Socio-Scientific Issues – A Way to Improve Students' Interest and Learning?
Paper presented at 2010 NARST Annual International Conference in Philadelphia.

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Subject/Problem

According to many documents (Osborne & Dillon, 2008, Tytler, 2008) there is a strong need to renew science education. Arguments for change are that young people's interest 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 but also that new strategies for increasing young peoples' interest and knowledge in science and their ability to use science outside school are needed. One way could be to bring in a humanistic perspective (Aikenhead, 2006), to focus more on *scientific literacy* than *science literacy* and work with socio scientific issues (SSI) in science education. Ratcliffe and Grace (2003) describe general characteristics of such issues as: important for society and have a basis in science, involve forming opinions, are frequently media-reported, address local, national and global dimensions with attendant political and societal frameworks, involve values and ethical reasoning, may involve consideration of sustainable development and may require some understanding of probability and risks, and there are no "right" answers. SSI are said to be vehicles, not only for raising students' interest 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). Research has 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 & Simmons, 2005) and that there is still significant work to do in order to ascertain the link between SSI curricula and the learning of science content (Sadler, Barab and Scott, 2006).

Teachers working with SSI experience 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). Edwards, Halpin, & George (2002) report 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 as Limón, (2006) argue 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 et al, 2006), the *instructional design*, student *attitudes toward learning science* (Osborne et al, 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 student 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/behaviour 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 (age 13-16). The project started in 2007 and will continue for at least four years. Our overall research questions are

- What knowledge do the students develop when working with socio-scientific issues?
- How do interest, engagement and self-efficacy develop in the work? What importance do the tasks have?
- How does the student's argumentation develop?
- What knowledge do teachers develop and how does their view of teaching develop?

Design/Procedure

The project can be described in three parts. First a conceptual framework for analyzing and constructing socio-scientific cases was developed (Authors, 2009). Six cases were constructed and published in the teachers' guide. The cases are 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 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 toward science in school and society, self-efficacy and beliefs about learning. The second aimed to measure the situational characteristics of the SSI work and its cognitive/behavioral and affective outcomes (Authors, 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 1500 students answered the first questionnaire, worked with the cases and then answered the second questionnaire and 55 teachers answered their questionnaire and 7 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 are 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 are to learn more and how good they think they are in different school subject on a scale 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 but also that the difference between girls and boys increase from grade 7 (13y) to grade 9 (16y). In grade 9 girls' self-efficacy for science is also much lower than for other subjects. Furthermore, less than half of the students agree 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 on five categories which are 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 Principal Component Analysis (PCA) and hierarchical Partial Least Squares analysis (PLS). In this analysis it seems as 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 will be added.

During the work with SSI students considered the cases interesting and relevant, especially the girls. Almost all students claim 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 to 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 only 25% reported an enhanced interest in science. On the other hand students from multicultural schools express a higher interest working with SSI compared with their normal science class. These students do not relate SSI to the public debate as much as students 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 SSIs: s frustrating.

Analysis of questionnaires showed that the teachers were satisfied with the work with SSI. They found the introductions and the content interesting and experienced that the students were engaged. The teachers found the learning goals appropriate in relation to the syllabus but not as much to the students' prior knowledge. In general they used between 5 and 10 hours for each case. 40% of the teachers taught part of the topic before introducing the case and 60% 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, applying scientific knowledge, scientific facts, understanding 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 content among the students. They gave several examples of how ideas emerged about development of science teaching in general.

The seven teachers who were interviewed differed in age, teaching experience, view of knowledge and learning and used different teaching strategies. They had chosen four different cases. In spite of the differences there were some similarities. They all chose a case 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 discussion, 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 content 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. This 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 content 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' interest 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 confirm that students are interested in working with socio-scientific issues. Some of the results are contradictory. The teachers felt safe with content and work forms but they still arranged SSI as something special and even if they were comfortable with group work they generally did not seem to know how to facilitate the students' work. The results so far indicate that teachers lack strategies to work with discussions and argumentation. Despite 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 content is the primary learning goal and their roles are dispensers of knowledge (Ratcliffe et al 2005) and supervisors. Results suggest 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', acknowledges own responsibility for learning, finds 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. We also have results indicating the importance of the teachers' way of introducing and structuring the work.

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