Quality of SSI Scenarios Designed by Science Teachers

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Introduction

Promoting students' interest and motivation towards science learning has been a focus of various recent studies (e.g. Abrahams 2009; Krapp and Prenzel 2011; cf. European Commission 2015). Students seem to lack the interest and motivation towards academic science studies, and hence the challenge is to improve cognitive and affective aspects of science instruction. A review about science education research (Potvin and Hasni 2014) concluded that real-life issues are beneficial for triggering students' interest and motivation. Thus one way to enhance students' interest and motivation towards science is to design teaching modules that have a connection to real life. The socio-scientific issue (SSI) approach emphasises societally significant science issues in school lessons (Aikenhead 2005; Sadler 2011; Potvin and Hasni 2014). Socio-scientific issues are controversial social issues with conceptual and/or procedural links to science; they are open-ended problems, which tend to have multiple plausible solutions (Sadler 2011).

Zeidler et al. (2005: 360) describe the focus of the SSI movement being "on empowering students to consider how science-based issues reflect, in part, moral principles and elements of virtue that encompass their own lives, as well as the physical and social world around them". The authors identify four central aspects in the teaching of SSI: nature of science issues, classroom discourse issues, cultural issues, and case-based issues. These issues act as entry points in the science curriculum, which can contribute to a student's personal intellectual development and in turn help to inform pedagogy in science education to promote so-called functional scientific literacy (Zeidler et al. 2005).

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Earlier studies suggest that the SSI approach enhances students' scientific literacy, reasoning, and decision-making (Hodson 2003; Zohar and Nemet 2002; Lewis and Leach 2006) in the context of real-life issues. Connecting science learning to everyday life from a societal viewpoint to a local or global problem triggers students' interest (Sadler 2004). Allowing students to generate problems and questions, as in the SSI approach, has a positive impact on motivation (Swarat et al. 2012). In addition, students could gain motivation in a SSI context when role-play, group work, discussion, or other social interactions are connected to the inquiry (Osborne et al. 2003; Toplis 2012). Recognising the inherent complexity of SSI, examining issues from multiple perspectives, appreciating that SSI are subject to ongoing inquiry, and exhibiting scepticism if there is potentially biased information are important practices for decision-making in the context of SSI (Sadler et al. 2007). Furthermore, motivation and fundamental conceptual understanding increase as students present their arguments to others (Benware and Deci 1984).

Our study focuses on the use of so-called scenarios in connecting socio-scientific issues to science learning. Scenarios, sometimes referred to as problems, cases, or vignettes relating to real-life situations (Abrandt Dahlgren and Öberg 2001), have, for instance, been used as starting points for problem-based learning (Akınoğlu and Tandoğan 2007) or engaging students in socio-scientific inquiry (cf. Sadler et al. 2007). Scenarios have been considered to provide a meaningful context for science concepts and principles (Abrandt Dahlgren and Öberg 2001). Thus, one way to enhance students' interest and motivation towards science is to design scenarios that have connection to socio-scientific contexts. With a scenario as a starting point, learning becomes more than the gaining of factual knowledge as students participate in the process of posing questions about the problems emerging from the scenario.

Much of the science education research addressing SSI has focused primarily on students and how they make decisions on such issues (Saunders and Rennie 2013); less attention has been paid to teachers' pedagogical practices with SSI. It has been argued that there is a challenge for teachers, who play a critical role in shaping how curricula are implemented in a classroom and experienced by students, to move beyond traditional modes of science teaching (Sadler 2009). However, there are some studies related to science teachers' perceptions of the SSI approach in science teaching. Ekborg et al. (2013) studied seven Swedish science teachers who conducted SSI teaching modules and found that the teachers appreciated the idea of SSI: the teachers interpreted the modules as a way to increase students' interest in school science. They all included elements of SSI but mostly to introduce the regular science content. Ekborg et al. (2013) interpreted that the teachers had the driving force to do something different but they did not exploit their freedom to make changes in the content.

