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Socio-scientific Issues—A Way to Improve Students' Interest and Learning?

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According to many documents, there is a strong need to renew science education. One way could be to work with SSI (socio-scientific issues). This paper reports on both students' and teachers' experiences and learning when working with socio-scientific issues in science education in secondary school (aged from 13 to 16). The approach is multidimensional, as factors that influence cognition as well as motivation and the forming of attitudes are complex. Results suggest that SSI work forms are more important than personal factors for explaining outcomes. Relevant issues, autonomy and functioning group work seem to be important aspects of successful SSI work together with structure provided by the teacher, and information that challenges previous knowledge. In general, SSI seems to be most efficient for students, who believe that they learn from presenting and discussing their knowledge, focus on "the large picture", acknowledge own responsibility for learning, find school science personally relevant and are self-efficacious. It seems that the outcomes from SSI work are much in the hands of the teacher. This paper is a short summary of the first year and quantitative part of the project. Further results from the project will later be found in our homepage (http://www.sisc.se).

Keywords: science education, secondary school, SSI (socio-scientific issues), interest, learning, quantitative study

Subject/Problem

According to many documents (Osborne & Dillon, 2008; Tytler, 2007), there is a strong need to renew science education. Arguments for change are that young people's interests in choosing a scientific career is declining, scientific ignorance in the general populace is extensive, economic importance of scientific knowledge is inclining, and last but not least, students' opinion that science in school is boring and not relevant for them. In the past decade, there has been mounting evidence that this problem has become more acute. Studies (Osborne, Simon, & Collins, 2003; Lyons, 2006; Sjøberg & Schreiner, 2006) have indicated that most youth expressed positive attitudes on the importance of scientific and technological issues to society, and that

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new strategies for increasing young people's interests and knowledge in science and their abilities to use science outside school are needed. One way could be to bring from a humanistic perspective (Aikenhead, 2006) to focus more on scientific literacy than science literacy and work with SSI (socio-scientific issues) in science education. Ratcliffe and Grace (2003) described general characteristics of such issues as: being important for society and having a basis in science, involving forming opinions, being frequently media-reported, addressing local, national and global dimensions with attendant political and societal frameworks, involving values and ethical reasoning, being likely to involve consideration of sustainable development and being likely to require some understanding of probability and risks, and there are no "right" answers. SSI are said to be vehicles, not only for raising students' interests in science, but also for strengthening generic skills as team-work, problem-solving and media literacy. At the same time, these skills are a presumption for successful work with SSI (Jarman & McClune, 2007; Ratcliffe & Grace, 2003). Researches have showed that such issues challenge students' rational, social and emotional skills (Sadler, 2004). However, several problematic factors are identified, such as students easily can be distracted when they are working with complex issues, where the outcome often is not clear (Zeidler, Sadler, Simmon, & Howes, 2005), and that there is still a significant work to do in order to ascertain the link between SSI curricula and the learning of science contents (Sadler, Barab, & Scott, 2007).

Teachers working with SSI experience that there is a tension between educational arguments for devoting time to developing students' understanding of scientific processes and the classroom reality. They often find it more important to reproduce scientific facts than to develop the idea that scientific knowledge has a degree of tentativeness associated with it (Bartholomew, Osborne, & Ratcliffe, 2004). Moore, Edwards, Halpin, and George (2002) reported that teachers tend to incorporate new policy into a largely unaltered practice due to belief systems that are more important than the new curriculum. Teachers often feel insecure about the extent to which they should be involved in the classroom discussions (Bryce, 2004).

Several researchers such as Limón (2006) argued that we need a multidimensional approach to understand the effects of educational interventions, since much of the ambiguity in education research is due to a failure to account for the complexity of factors that influence cognition as well as motivation and the forming of attitudes. Examples of such factors are student emotions (Pekrun, Elliot, & Maier, 2006), the instructional design, students' attitudes towards learning science (Osborne, Simon, & Collins, 2003), epistemological beliefs (Hofer, 2001) and social belonging, self-efficacy and sense of autonomy/locus of control (Ryan & Deci, 2000). Windschitl and Andre (1998) found that students' epistemological beliefs functioned as predictors of learning outcomes, only if the degree of autonomy in the learning situation was considered simultaneously. Similarly, students' persistence on a difficult task is considered to be a result of an appraisal of the attitude toward the task/behavior and self-efficacy and locus of control (Carver & Scheier, 1990). Depending on the result of this appraisal, different emotions occur (Schutz & DeCuir, 2002). Hence, motivated behavior as well as cognition and emotions during learning from SSI are probably dependent on a wide range of factors.

