachers and their students, first, it is important to start underlying that Nanoscience area is in a huge development nowadays, and studies nanophenomena, in the direction of how materials are manipulated at the atomic, molecular and macromolecular level, where the properties differ significantly from those found on a larger scale (The Royal Society & The Royal Academy of Engineering Report, 2004). By extending the frame, Nanotechnology is part of the cutting-edge area of modern engineering, in which nanoscience methods are applied, with the view to obtain usable, marketable, and economically viable products (ESRC, 2003). This means that a multidisciplinary sector is targeted - in which Physics, Chemistry, Biology, Materials Science, and Engineering fields are shaking their hands -, and where specialists and researchers are working collaboratively to better understand and apply knowledge about objects that have nanometric dimensions - the size of such particles being smaller than 100 nanometers (Clark, & Ernst, 2007). In a broad sense, Nanotechnology comprises any technology whose finite result is framed in a nanometric scale, and in a narrow sense, Nanotechnology includes any technology based on the ability to build complex structures, respecting specifications at the atomic level, and using mechanical synthesis (Bejan, 2013). In this respect, the interdisciplinarity of Nanoscience is relevant, and consequently, its implications and applications target a diversity of domains - near Physics, Chemistry, Biology, and Materials Science, there are clear implications in Biochemistry, Biotechnology, Microelectronics, and Information Technology.

Taking into account the abovementioned issues, it can be stated that Nanoscience promotes an impressive bridge between all sciences. Those connections represent a real help for students to try to understand the relationships established between different disciplines. Moreover, a multitude of materials resulted from the research performed in the field is currently used in our everyday life, by improving the performances and quality of products, but also offering viable examples of promoting cutting-edge science. In a certain manner, the knowledge related to nanoscience, the direct contact with several nanomaterials, the explanations related to how they are produced, but also the discussions concerning the possibilities for being introduced in practice, can easily demonstrate and justify the importance of Nanoscience for being included - at least - in some contents of school curricula dedicated to Science, by integrating into the actual disciplines relevant and significant concepts, which can be approached and understood by students (Gorghiu, Gorghiu, & Petrescu, 2020). In this regard, nano-education - as an important part of science education - should be gradually introduced in school, starting primary level. For curriculum designers, it should be essential how specific nano-concepts are presented and approached, but also how practical activities can be introduced in lessons, with the view to increase and maximize the process of students' gaining knowledge and understanding science.

As Nanoscience offers a powerful frame for the development of state-of-the-art materials - through the control and manipulation of matter at the nanoscale -, challenges have been noticed related to the implementation of specific content in the educational activities with students, but, on the other hands, advantages have emerged from such approaches (most of them being mentioned by Uddin & Chowdhury since 2001):

- understanding the properties of nanostructures and characterization of nanomaterials;
- transferring related knowledge of such materials and their applications: sensors, nanoscale biostructures, smart materials, magnets, electronics materials, etc.;
- understanding how nanocomponents are synthesized, processed and manufactured;
- developing students' abilities for analysis, modeling and simulation;
- understanding the specific processes of research - in terms of developing innovative applications related to the use of nanomaterials in daily life;

- providing multiple possibilities for designing and undertaking learning activities by creating knowledge-centered frames;
- understanding the interdisciplinary nature of the nano-area - there is no doubt that the teacher must design the learning units by including scientific concepts especially from Physics, Chemistry, Biology, and Materials Science.

On the other hand, it is more than evident that nano-education should be based on a powerful practical component, with the real help of economic actors (industry, companies), research institutions and the Ministry of Education. Unfortunately, in Romania, there are still fewer discussions about nano-education. In the current curricula for secondary education, there is no well-defined set of contents related to nano-area, although there are sufficient topics (especially in Physics, Chemistry or Biology) in which nano-concepts can be addressed. Moreover, most of the teachers involved in teaching the mentioned disciplines, do not have solid knowledge about nano-area, the offer dedicated to their continuous professional development being practically non-existent.

The Physics curriculum can address connections with nanomaterials when approaching magnets and electronics. In the frame of the Technology curriculum, practical applications of nanomaterials can be easily illustrated. Essential concepts of nano-area could be integrated into the Chemistry program, considering the learning units about atoms, ions, molecules, that can be developed in topics that deal with advanced notions about atoms and their structure, ionic compounds, polar and non-polar bonds, molecular networks, complex compounds, etc. (Kaya, & Karataş, 2016).

By sure, efforts must be made also by the nano-specialists for disseminating and correct informing teachers - during dedicated continuous professional development programs - concerning the advantages of nanomaterials, but also their possible negative effects. A good strategy means to mix formal education with non-formal one, through the design of educational activities, in which nano-specialists and researchers can transfer knowledge, and communicate directly with students, providing hot nano-issues and answering students' questions.

Another important help coming from the presence of ICT tools in the teaching/learning process. Videos, simulations, and virtual experiments related to the nano-world, and new valorization of several didactic approaches - like problem-solving methods, case studies, educational games, project-based learning techniques - facilitate students' learning and increase their motivation for learning Science, with valuable and positive effects on long-term learning. In this regard, teachers should find (or design) and exploit digital tools suitable for transferring scientific content and adequate for sustaining the didactic demarche. Teachers should constantly encourage students to be engaged in exploratory science learning, promoting collaborative and relevant learning, by benefiting from the advantages of new technologies (Gorghiu, & Gorghiu, 2014).

Moreover, a well-designed didactic approach can mix real and virtual learning (virtual experiments and simulations represent a must in this case), with the view to make students able to make solid connections between the learned content and real life.

4. CONCLUSIONS

The assurance of qualitative education is in strong relation to the development of our society. Nano-education fully answers to the actual educational challenges, being important to be present not just in universities, but also in secondary or even in primary education.

However, as happens in many situations, when deciding to promote and introduce nano-education in schools, teachers (mainly) raise a series of questions, such: "How can integrative topics - already designed in terms of didactic approaches, taking into account the connections between Physics, Chemistry, Biology, and ICT - can be adapted and presented from the perspective of Nanoscience?"; "What topics can be selected to address the specific issue of Nanoscience?"; "Are the nano-subjects proper to be easily integrated into the school curriculum (and if so, how can be done)?"; "To what extent science teachers are trained to design consistent didactic nano-approaches for students, including relevant scientific knowledge?"; "What are the possible future contexts, where the content of actual Physics, Chemistry and Biology disciplines can include nano-topics or how those can be concentrated in one Sciences discipline?"

The answers to those questions may become very useful, especially since there is no long-term educational experience in Romania. In any case, the main objective of nano-education remains oriented on making students understand the main Nanoscience concepts, present models and simulations of specific processes at the nanoscale level, or even familiarize themselves with the production of simple nanostructures, assembled into systems (or products) with special features and functionalities.

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