Similar findings were found among 86 Korean science teachers whose perceptions revealed a disparity between participants' beliefs about the need to address SSI and their actual commitment and teaching of these issues in their classrooms (Lee and Abd-El-Khalick 2006). Furthermore, the Korean teachers expressed low confidence in their abilities to develop materials for teaching about SSI. Lee and Witz (2009) conducted in-depth interviews of four science teachers in Illinois, and they found that the teachers' initial motivations for teaching SSI are basically disconnected from the SSI reform efforts. In addition, the teachers developed their own approaches to SSI according to their own values and ideals during the study.

Our study is related to the PROFILES project (www.profiles-project.eu), which supports science teachers' continuous professional development in regard to implementing SSI in science classrooms as its core idea (see Bolte et al. 2011). Our aim is to find out how Finnish science teachers have succeeded in creating SSI scenarios that could trigger students' situational interest and intrinsic motivation.

Scenario-Based Science Teaching

Triggering students' situational interest (Krapp and Prenzel 2011) through positive, affective, and cognitive experiences could be seen as an essential goal for a scenario. On the other hand, activation of intrinsic motivation (Ryan and Deci 2009) is needed for maintaining readiness to acquire new information. From an educational perspective, motivation can be interpreted as any process that activates and maintains learning (Palmer 2005). Intrinsic motivation can be maintained by presenting possibilities in a task within the range of students' skills (Ryan and Deci 2009). Situational interest is triggered by the environment and also considered to be motivating, although teachers often struggle with how to influence students' interest (Hidi and Renninger 2006). Another challenge for situational interest is that it is unlikely to endure beyond a particular lesson (Abrahams 2009). Hence a high-quality scenario should be designed to stimulate cognitive and affective features of learning that will encourage the students to investigate the problem in depth. The instructional innovation of the PROFILES project is the so-called three-stage model (TSM) which aims to arouse students' intrinsic motivation undertaken in a familiar, socio-scientific context (scenario), to offer a meaningful inquiry-based learning environment (inquiry), and to use the science learning in solving socio-scientific problems (decision-making) (cf. Bolte et al. 2011).

Three-Stage Model

The three-stage model (Fig. 1) is designed to promote students' interest and motivation in learning science content and to undertake inquiry learning and, in particular, to meet the aims of "education through science" (cf. Valdman et al. 2012). The following description is based on the descriptions of the TSM by Bolte et al. (2011) and Sormunen, Keinonen, and Holbrook (2014).

The intention of Stage 1 (scenario) is to involve students in undertaking activities that lead to better understanding of the issue – an issue seen by students as relevant to their lives, not simply relevant to the curriculum – and worthy of greater appreciation. The motivation is intended to be activated by a scenario including an appealing title and a purposely chosen phenomenon related to nature, everyday life, or socio-scientific issues. In facilitating the move to the second stage, the initial

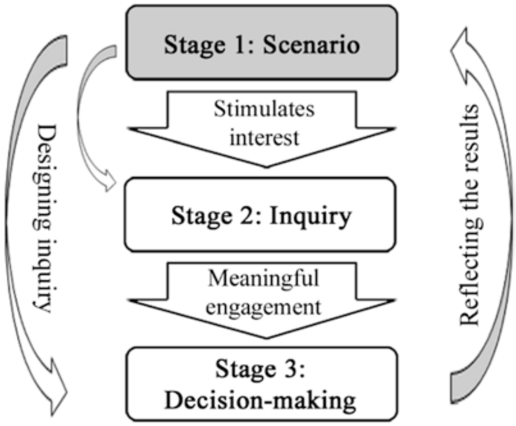

Fig. 1 The central role of a scenario in the TSM approach

motivation forms a key launch platform for the intended science learning. It seeks to draw the students' attention to think about deficiencies in their prior knowledge and to undertake a meaningful discussion related to the scenario. This facilitates the posing of the scientific question or questions intended for investigation.

Stage 2 (inquiry) is expected to maintain the motivational learning from Stage 1 and to meet science learning outcomes that relate to cognitive processes, operationalize scientific process skills through the intended inquiry-based learning, develop personal attributes (e.g. creativity, showing initiative, perseverance, and safe working), and also promote students' social development through collaborative teamwork. These processes, together with the learning outcomes from inquiry, facilitate the move to consolidation that can be enacted through, for instance, interpretation of the outcomes, presentation of the findings, and discussion of the relevance and reliability of the outcomes.