Out of this background, we have designed a research project to learn more about both students and teachers' experiences and learning when working with socio-scientific issues in science education at senior level (aged 13-16). The project started in 2007 and will last for at least four years. Our overall research questions are:

(1) How do students' interests, engagements and self-efficacies develop in the work? What factors are important?

(2) How do the students' argumentations develop?

(3) What knowledge do the students develop when working with socio-scientific issues?

(4) How do teachers describe their work with SSI cases in terms of students' work and learning, and what can this tell us about their views of science teaching?

Design/Procedure

The project can be described in three parts. First, a conceptual framework for analyzing and constructing socio-scientific cases was developed (Ekborg, Ideland, & Malmberg, 2009). Six cases were constructed and published with the teachers' guide. The cases were introduced by current authentic situations, e.g., TV-programs, personal homepages and newspaper articles, and deal with near sightedness and laser treatment, mobile phones, climate change, cochlea implant and nutrition. Two student questionnaires were developed, the first one aimed at describing the work forms that the students were accustomed to in science class and students personal characteristics from several aspects: learning goals, attitudes towards science in school and society, self-efficacy and beliefs about learning. The second one aimed to measure the situational characteristics of the SSI work and its cognitive/behavioral and affective outcomes (Winberg & Lindahl, 2008). A teacher questionnaire with 61 questions about working forms, assessment, learning and personal experiences was also developed together with an interview guide. The items in all questionnaires were collected from extant questionnaires or constructed based on theory within the field.

In the second step, we invited teachers from lower secondary school to participate and 70 teachers volunteered. They were free to organize their work in their own way, but had to use our starting points and allow their students to discuss at least once. The data collection was mostly quantitative. Nearly 1,500 students answered the first questionnaire, worked with the cases, and then, answered the second questionnaire, and 55 teachers answered their questionnaire and seven of them were interviewed. For the analysis, we have used SPSS® and Simca® for descriptive statistics and multivariable analysis.

The third step is a still ongoing qualitative study in six classes to learn more about teachers' and students' development in detail. For this part, we have developed our questionnaires to have a stronger focus on what we found important in the quantitative part. Besides questionnaires, all lessons have been observed and/or video recorded all discussions tape recorded, and both students and teachers were interviewed.

Analyses and Findings

The data analysis is still going on, but here we will summarize results from the second step described above. In the first questionnaire, students were asked how interested they were to learn more and how good they thought they were in different school subjects on scales 1-5. Then the average value has been calculated for each subject. The result shows that boys have more self-efficacy than girls in all subjects (in all grades) except in their mother tongue, and that the difference between girls and boys increases from grade 7 (13 years) to grade 9 (16 years). In grade 9, girls' self-efficacy for science is also much lower than for other subjects. Furthermore, less than half of the students agreed on statements like "Science and technology is important for society" and "The benefits of research are greater than the harmful effects it could have".

The items from both student questionnaires were distributed in five categories: (1) Attitudes; (2) Beliefs about learning and knowledge; (3) Self-efficacy/locus of control; (4) Common work forms; and (5) SSI work forms and then subjected to PCA (Principal Component Analysis) and hierarchical PLS (Partial Least Squares analysis). In this analysis, it seems that such work forms (i.e., issues are up to date, frequent discussions, equally shared work load and autonomy), are most important to explain positive affective and cognitive outcomes. Students' achievement goals also seem important for predicting these types of outcomes. Unfortunately, only one item measured this, and therefore, no far going conclusions should be drawn on this result. For the last part of the study, items that focus on these goals would be added.

During the work with SSI, students considered the interesting and relevant cases, especially the girls. Almost all students claimed that they have learnt new facts during the work. The more interesting they found the case, the more they claimed they have learnt. The students reported that they learnt to argue for their standpoint and search for and scrutinize information. The principal component analysis shows that SSI work forms are important for explaining outcomes, with functioning group work and discussions being especially important. The work forms did not differ much between the cases and were quite similar to what they were used to in regular teaching. One difference is that most classes exclude laboratory exercises when working with SSI. The students considered the assignments easy to solve. They did not find it difficult to search for information, mostly from Internet, about the cases. Very few students were interested in doing more SSI assignments, and 25% of them reported enhanced interests in science. On the other hand, students from multicultural schools express a higher interest in working with SSI compared with their normal science class. These students do not relate SSI to the public debate as much as those from mono-cultural schools, neither do they use Internet as much in their work with SSI. The students in the multi-cultural schools found the discussions interesting, and that their opinions were considered important by their peers. Given this, it was somewhat surprising that they also found the lack of single correct answers that is inherent in SSI: frustrating.

