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Preparing Elementary and Secondary Pre-Service Teachers for Everyday Science

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ABSTRACT: The purpose of the paper is to present the framework and design of modules aiming to teach socio-scientific issues and the related pedagogy to pre-service teachers. Specifically, the work presented in this paper is part of the PreSEES project, a Comenius/LLP project with the main aim of engaging elementary and secondary pre-service teachers in critical discussions of everyday science through socio-scientific issues (SSI) and prepare them to teach SSI. We first present the aims of our project, and a framework designed around learning to teach SSI, including pedagogical and theoretical aspects concerning teaching SSI. Finally we present three modules that were designed based on the framework aiming to present these guidelines to pre-service teachers (primary and secondary). The emphasis of the modules is on presenting pedagogical issues related to SSI, with an emphasis on the nature of SSI issues, and pedagogical implications of teaching and assessing SSI. The aforementioned issues are presented in various contexts, such as global warming and edible insects.

KEY WORDS: PreSEES, socio-scientific, pre-service teachers, SSI

INTRODUCTION

Socio-scientific issues (SSI) are those that significant numbers of people would argue about, without necessarily reaching a conclusion or consent. Socio-scientific problems are ill-defined and value-laden, invoking aesthetic, ecological, economic, moral, educational, cultural, religious and recreational values that are constrained by missing knowledge. The ability to deal with everyday scientific issues and socio-scientific issues has been recognized as an important goal of science education (Sadler, 2009a). Furthermore, the inclusion of SSI in science teaching could move science classes towards unwrapping and engaging discussions and, thus promote dialogic arguments, understanding the nature of science, and conceptual understanding. The inclusion of SSI in the curriculum offers a means of expanding both the curriculum and the range of instructional practices commonly experienced in the school science classroom. Studies in SSI so far have focused on students' decision making (Jimenez-Aleixandre &

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Pereiro-Munoz, 2002), conceptual understanding, and engagement with science (Albe, 2008b). An area that is still relatively unexplored however is how teachers, either elementary or secondary school teachers, understand and approach everyday science and SSI in their teaching (Evagorou, 2011).

THE AIM OF PRESEES

Starting from the aforementioned gap in the literature, the aim of the PreSEES project is to engage elementary and secondary pre-service teachers in critical discussions of everyday science through socio-scientific issues, and prepare them to teach SSI. The motivation to design and implement such a project comes from limited research and curriculum development in the area of everyday science, SSI and teacher development (Evagorou, 2011), and the fact that this area can potentially engage students with science and scientific practices (Zeidler & Sadler, 2007). More specifically, science poses political and moral dilemmas and engaging with socio-scientific issues that can enable students to understand the relevance of science to everyday life, gain insight into how people use science, and develop their capacity to be critical consumers of scientific information (Kolsto, 2001). Studies in SSI and everyday science so far have focused on *students'* decision making (Ratcliffe, 1996), conceptual understanding (Zohar & Nemet, 2002), and engagement with science (Albe, 2008a) but there is minimal research in the area of teacher education and teaching the connections of science to everyday life through the use of SSI (Venville & Dawson, 2010). Published studies have shown that teachers do not make the connection between science and everyday life since they find it difficult to coordinate between scientific data and the social aspects of the problem which bring uncertainty into the discussions (Zeidler, Sadler, Simmons, & Howes, 2005). Based on this gap in the literature we (1) designed a framework to *address teachers' difficulties* when teaching everyday science and SSI and (2) designed curriculum materials that will focus on *empowering teachers* to understand the connections of science to everyday life and the implications of their decisions.

Even though SSI are an important aspect of science, European educational systems have yet to place an emphasis on the fact that we are facing common scientific and socio-scientific issues that need to be understood systemically (as systems interacting within and across countries) in order to be able to make informed decisions. Hence an additional motivation for this project is to design and implement curriculum materials to engage pre-service (elementary and secondary school) teachers (and thereafter their students) in critical discussions of everyday scientific problems that are common across Europe, and prepare

them to teach SSI in their classes providing examples of pedagogical approaches, and placing an emphasis on the European (and international) dimension of the problems.