Stage 3 (decision-making) is the consolidation phase for the science learning, in which the acquired science ideas are given relevance by including them back into the socio-scientific scenario, which provided the initial student motivation. This enables the students to reflect on the issues, while placing the newly learned science knowledge alongside other attributes important for participating in argumentation and reasoning to reach consensus, first within a small group and then for the class as a whole. This can take place in a range of formats, e.g. argumentation debates, role-playing, or discussion, so as to derive a justified, society-relevant decision or a consideration seen as reasonable by the class.

Towards an Ideal Scenario

We have chosen the scenario stage for our focus in this study because of its central role in creating a socio-scientific context for science learning. We have found that quite a remarkable part of the Finnish teachers' concerns related to the TSM have been interconnected with the scenario stage (Sormunen et al. 2014). In the

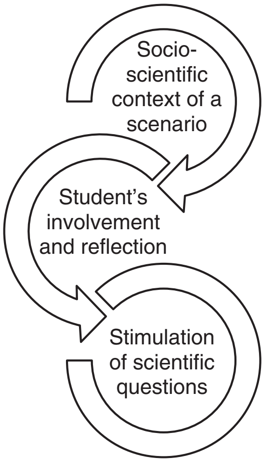

Fig. 2 The components of an ideal scenario

following, we describe the components of an ideal scenario (Fig. 2) that comprise our focus points for analysing the scenarios created by teachers.

The scenario stage of the TSM is meant to trigger students' situational interest and intrinsic motivation in a familiar daily life or socio-scientific context. The *context of a scenario* should be a real-life problem in an open-ended form in order to arouse a sense of curiosity (Akınoğlu and Tandoğan 2007). Scenarios should be complex enough but not overloaded or too structured (Abrandt Dahlgren and Öberg 2001). Furthermore, the scenarios should lead to multiple plausible solutions (Sadler 2011) in the decision-making stage. The intention is to *involve* students in undertaking activities that relate to better understanding of the issue; scenarios should help students to *reflect on* their prior knowledge and share their conceptions and views with peers (cf. Abrandt Dahlgren and Öberg 2001; Akınoğlu and Tandoğan 2007). This all facilitates the students to *pose scientific questions* intended for investigation (Bolte et al. 2011); the initial interest and motivation in the scenario stage form a key launch platform for the intended science learning (cf. Fig. 1).

Altogether, when the context of a scenario is carefully chosen and the scientific ideas are embedded in it, the actual science learning can begin after the ideas are decontextualised from the initial context and an inquiry-based approach is then applied (Bolte et al. 2011). Based on the importance of SSI in science teaching, teachers' role in implementing interventions such as TSM instruction, and the components of scenarios, our research question is what kinds of scenarios did the Finnish PROFILES teachers design?

Method

The data for this qualitative case study was gathered from 30 Finnish teachers who participated in the PROFILES project. We went through all the teaching modules that the teachers planned and implemented, concentrating only on those 24 teaching modules that the teachers created by themselves; the rest of them (6) were based on ready-made materials. The curricular content of the scenarios in our sample was mainly related to physics (18), chemistry (3), biology (2), and earth science (1); 2 of them were implemented at the primary level, 12 at the lower secondary, and 10 at the upper secondary level. The themes of the scenarios concerned energy production (7) and consumption (6), environmental issues (5), water (2) and other natural resources (1), motion of an object (1), and a practical everyday problem (1). The scenarios were presented in the forms of a realistic (11) or fictional story (9), an authentic news article (3), or an attitude questionnaire (1); three of the realistic stories were illustrated with photos.

Deductive content analysis, including the preparation, organising, and typification phases (cf. Elo and Kyngäs 2008), was used to compare the features of an ideal scenario to the scenarios designed by the teachers. In the preparation phase, the units of analysis were selected from the teaching modules. Besides the scenario stage, we also had to pay attention to the inquiry and decision-making stages in the modules in order to analyse the nature and use of the scenario as a whole, because the three stages are interconnected. Next in the analysis process, data was read through several times in order to be thoroughly acquainted with it.

