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RELATIONS AND RESPONSIBILITY IN PRE-SERVICE SCIENCE TEACHERS' TALK ABOUT NANOTECHNOLOGY EDUCATION

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This study was made in connection to Teacher Development Programmes (TPDs) within the EU-financed project PARRISE. The overarching context of PARRISE is Socio-Scientific Inquiry Based Learning (SSIBL) (Levinson, 2016), which addresses contemporary problems of Science-Technology-Society-Environment-Health (STSEH) issues. It is important to recognize that there are many diverse actors, stakeholders and perspectives, and, consequently, many different orientations of STSEH education. SSIBL is based on three approaches, often independently pursued in schools: Inquiry Based Science Education (IBSE), Socio-Scientific Issues (SSI) and Citizenship Education (CE), and the overall umbrella is Responsible Research and Innovation (RRI) (Levinson, 2016). The chosen theme of these TPDs with pre-service upper-secondary general science teachers was nanotechnology, the engineering of systems at the molecular or nanoscale level. While nanotechnology offers new products that can benefit many, there are also many possible risks, both to health and the environment. Therefore, it is an example of a complex SSI, characterized by risk, uncertainty, ignorance and indeterminacy, but also possibilities (Fensham, 2012). There are many complex relations both between human and non-human entities. We are interested in the teacher identity of pre-service science teachers after the TPD and their thoughts about implications for their teaching practice. We study how they talk about nanotech education and will analyze the interview material using a theoretical framework based on reflexive Bildung and Vision III of science education (Sjöström & Eilks, 2017; Sjöström, in press). These ideas can be used as an educational-philosophical framework of SSIBL.

Keywords: complex socio-scientific issues, STSEH pedagogy

INTRODUCTION

This study was made in connection to the EU-financed project PARRISE (FP7; grant agreement 612438), in which 18 universities from eleven countries cooperate. The overarching context of the project is Socio-Scientific Inquiry Based Learning (SSIBL), which addresses contemporary problems of Science-Technology-Society-Environment-Health (STSEH). SSIBL is based on three approaches often independently pursued in schools: Inquiry Based Science Education (IBSE), Socio-Scientific Issues (SSI) and Citizenship Education (CE), and the overall umbrella is Responsible Research and Innovation (RRI) (Levinson, 2016). Empowered democratic citizens who are able to engage in socio-scientific inquiry and debate are needed to "build a scientifically literate society, which enables its citizens to participate in the research and innovation process" (http://www.parrise.eu/about-parrise/; 2017-01-17). Obviously, education in school, as well as teacher education, have important roles in this.

We performed Teacher Development Programmes (TPDs) with both pre-service upper-secondary general science teachers and in-service lower-secondary school science teachers. In this paper we focus on the former group. The chosen theme of the TPD was nanotechnology, the engineering of systems at the molecular or nanoscale level. We studied how the pre-service teachers talked about nanotechn education after the TPD.

During the last decade, quite a lot of research has been performed focusing on nanotech in relation to teaching and learning (e.g., Jones et al., 2013; Winkelmann & Bhushan, 2016), but not much has focused also on risk aspects (e.g., Simonneaux et al., 2013). While nanotechnology offers new products which can benefit many, there are also many possible risks both to health and the environment. Therefore, it is an example of a complex SSI, characterized by risk, uncertainty, ignorance and indeterminacy, but also possibilities (Fensham, 2012). There are many complex relations, both between human and non-human entities, and there is need for responsibility in research and innovations. Here, we are interested in the identity of science teachers in this context and their thoughts about its implications for their teaching practice.

THEORETICAL FRAMEWORK

For the analysis we will use a theoretical framework based on reflexive *Bildung* and Vision III (Sjöström & Eilks, 2017; Sjöström, in press). *Bildung* consists of two elements: "autonomous self-formation and reflective and responsible action in (and interaction with) society" (Fellenz, 2016, p. 273). It is about 'the individual embedded in a world' (Løvlie, Mortensen & Nordenbo, 2003) and, accordingly, *Bildung* can be seen as an educational ideal for all citizens (Elmose & Roth, 2005).