THE FRAMEWORK FOR TEACHING SSI

An initial analysis of the curriculum of the participant countries (Cyprus, Spain, Turkey, UK, Denmark, Romania, France) revealed that all seven countries place an emphasis on scientific literacy in their policies, and consider SSI as important in their reform documents. Despite the emphasis in policy documents in all countries, only the UK and Denmark place explicit emphasis in approaching science issues in controversial topics and discussing them (more information about the state of SSI in the curriculum of consortium countries can be found on our website http://www.ssieurope.net/ deliverables.html). In the remaining countries the emphasis is on using everyday issues to teach science, issues that are not necessarily controversial. Additionally, an examination of the teacher training system in all participant countries revealed that SSI and SSI pedagogy are not explicitly taught as part of teacher professional developments.

Based on the aforementioned findings and findings from studies explaining the importance of teacher training (Abd-El-Khalick, 2003; Kılınç et al., 2013; Sadler, 2009b; Zeidler, 1997), the consortium designed a framework to be used as a guideline in the development of SSI modules for pre-service teachers. Specifically, each module consists of four tasks:

a. Contextualisation: Introduction and engagement in SSI related issues
b. Discursive activity: Reflection on experienced SSI related issues
c. Elaboration: Transferring knowledge to teaching practice by connecting SSI issues to curriculum, developing teaching and assessment materials
d. Further work: Research and implementation of SSI topics to strengthen pedagogical content knowledge and skills.

The four tasks are designed to have an approximate duration of 3 hours each, making each one of the modules long enough to allow for in-depth exploration of the issues and have an impact on the pre-service teachers' knowledge and pedagogy. The framework (see Table 1) is designed based on the notion that , pedagogical content knowledge (Park, Jang, Chen, & Jung, 2010) is as important as content knowledge for teachers. Therefore the pre-service teachers need to experience the content, pedagogy and then transform it into teaching practices, but they also need to experience the difficulties of dealing with the uncertainty of the solutions in a socio-scientific issue, before they are able to design their

own lessons (Evagorou, 2011). Through our framework and provided experiences in the modules, following dimensions of pedagogical content knowledge are addressed; knowledge of science curriculum, knowledge of instructional strategies, knowledge of students' understanding of science and knowledge of assessment. The modules are designed in such a way so as in the first module the pre-service teachers are scaffolded during their discussions and activities, and as the modules progress the scaffolding fades in the design.

Table 1. Framework designed to be used as guideline for SSI module development

Modules	Module 1: Nature of SSI	Module 2: Teaching SSI	Module 3: Assessment of SSI learning
Contextualization	Introducing the SSI through the climate change	Introducing the teaching SSI through edible insects	Introducing the SSI assessment through various SSI issues
Discursive Activity	Reflection on nature of SSI	Reflection on issues of teaching SSI	Reflection on SSI assessment
Elaboration	Connecting and justifying a curricular topic to SSI	Planning and designing materials to teach SSI	Designing materials to assess SSI learning
Further work	Reading research on SSI	Pre-service teachers' sharing SSI designs and materials through microteaching	Pre-service teachers' sharing SSI assessment designs through microteaching
Transfer of SSI teaching to Primary / Secondary Classrooms			

Using the framework as a guideline, the consortium designed three modules based the following topics: (a) Global warming, (b) Edible insects, and (c) Various SSI topics assessment. All modules are available on our website (http://www.ssieurope.net). The choice of modules was based on issues of common concern between the partners, and topics that could be taught as part of the curriculum of all the partner countries. Specifically, the Global Warming Module was designed in order to help pre-service teachers understand the nature of SSI issues, the edible insects module was designed to support pre-service teachers to reflect on teaching strategies for SSI and develop their own lesson plan to teach the topic, and finally, the third module was designed to scaffold pre-service teachers in

their efforts to assess socio-scientific issues. Since the emphasis of the modules is on pedagogical practices and not on the content, all three modules can be easily adapted and be used with either primary or secondary school students. At the end of these modules, which are expected to be implemented in methods classes of pre-service teacher programs, pre-service teachers are guided to transfer their SSI related knowledge and skills in to their internship practices.

THE MODULES

The Global Warming Module: Introducing the Nature of SSI

The Global Warming Module, the first module, was designed in order to help pre-service teachers understand the nature of SSI issues, and begins by asking them to present their views on global warming. Then the pre-service teachers are asked to work in two groups, each one focusing on one of the opposing view (global warming as a natural phenomenon or as cause by human activity) and collect information about the causes and effects of global warming and discuss them in their groups. The pre-service teachers are invited to form heterogeneous groups (see Figure 1) and prepare a presentation in which all aspects of the phenomenon are covered and explained, using evidence based explanation.

