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Document Version:

Publisher's PDF, also known as Version of record

Citation for published version:

Blonder, R 2015, "Chemistry of tomorrow" should be part of the school chemistry of today', *EC2E2N Newsletter*, vol. 16, no. 1.

Total number of authors:

1

Published In:

EC2E2N Newsletter

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"Chemistry of tomorrow" should be part of the school chemistry of today



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Abstract

The 21st century presents many challenges for chemistry educators. Chemistry as an evolving entity is not reflected in the existing high school chemistry curriculum and the Web 2.0 generation is still learning in the previous century. My goal is to promote the modernization of both – chemistry contents and chemistry teaching pedagogies by promoting the chemistry teachers community. I chose the field of nanotechnology, in which I conducted my PhD study, as an example for modern contemporary chemistry research reflecting an authentic view of the chemistry process and knowledge employed in modern research labs. I designed an advanced nanotechnology course for chemistry teachers and studied their knowledge development and their attitudes towards teaching nanotechnology (Blonder, 2011). It was found that chemistry teachers successfully dealing with the high difficulty level of the course with appropriate support and strengthen their content knowledge (CK). However, they perceived the topic of nanotechnology as very difficult and therefore not suitable for their high school students. The use of a variety of teaching methods (e.g., teaching model (Blonder, 2010)) influenced their attitudes towards bringing nanotechnology to their students. Several teachers even developed taught a novel nanotechnology module (Blonder & Dinur, 2011; Blonder & Sakhnini, 2012). In a longitude study accompanying teachers who took the course over five years we found that the teachers develop high self-efficacy beliefs that influenced their teaching and their status in their school organization. They started to implement alternative teaching methods, which were introduced in the nanotechnology teachers' course, in the nanotechnology module they developed. Most of the teachers were able to transfer these teaching methods to their chemistry teaching (Blonder & Mamlok-Naaman, 2014).

I am concerned about two central dimensions in chemistry education in Israel and around the world: First, school chemistry content does not present contemporary chemistry and does not reflect an authentic view of the chemistry process and knowledge employed in modern research labs. Second, much of the pedagogy of chemistry teaching is not congruent with the ways young people learn today in the age of the Web 2.0. Many teachers lack the knowledge and skills to promote change in these dimensions of chemistry education. They lack the content knowledge and the pedagogical content knowledge for teaching contemporary sciences as well as the technological pedagogic knowledge to use advanced technological teaching methods. In this paper I will refer to the first concern, namely integration of contemporary scientific contents in high school chemistry curriculum.

I believe that the "**chemistry of tomorrow**" should be part of the school chemistry of today (<http://www.weizmann.ac.il/weizsites/blonder/>). I chose the field of nanotechnology, in which I conducted my PhD study, as an example for modern contemporary chemistry research reflecting an authentic view of the chemistry process and knowledge employed in modern research labs. I therefore would like to introduce aspects of contemporary chemistry and nanotechnology (Jones et al., 2013) to school chemistry and adapt the teaching methodology to the 21st century modes of students' learning. The educational challenges that are driven by these goals are to study and develop ways of teaching students contemporary content and authentic processes of science and to investigate ways for providing chemistry teachers with continuous professional development updating their scientific content knowledge (CK), their pedagogic content knowledge (PCK) and their technology pedagogic content knowledge (TPCK). The following describes my research, development and implementation activities.

Research and development activities

My research is focused on various aspects of the interaction of chemistry teachers and their students with contemporary science. This interaction raises many questions worthwhile to study: In which ways teachers and students are able to study advanced contemporary scientific topics? What support is needed to turn the learning meaningful? How do teachers develop pedagogical content knowledge for a new learned scientific content? How do they transfer the new knowledge to their students? Are they able to better interact with gifted students in their class when they are "equipped" with updated scientific knowledge? Are they able to blend advanced technology methods in their teaching? These questions describe the focus of research that I perform together with my research group.