Next, the categorisation matrix was developed in the organising phase. The leading focus points of our analysis were constructed on the basis of the components of an ideal scenario (cf. Fig. 2) with categories derived from Bolte et al. (2011), the focus points being relevance of the scenario (categories: title, interdisciplinary content, meaningful socio-scientific context, and interesting introductory materials), students' involvement and reflection (interesting involvement activities, collective thinking), and facilitating scientific questions (enabling students' open-ended questions and enhancing several solutions) (see Table 1). The data from the scenarios was gathered according to the categories. Next, the features of the scenarios related to the categories were inductively analysed according to their quality. As three researchers, we have utilised investigator triangulation (cf. Gibbs 2007); the features describing the quality of the scenarios in each category were checked regularly by all the authors.

After deductive content analysis, we typified the scenarios: by using scenario-by-scenario comparisons according to how extensive the quality categories emerged (cf. Table 1), we constructed three typologies (cf. Gibbs 2007): high-quality scenarios scored seven or more quality categories, mediocre scenarios four to six, and low-quality scenarios three or less. The aim of the typologies is to describe how the focus points were considered in a scenario in order to trigger students' situational interest and activate intrinsic motivation.

Table 1 Scenario types

Scenario	Relevance of the scenario							Involvement and reflection		Facilitating scientific questions		Scenario type
	Appealing title			Meaningful socio-scientific context								
	Relatedness to the students' life	In the form of an appropriate question	Inter-disciplinary content	Everyday issue	Local issue	Global issue	Interesting introductory materials	Interesting activities	Collective thinking and reflection	Leading to 1–2 open-ended question(s)	Enhancing several solutions	
S20	x	x	x	x		x	x	x	x	x	x	High-quality (n = 8)
S2	x		x	x	x		x	x	x	x	x	
S17	x	x	x		x			x	x	x	x	
S3	x	x		x			x	x	x	x		
S1	x		x	x	x				x	x	x	
S10	x		x	x	x				x	x	x	
S14	x	x	x	x					x	x	x	
S19	x	x	x	x	x				x		x	

(continued)

Table 1 (continued)

Scenario	Relevance of the scenario							Involvement and reflection		Facilitating scientific questions		Scenario type
	Appealing title			Meaningful socio-scientific context								
	Relatedness to the students' life	In the form of an appropriate question	Inter-disciplinary content	Everyday issue	Local issue	Global issue	Interesting introductory materials	Interesting activities	Collective thinking and reflection	Leading to 1–2 open-ended question(s)	Enhancing several solutions	
S7			x		x		x	x	x		x	Mediocre (n = 14)
S15	x	x	x						x	x	x	
S18			x		x		x		x	x	x	
S23	x		x	x					x	x	x	
S22			x				x	x	x	x	x	
S9			x			x		x	x	x	x	
S5	x			x					x	x	x	
S11				x			x	x	x	x		
S16				x				x	x	x	x	
S24						x		x	x	x	x	
S6			x						x	x	x	
S12					x		x	x		x		
S21						x			x	x	x	
S8				x			x	x		x		
S4				x						x	x	Low-quality (n = 2)
S13					x						x	
	11	6	14	13	9	4	9	12	20	21	20	

Results

In the following, we describe our findings according to the three focus points of our analysis, which in turn are related to the components of an ideal scenario, i.e. relevance of the scenario, students' involvement and reflection, and stimulation of scientific questions.

Firstly, regarding our first focus point (relevance of the scenario; see Table 1), the teachers were interpreted as using appealing or relevant scenario titles related to the students' life (11), such as "Window and wall element options in Alice's wonderland" (the scenario S1, cf. Table 1) or "Competition: conserve electricity!" (S2), and/or they included an appropriate question (6), e.g. "How to protect your hearing while using an mp3-player?" (S5) and "Does an electricity invoice make my family happy?" (S19). Many of the scenario themes were interdisciplinary (14), and almost all of them were related to sustainable development: the students were supposed to ponder how power production and/or consumption is related to sustainability. The socio-scientific context in the scenarios was related to everyday (13) and/or local issues (9), e.g. writing an exemplary article about the water cycle for a summer job application in a popular science journal or solving a local environmental issue related to a pond, which is polluted and eutrophic. Four scenarios included a global problem, e.g. "You only consumed one cubic meter of water for food preparation before noon: are you to blame for the global water crisis now and in the future?" (S20) The everyday contexts were usually based on popular events or phenomena in youth culture, e.g. a scenario titled as "Why do the Dudesons fall?" (S3). The scenarios included also interesting introductory materials (9), e.g. a piece of news or an article.