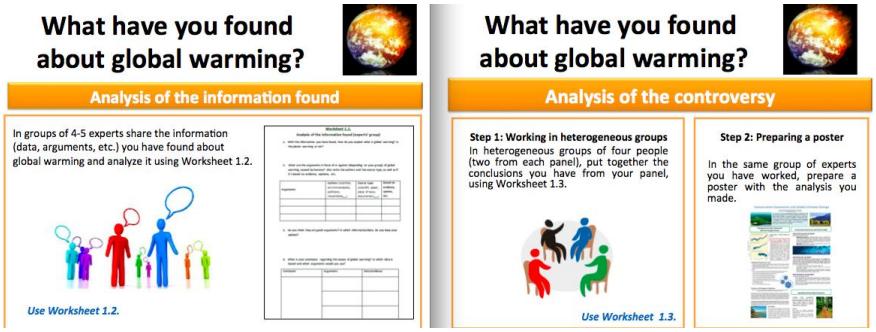

Figure 1. Part of the activity on global warming

In order to scaffold the collection of evidence and evaluate the evidence, the pre-service teachers need to use a worksheet that asks them to record their evidence, the source of the evidence, and the interest group that is presenting the argument (e.g. scientists, environmentalists, politicians). The final posters are presented during a whole classroom session and the different aspects of the problem, and the controversies are discussed.

After the first part of the lesson in which the pre-service teachers engage in understanding and explaining the phenomenon, they are assigned specific roles (environmentalists, politicians, car manufacturers, scientists) and are asked to collect all the information necessary to engage in a debate about possible solutions from their assigned roles. After the debate the trainees reflect on the nature of the issue under discussion, the controversy of global warming and what other socio-scientific issues they are aware of that could be part of teaching science in schools, and what is the controversy in the issue they have been discussing. Figure 2 below presents how we define controversy at the end of the first module, and what other issues we perceive as controversial.

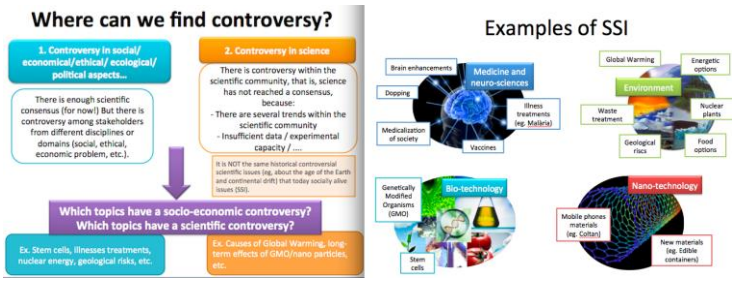

Figure 2. Controversy and examples of socio-scientific issues

Finally, during the last part of the lesson the teachers have to reflect on the importance of teaching socio-scientific issues in the science classroom, and also on the kind of difficulties that they, as learners are facing while discussing the global warming issue.

The Eating Insects Module: Pedagogical Implications of Teaching SSI

The second module is focusing on the controversial issue of eating insects as an alternative source of protein, and the main emphasis of is on pre-service teachers experiencing the topic as learners, and then reflect on the lesson plan and design their own lesson plan. The purpose of the module is twofold: (a) to help pre-service teachers experience various pedagogical strategies that can be useful in designing and teaching SSI lessons, and (b) to support pre-service teachers to identify issues that might not be included in their national curriculums explicitly, but can be linked to the curriculum in order to teach socio-scientific issues. The lesson begins with a presentation of the fact that people choose to eat insects as part of their diets (see Figure 3) for reasons related either to lack of other sources of food, cultural reasons, or dietary reasons.

