Towards relevant integrated chemistry education

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Integrated education has been promoted by many science education researchers and educational reforms for its potential to teach the key competencies to cope in society in the 21st century and in making science subjects more interesting. Part of this is an understanding of chemistry and its role in everyday life as well as in building a sustainable future. In order to transfer integrated education into classroom practices, it is not enough to implement integrated approaches. It needs to be done in a relevant manner that supports the pupils' understanding of chemistry as well as the general aims of integrated education. Teachers need support on this, therefore, more pedagogical models for relevant chemistry education are needed as well as models for in-service training on implementing it.

It is quite easy to agree that education should provide the skills and knowledge needed to cope in society today and tomorrow, but in a rapidly changing world of today it is a lot harder to say how this can be achieved. The amount of knowledge at our hands increases and technology advances affecting our everyday life. The challenges we face nowadays, especially regarding sustainability, are often complex interdisciplinary phenomena, which require understanding of chemistry and skills to apply our knowhow. But how to take this into account in chemistry education?

Many science education researchers (e.g. Czerniak & Johnson, 2014; Samson, 2014; Wei, 2009) and curriculum reformers (e.g. Finnish National Board of Education, 2014; Next Generation Science Standards, 2013) promote the use of integrated approaches in teaching the key competences of the 21st century. The basis of integrated education is derived from Dewey's (1902, 1915) concepts of school as a small society where learning is based on everyday life and activities, and it aims at learning skills and knowledge relevant to the learners as individuals and members of society. Therefore interdisciplinary contexts and student-centered approaches are at the core of integrated education. As an example, sustainable food production offers an interesting context for chemistry education. One could start by discussing the pros and cons of vegetarianism or meat eating with pupils and make pupils research agriculture further to assess the claims made (for example the use of fertilizers, methane and nitrogen oxides as greenhouse gases and their circulation in nature).

Studies on the education of science and math (e.g. Brante & Brunosson, 2014; Bennett, Lubben & Hogarth, 2007; Lavonen & Laaksonen, 2009) have shown that similar interdisciplinary and contextual approaches to education can potentially give pupils a more coherent understanding of complex everyday life phenomena and increase students' interest towards school and subjects.

The lack of interest has especially bothered chemistry education. As a subject it appears difficult and abstract. Chemistry explains phenomena from our daily life, such as the freezing of water, rusting iron or the rising of buns in the oven with submicroscopic particles, atoms and molecules that cannot be seen even with a microscope. Therefore, a visualization of these different kinds of models is needed. Furthermore, chemistry knowledge is communicated through the use of symbols, math and scientific concepts. This abstract nature is present in the chemistry subject and many students are unable to see the connection between the submicroscopic chemistry and everyday life phenomena. (Aksela & Karjalainen, 2008; Johnstone, 2000; Kärnä, Hakonen & Kuusela, 2012; Taber, 2013).

A good teaching context should make students active participants, it should be linked to the students' lives and take their prior knowledge into account (Gilbert, 2006). Food and cooking offer a good, everyday life, context for looking into the properties of many organic substances and also into chemical reactions, thus they make up a good context for chemistry education. We all eat, but the way we eat, how we cook or what we consider delicious, edible, healthy or ethical differs from culture to culture. There are also interesting questions regarding the sustainability that can be tackled by an integrated approach in schools' chemistry or science classes. Food is also a context that can be interesting to both genders and therefore it is a diverse starting point for relevant integrated chemistry education. (Fooladi, 2013; Haatainen, 2014).

Åström (2008) highlights four different categories for integrated science education in her doctoral dissertation:

1) Concepts in Science. For example the Energy concept can be studied from the perspectives of chemistry, physics and biology. This does not necessarily mean that education is interdisciplinary, as the subject matter related to this concept can be studied during subject lessons parallel with other subjects.

2) Science in Contexts. Or more commonly problem-based science education, where learning often involves problem-solving, project-working in small groups and real-life phenomena as context. Again interdisciplinary is not a requirement as these phenomena can be studied within a subject.

3) Concepts in Context. This is a combination of the previous two categories.

4) STS (science, technology and society) education, which emphasizes the importance of focusing on questions relevant to society and the interrelated nature of these topics with science and technology. Thus learning science subject matter relevant to society and environment and, therefore, making science more meaningful. (Mansour, 2009; Åström, 2008).

Haatainen, Turkka and Aksela (2016) revealed study results on Finnish secondary school science teachers' perceptions on integration. Most science teachers seem to have an understanding of the meaning of integration, but these vary. Furthermore, teachers' attitudes towards integrated education were positive in general, but they do not see the benefits of integration for teaching the subject matter itself. Also integrated approaches were not implemented into their own science teaching or it was done irregularly and seldom. Similar results have been found in other studies (Czerniak & Johnson, 2014; Samson, 2014; Wei, 2009).

The main barriers for implementing integrated approaches to science teaching are lack of time for planning with other teachers and rigorous timetables in school. Also personal chemistry between teachers and the support (or lack of it) from the school's community have an effect on the implementation of integrated education (Czerniak & Johnson, 2014; Samson, 2014). With teaching models and examples of integrated science education, teachers can be shown how to overcome these barriers.

Research has not sufficiently shown how integrated education should be implemented into chemistry teaching, particularly, in a relevant manner that supports also the learning of chemistry as a subject. If moving towards more relevant and integrated chemistry education is a desired goal as has been suggested by researchers and educational reforms, then there is an acute need for research and mapping out of the potential models for successful implementation.

On the other hand, it is not sufficient to solely offer pedagogical models and teaching material. The most efficient way to ensure research results and pedagogical models transferring into classroom practices is a long-term training that is closely linked with the participating teachers' own teaching, includes reflection and offers peer support (e.g. Van Driel & Berry, 2012; Nilsson, 2014). Thus in order to transfer integrated chemistry education from models into actual classroom practices, in-service training should be developed accordingly.

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Specialization: integration in education, cooperation between subjects, different types of media in education and using everyday phenomena, especially food, as teaching contexts. The doctoral dissertation concerns the realization of integrative education.

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