Secondly, relating to students' involvement and reflection, interesting activities were planned to be based on reading and discussion, role-play, fieldwork, or the use of pictures; in many cases (12), there was a combination of these activities. Collective thinking and reflection on prior knowledge were also included in most scenarios (20). In the scenario stage, the actual scenarios were followed by small and/or whole group discussions, interesting activities, collective thinking, and reflection, e.g. in an electricity conserving competition in which the students individually responded to an attitude questionnaire and then pondered their views together and formed a consensus standpoint for conserving electricity (S2).

Thirdly, in regard to the stimulation of scientific questions, the majority of the scenarios (15) included one problem, which could stimulate students to pose research questions. Some scenarios (6) included a problem with ready-made research questions, although the students had a choice to form some research questions of their own. The rest of the scenarios (3) included several predetermined questions, which restricted the students from framing their own questions. In sum, most of the scenarios (21) were interpreted to enable the students to form open-ended research questions for the inquiry stage. In regard to the possible solutions, four of the scenarios were closed in their nature, leading to only one "correct" solution. The themes of the majority of the scenarios (20) were complex enough to enable several solutions at the decision-making stage.

After the content analysis, the scenarios were typified. Eight of them were of *high quality*, i.e. they took variously into account most of the features in each focus point (cf. Table 1). We consider that the higher the quality of a scenario is, the better the scenario triggers students' situational interest and activates their intrinsic motivation. These kinds of scenarios are related to the students' everyday life, are interdisciplinary, use interesting activities, and involve them in collective thinking and reflection on their prior knowledge, as well as stimulate them to ponder open-ended scientific questions with multiple solutions. The majority of the scenarios (14) were *mediocre* scenarios, which weakly included the features related to the relevance of a scenario. The mediocre scenarios did not include all the necessary features that describe a relevant scenario, i.e. an appealing title, interdisciplinary content, meaningful socio-scientific context, or interesting introductory materials (see Table 1). The *low-quality* scenarios (2) lacked an interdisciplinary approach, appealing titles, and interesting introductory materials; the scenarios lacked interesting involvement activities and they did not encourage students to think collectively nor to reflect on their prior knowledge.

Discussion

The current problem related to science education is that students seem to lack interest and motivation towards science studies both in secondary and higher education (cf., European Commission 2015; Potvin and Hasni 2014). The SSI approach is related to the promotion of scientific literacy and the improvement of science learning experiences (Sadler 2011), which in turn could trigger students' interest and activate their motivation.

The goal of the presented TSM-based instruction follows a SSI approach, and it has been developed to arouse students' situational interest and intrinsic motivation (cf. Valdman et al. 2012). The TSM approach is likely to maintain students' interest over several lessons in contrast to a short-term effect of situational interest (cf., Abrahams 2009). Instead of handing out ready-made teaching materials for teachers (cf., e.g. Ekborg et al. 2013), the novelty in our research setting was that the teachers designed SSI modules themselves during their participation in the PROFILES project. In this study, we focused on the quality of the scenarios as they should evoke students' affective involvement and adjust their cognitive evaluation of the science content to be more meaningful (Bolte et al. 2011).

The theme and the form of a scenario are important in developing students' interest and motivation. The themes of a total of 24 scenarios created by science teachers were mostly about energy production and consumption, environmental issues, or natural resources, which are in line with crucial areas of global concern (cf. Hodson 2003; Hogan 2002). Most of the scenarios (20/24) were in a form of a realistic or fictional written story; some of them were illustrated with photos (cf. Sadler et al. 2007); news articles were also used in scenarios (cf. Abrandt Dahlgren and Öberg 2001).