Analysis of questionnaires showed that the teachers were satisfied with the work with SSI. They found the introductions and the contents interesting, and experienced that the students were engaged. The teachers found the learning goals were appropriate in relation to the syllabus, but not as much to the students' prior knowledge. In general, they used between five and ten hours for each case. Forty percent of the teachers taught part of the topic before introducing the case, and 60% of them introduced the learning goals early. The teachers used a variety of work forms, and group work was frequently used. Only a few included lab work. The most common resource was Internet. The teachers indicated that the students had learnt as much as they usually do in science. The students learned critical thinking, to search information, apply scientific knowledge, scientific facts and understand scientific facts and argumentation. The seven interviewed teachers appreciated getting a material with new ideas and they saw benefits beyond the actual work, e.g., involvement from parents and a lasting interest in the contents among the students. They gave several examples of how ideas emerged about the development of science teaching in general.

The seven teachers who were interviewed differed in age, teaching experience, view of knowledge and learning, and they used different teaching strategies. They had chosen four different cases. In spite of the differences, there were some similarities. They all chose a case that they could fit in with their regular planning. They all implicitly understood that working with SSI means giving students lots of freedom. Group work was frequent and they expressed that students had difficulties in formulating "good" questions that encouraged student to discuss, further questions and search for answers. However, only two of them expressed explicit strategies for dealing with this. Although they saw potential in learning science by working with these cases, they all worked as if this implementation was a special event. For instance, one teacher chose an overachieving class, and they had all prepared the students by teaching the contents before starting the case. Also, one teacher worked with the case as a special project besides the regular teaching, and most of them did not assess the work as thoroughly as they usually do. It is in accordance with the questionnaires where 25% of the teachers mentioned the case as "a special project". The seven teachers had different ideas of how students learn, but they all explicitly and implicitly talked bout knowledge as a set of facts which should be taken in by the students. However, they all felt secure with both the contents and the chosen work forms.

Contribution/General Interest

So far, we can see that students at senior level appreciate working with SSI. Thus, working with SSI could be considered as an appropriate activity for all students. However, the work with SSI might not so much raise students' interests in science, but it can strengthen generic skills as team-work, problem-solving and media literacy. We notice that students are ill-prepared to work autonomously. The teachers in this study confirmed that students are interested in working with SSI. Some of the results are contradictory. The teachers felt safe with contents and work forms, but they still arranged SSI as something special and were comfortable with group work, even if they generally did not seem to know how to facilitate the students' work. The results indicate that teachers lack strategies to work with discussions and argumentation. Despite of information from the researchers on aims and work forms for SSIs, the teachers observed in the qualitative study tended to fall into old habits, e.g., science contents are the primary learning goal and their roles are dispensers of knowledge (Ratcliffe et al., 2005) and supervisors. Results suggested that although all categories contributed, SSI work forms are more important than personal factors for explaining outcomes. Relevant (current) issues, autonomy and functioning group work (good discussion climate and equally distributed workload) seem to be important aspects of successful SSI work. Structure provided by the teacher, and information that challenges previous knowledge also seems to be aspects of SSI work that contributes to positive affective and cognitive outcomes. In general, SSI seems to be most efficient for students who believe they learn from presenting and discussing their knowledge, focus on "the large picture", acknowledge own responsibility for learning, find school science personally relevant and are self-efficacious (data not shown). It seems that the outcomes from SSI work are much in the hands of the teacher. Thus, working with SSI could be considered as an appropriate activity for all students. However, educators should continue to look for ways to promote development of students' attitudes and epistemological beliefs.

Further analysis and data from the qualitative study will give us more information about what is crucial and how we can improve this way of working. Here, one focus will be "What knowledge do students develop when working with SSI?". We also have results indicating the importance of the teachers' way of introducing and structuring the work. All publications from this project will be found in our homepage (http://www.sisc.se).

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