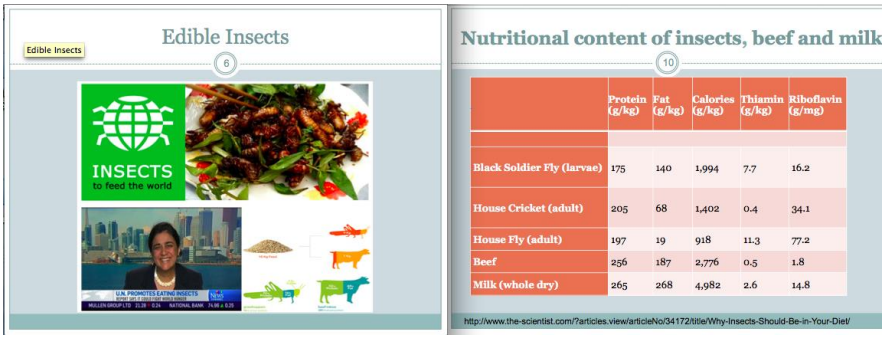

Figure 3. Edible insects as part of our diets

The pre-service teachers are then asked to explore a number of resources that are provided about edible insects and discuss in their groups the advantages and disadvantages of doing so, and decide whether they would agree to eat insects themselves. At the end of this process the pre-service teachers are provided with the lesson plan that was used to teach the Edible Insects lesson, and they are asked to reflect on the lesson using specific guiding questions. Additionally the pedagogical design of the lesson plan is discussed with the students. Finally, after reflecting on the design of the lesson plan and the issues of concern when teaching socio-scientific issues, the pre-service teachers are asked to prepare their own lesson plans to teach a socio-scientific issue of their choice.

The Assessment Module: Assessing SSI Learning

Third model aims to engage pre-service teachers with assessment of SSI learning. The module includes both formative and summative assessment but is mainly focused on formative assessment. Assessment is considered as part of a whole, not treated in isolation from teaching and learning. Therefore, in this module pre-service teachers are asked to integrate assessment into the materials and lesson plans that they prepared in Module 2 as it was not discussed before. To initiate discussion and engagement related to the SSI assessment, pre-service teachers are asked to discuss the following guiding questions in small groups:

1. What challenges do you see in **assessing** your students as they engage with SSI? What knowledge, understandings, skills and attitudes are you trying to develop?
2. What challenges do you see in **evaluating** your SSI teaching? What might be considered effective teaching of SSI?
3. What are the personal benefits that result from **evaluating** your SSI teaching? Please support your answer with examples.

Issues of assessing socio-scientific issues are then reflected upon as whole class. Pre-service teachers are then provided with various formative assessment strategies considering the objectives of SSI teaching. Some of the strategies discussed with pre-service teachers are questioning, monitoring student engagement and providing feedback, encouraging self-assessment of the students, developing rubrics to assess various dimensions of SSI learning (e.g., quality of argumentation). Finally, how to assess instructional effectiveness with the data gathered with the use of formative strategies and guide instructional choices are discussed.

CONCLUSION

Socio-scientific issues are an integral feature of developing what Norris and Phillips (Norris & Phillips, 2003) term 'derived scientific literacy, that is "being knowledgeable, learned, and educated in science" (p.224) since consideration of SSI requires students to make informed decisions, deal with ethical and moral issues, develop critical thinking, resolve ambiguity, and deploy scepticism and open-mindedness (Sadler & Zeidler, 2005). Studies in science education have shown (a) that there is a gain in the learning of content knowledge as a result of engaging in a consideration of SSI (Pedretti, 2003; Zohar & Nemet, 2002); (b) that SSI can serve as effective context to help students understand the nature of science (Khishfe, 2012) since amongst others it is through this process the students understand that some science is tentative, and there is ambiguity even in some scientific knowledge; (c) SSI can help students find links between science and society, and can be used as a way to develop citizenship (Albe, 2008b); (d) and there is evidence that SSI can enthuse students and drive them into a discussions around scientific issues (Levinson, 2008). Many educators use SSI either to encourage their students to develop social consciousness or to develop scientific habits of mind. Finally, according to Simonneaux and Simonneaux (2008) an important aim of science education should be to use socio-scientific issues to empower students in their decision making in their everyday life.

In our group we have worked towards designing modules that can potentially help pre-service teachers to appreciate the importance of teaching socio-scientific issues as part of their science curriculums. This is especially important in countries in which socio-scientific issues are not explicitly part of the curriculum, as is the case with some countries in our consortium. Our modules are designed in a way that not only do they highlight the importance of teaching socio-scientific issues, but also help pre-service teachers: (a) to experience socio-scientific issues and understand ways in which these issues can be linked to their existing curriculum (b) to understand of SSI teaching and appreciate the

difficulties, (c) and to study various ways to assess socio-scientific learning.

We maintain that by engaging our pre-service teachers in this process we can help them acquire both the content knowledge, and the pedagogical skills necessary to approach controversial socio-scientific issues in the science classroom. The modules are currently implemented in all the partner countries and the full versions of all modules are available on the project's website: http://www.ssieurope.net .

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