Relevance of the Scenario for Students Most of the teachers (22/24) succeeded in creating meaningful socio-scientific contexts in their scenarios by connecting curricular content to everyday, local, or global issues. The fact that the scenarios are connected to students' daily lives enables students to understand how science classes are interrelated with real life (Zeidler et al. 2005; Akınoğlu and Tandoğan 2007). However, it seems that some of the teachers did not include an interdisciplinary approach in their scenarios; that might be due to the Finnish subject-divided science teaching in secondary level (Lampiselkä et al. 2007). It is also challenging for teachers to use materials and formulate scenario titles in ways that attract students' attention and interest (cf. Sormunen et al. 2014); one way might be to use scenarios that are provocative or evoke emotional involvement (Abrandt Dahlgren and Öberg 2001).

Students' Involvement and Reflection The teachers used strategies such as reading and discussion, role-play, and use of pictures in their scenario activities, i.e. strategies to engage learners in SSI (Sadler 2011). Twenty of the scenarios were based on instructions that encouraged students to think collectively and reflect on the topics in light of their prior knowledge (cf. Abrandt Dahlgren and Öberg 2001) fulfilling the aim of the SSI approach to engage students in dialogue, discussion, and debate (Zeidler and Nichols 2009). This provides a venue where students simultaneously develop their critical thinking and moral reasoning skills while learning curricular content (Zeidler et al. 2005).

Stimulating Scientific Questions Almost all of the analysed scenarios (21/24) were interpreted to enable students to formulate scientific questions of their own for the inquiry stage in the TSM approach; if a scenario is relevant enough for the students, they treat it as their own and thus they are willing to solve the questions that emerge (Akınoğlu and Tandoğan 2007). Furthermore, when designing a scenario, the level of students' cognitive skills should be considered so that they are able to formulate questions related to the problem of a scenario. Intrinsic motivation should be maintained with a suitable challenge (Ryan and Deci 2009). The majority of the scenario themes (20/24) were complex enough to enable several solutions at the decision-making stage in the TSM approach; complexity is an important feature of scenarios that makes students problematize them in depth (Abrandt Dahlgren and Öberg 2001). This result highly supports the idea of maintaining intrinsic motivation with possibilities to make choices (Ryan and Deci 2009).

Possible Reasons for Modest Quality of Scenarios One third of the scenarios were typified as high quality; they paid attention to almost all of the features of an ideal scenario. Yet, the majority (14/24) of the teachers' scenarios were mediocre in regard to their quality as they did not fully take into account the relevance of an ideal scenario, i.e. a title related to students' life in the form of an appropriate question, interdisciplinary nature of the content, meaningful scientific context, or interesting introductory materials (see Table 1). However, some of them were interpreted to include activities for student involvement, and almost all of them encouraged students in collective thinking and reflection. Two of the scenarios were of low quality as almost all of the features of an ideal scenario were missing. The teachers tend to lack confidence in addressing scenario-based teaching in their science classrooms (Sormunen et al. 2014); this might be a consequence of constraints such as a lack of awareness of pedagogical choices and guidance of how to apply them (cf. Saunders and Rennie 2013). Findings in earlier studies also indicate that science teachers appreciate the SSI approach and teaching modules for that purpose (Ekborg et al. 2013), but the actual use of an SSI approach is dependent on their values (Lee and Witz 2009) or teachers' pedagogical knowledge and skills (Lee and Abd-El-Khalick 2006).

Conclusion

The quality of SSI scenario in our study seemed to depend on its relevance to students (see Table 1). The majority of the scenarios acknowledged the cognitive aspects such as collective thinking and reflection, and practically all of the scenarios facilitated students' scientific questions. In contrast, quite a few scenarios disregarded the affective features such as the interesting and appealing form and context of the problem. We consider this result to be significant from both research and theoretical perspectives; it extends our understanding of challenges related to SSI scenario design. Our findings indicate that it seems to be challenging but possible for science teachers to develop an SSI scenario that is interesting and motivational from the students' point of view. Although the present study does not concern itself with how students benefit from the scenarios, our preliminary findings (Jäppinen et al. 2015) support the conclusion that the scenarios trigger students' interest and motivation.

It can be noted that affective features in scenario-based science education need to be particularly emphasised. This cannot be achieved without teachers' awareness of the importance of affective aspects of science education. Therefore, there is a need for systematic and longitudinal support for science teachers to create SSI scenarios (cf. Saunders and Rennie 2013).

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