A three-stage model was developed to provide chemistry teachers with opportunities to enhance their knowledge in contemporary scientific areas and support them in adapting it for use with students (Mamluk-Naaman, Blonder, & Hofstein, 2010). The three-stage model consisted of the following stages:

- ❖ The first stage focuses on content knowledge (CK) and carried out in traditional lectures.
- ❖ The second stage still focused on content, but with more attention to pedagogy. In this stage more attention is given to teachers' needs, supporting their ability to understand the content.
- ❖ The third stage, adaptation of the advanced scientific content to education, is focused on pedagogic content knowledge (PCK). In this stage the teachers use their CK and Pedagogic knowledge, and transform them into PCK.

In the research, conducted in the context of a nanotechnology course I developed (Blonder, 2011), I have found that a thorough learning of an advanced course (namely, the first two stages in the three-stage model) is not enough in order to develop PCK. Special attention should be given to the third stage concerned with transfer of CK to PCK (Blonder, 2010, 2011). In studies that we conducted on a full implementation of the three-stage model in advanced chemistry courses we found that it is effective (Mamlok-Naaman, Blonder, & Hofstein, 2013), and the teachers that completed these courses were able to integrate new content into their teaching (Blonder & Dinur, 2011; Blonder & Sakhnini, 2012). We also have preliminary results showing that teaching the contemporary nanotechnology field to school students positively affect students' continued motivation to learn chemistry and science (Blonder & Dinur, 2011; Blonder & Sakhnini, 2012).

In a longitude study accompanying the teachers who took the course over five years we found that the teachers develop high self-efficacy beliefs that influenced their teaching and their status in their school organization. They started to implement alternative teaching methods, which were introduced in the nanotechnology teachers' course, in the nanotechnology module they developed. Most of the teachers were able to transfer these teaching methods to their chemistry teaching. We suggest that although nanotechnology is outside the science curriculum it was used in this study as a mediator to carry out a change in the way chemistry teachers teach the chemistry curriculum (Blonder & Mamlok-Naaman, 2014). We apply our experience with teachers professional development in regarding to nanotechnology in the EU project: "Irresistible" (www.irresistible-project.eu/index.php/en/).

While we learned and developed the field of nanotechnology education, we found that although many nanotechnology programs for students and teachers were developed (including ours) no systematic mapping of the nanotechnology field was done for the purpose of education. There is a need to identify basic concepts and basic applications in nanotechnology that should be taught in high school science. We therefore decided to explore this question. We build two experts communities (nanotechnology researchers, and science teachers) to construct a valid Delphi study (Sakhnini & Blonder, Submitted for publication). Ten basic nanotechnology concepts were identified in the first round of the Delphi study each concept is accompanied by its explanation, definition, why it is important to be taught and suggestions how it should be taught.

The same results were obtained for the 19 identified applications (e.g., Nano-electronics, Nano-medicine, Nano-filtering Nanorobots, etc.). Three concepts emerged in the Delphi study, which were not identified before: Functionality, fabrication approaches of nanomaterial, and the making of nanotechnology (Blonder & Skhnini, 2015). A Significant difference was found between teachers and researchers, related to two concepts: Size & scale, and classification of nanomaterials. The significant different emphasizes the importance of including the two communities (researchers and educators) in the Delphi study since each community brings its significant viewpoint. A new course for teachers was designed based on this results and an on-line version of the course is given within the frame of a TEMPUS EU project called "EduNano" (<http://edunano.eu/index.php>).

After the identification of the basic concepts and application of nanotechnology we will examine different nanotechnology programs that were developed, and analyze their structure according to the results of the Delphi study. The next stage of this study is to find suitable places in the science high school curriculum for integrating the identified concepts and applications. In addition we will develop a deeper view on the concepts that were not identified so far in the literature, and examine of the connections between the suggested

nanotechnology concepts and applications. In order provide the foundations for teaching nanotechnology basic concepts in the context of nanotechnology applications.

I believe that the example of nanotechnology that includes: a research based integration nanoscale science and technology into the chemistry curriculum and the accompanying professional development programs provides a methodology that can be used for the integration of new emerging scientific fields.

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