Bildung "involves competences for self-determination, constructive participation in society, and solidarity towards persons limited in the competence of self-determination and participation" (Elmose & Roth, 2005, p. 21). During the last fifteen years, the concept has been problematized by postmodern theorists (e.g., Løvlie et al., 2003). Some scholars have claimed that the concept should be abandoned, whereas others claim that *Bildung* still works as a critical concept in a postmodern world. Gur–ze'ev (2002, p. 405) writes: "As counter-education, today's *Bildung* can contribute greatly to the reconstruction of […] subjectification". According to Biesta, a result of the process of subjectification is that individuals become 'autonomous – subjects of action and responsibility'. This point "tries to capture a conception of human subjectivity that is not selfish or self-centred but always understood as being in responsible relation with other human beings and, by extension, with the natural world more generally" (Biesta 2013, p. 739). Instead of truth, *Bildung* should be about cultural respect and socio-political justice (Løvlie et al., 2003). *Bildung*-oriented science education is informed by the research field of Science and Technology Studies (STS) (Sjöström, 2013).

Reflexive *Bildung* is a late/post-modern version of *Bildung* (Sjöström, in press). The philosophy of this orientation can be characterized with terms like: skepticism, post-positivism, reconstructionism, embodied science, relationalism, and eco-reflexivity (Sjöström, in press). Here the pre-service teachers' talk about nanotech in relation to teaching is analyzed from such late/post-modern perspectives, which can be used as a theoretical framework for SSIBL.

The SSIBL-approach is characterized by understanding of the complexity of STSEH relations, knowledge uncertainties, and disagreements due to different ethical propositions, as well as a recognition "that there are diverse ways of negotiating SSIs which depend on the evidence available, the personal, political and social consequences of any decision, and the extent to which the issue divides diverse sectors in society" (http://www.parrise.eu/our-approach/; 2017-01-19).

PRELIMINARY RESULTS AND DISCUSSION

The TPD with the pre-service teachers was made during the spring 2016, and another round will be made during the spring 2017. After the TPD, most teachers were interviewed in groups. So far, we have made a preliminary analysis of the group interview made in 2016 with five pre-service general science teachers, where we for more than one hour talked with them about their view on SSIBL-driven science teaching, especially in relation to nanotech. In Sweden, most upper-secondary teachers teach in two different subjects. The most common subject together with general science is biology. However, in the interviewed group the other teaching subject – in addition to general science – was Swedish language, art or mathematics.

The TPD started with an introduction to the research field by two nano researchers, one very much pro development (podcast) and one working with risks (invited to present and discuss the questions put by the participants of the TPD), and by various literature from both 'sides'. The pre-service teachers worked in groups and were told to choose a product on the market which contains nano particles and work out a life-cycle analysis (LCA) of the product. Furthermore, the project report should include a lesson plan for working with pros and cons in the teaching.

After the TPD, the interviewed pre-service teachers were very positive towards teaching about complex SSIs related to science-in-the-making. One student teacher said, "I think it is extremely important to include society in education. […] It helps to make it real, and that you learn something that is useful outside school."

They thought that such teaching is relevant and motivating, "It is a great teaching method for developing critical citizens who are able to assess different information." They emphasized that science content is important, but also the importance of other knowledge and perspectives. Due to the frontier character of

nanotech, the teachers have to learn together with the students, "You create something together with the students." However, they were also humble and reflective in relation to the complex teacher role and thought that science teacher education should include even more discussions about ethical-political dilemmas.

As a result of the TDP, they even better realized the knowledge uncertainties of post-academic science. One student said, "There is not only one truth, but different kinds of truth, depending on how you look at it." Another student said, "It gives you an insight that it is much more complex than you thought initially. There are many different aspects to consider. [...] You get a more dynamic picture – a whole, where it will be gray, and not black or white, and that's positive, because then you get a healthier understanding of what science is all about."

They also mentioned the interplay between different actors, with different values and interests, "I think it was really exciting to get an overall picture of how it works between researchers, investors, businesses, politicians. It is the interactions that it is important to have knowledge about."

Previous studies have shown that pre-service science teachers often have problems with identity and ideology in relation to science teaching driven by STSE(H) (Pedretti et al., 2008). This preliminary study shows that a TPD on nanotech performed in this way makes the pre-service teachers aware of the complexity and dilemmas with STSEH pedagogy, but they also support it, and it seems to be in line with their teacher identities. This will be analyzed further and problematized during the spring and summer of 2017.

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