Working with SSI: Factors influencing emotional and cognitive outcomes

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Abstract

According to many stakeholders, there is a strong need to renew science education to bring about a radical change in young people's interest in science. A suggested way could be to focus more on *scientific literacy* than *science literacy* and to work with socio-scientific issues (SSI). This evidence-based research project investigates what happens with interest, knowledge and self-efficacy when students in lower secondary school work with such issues. Here we present results from the quantitative part of the study with a focus on the relations between personal and situational factors and their relative effects on learning experiences and outcomes. Two questionnaires were developed, one pre-SSI work to describe common work forms and pupils' personal characteristics from several aspects and one post-SSI work to measure the situational characteristics of the SSI work and its cognitive/behavioural and affective outcomes. Results show that SSI work forms are more important than personal factors for explaining outcomes. Relevant issues, autonomy and functioning group work are important aspects. In general, SSI seems to be most efficient for pupils 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.

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Background, Framework, and Purpose

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. One way to increase students' interest and learning could be to bring in a humanistic perspective (Aikenhead, 2006) and to focus more on *scientific literacy* than *science literacy*. From this background we have designed an evidence-based research project to see what happens with interest, knowledge and self-efficacy when students in lower secondary school work with socio-scientific issues (SSI). 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, involve values and ethical reasoning, and there are no "right" answers. First we developed a teacher guide with six authentic cases (Ekborg at al. 2009) and different attitude questionnaires. The data collection started in 70 classes where students answered a questionnaire, worked with the cases and then answered another questionnaire. Currently we are performing a qualitative study in six classes aiming at studying teachers and students' development in more detail. In this paper we present results from the quantitative part of the study with a focus on the relations between personal and situational factors and their relative effects on learning experiences and outcomes.

Rationale

Several researchers (e.g., 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 behaviour as well as cognition and emotions during learning from SSI are probably dependent on a wide range of factors. Due to the relatively short duration of the intervention, we did not expect any measurable effects of SSI work on students' attitudes toward school science. Instead we have investigated students affective and cognitive experiences during SSI since these are considered central in the development of future attitudes.

Methods

Two questionnaires were developed, the first aimed at describing the work forms that the pupils were accustomed to in science class and pupils personal characteristics from several aspects; learning goals, attitudes toward science in school and society, self-efficacy and beliefs about learning. The second questionnaire, which measured the situational characteristics of the SSI work and its cognitive/behavioural and affective outcomes, was completed immediately after an SSI activity. In total, the instruments comprised 144 items, completed by 1427 pupils. To facilitate overview and interpretation, items were distributed on five different categories (table1) and projection to least squares analysis (PLS) was applied to items in each category to investigate their relation to outcomes and to "condense" the individual items into a few latent components. The development of these categories has been described elsewhere (Winberg & Lindahl, 2008). A hierachical PLS "top model" was then calculated to evaluate the relations between categories and outcomes. Throughout all models, the number of components to retain was decided by cross validation. To get a clear picture of the relative importance of the different categories for explaining outcomes, 'variable importance for projection values' (VIP:s) were calculated for each variable in the top model. This was done by summing the squared loadings of the variables on the components in the top model, weighted by the amount of outcome variation explained by the respective components.

Results

VIP:s (within brackets) show that all categories had a significant impact on outcomes. The first component in the SSI work forms-category (1.83) was the most important variable followed by the first components of the Beliefs- (1.21), Attitudes- (1.11), and Self-efficacy (1.04) categories. Confidence intervals for these VIP suggest that only the first two categories had a VIP significantly higher than 1, which makes them more important than average for explaining outcomes. Being almost twice as important as the average, only the SSI-workforms category will be discussed further within this paper.

Table 1. *Number of components in each category, percentage of described variation among questionnaire items (R^2X) and outcomes (R^2Y), and predictive ability (Q^2) of models*

	Category	Comp.	R^2 X	R^2Y	Q^2
1	Attitudes	2	29	17	12
2	Beliefs about learning and knowledge	1	22	15	13
3	Self-efficacy / locus of control	2	49	17	14
4	Common work forms in science class	1	28	4	3
5	Work forms during SSI-work	3	33	35	32
	Top model				
	Components from category 1-5 vs. outcomes	2	42	43	41

The SSI work forms category

By the same procedure as for the top model, it was found that the most important *items in the first component of this category* for explaining affective and cognitive outcomes were; current task (1.7), frequent discussions within the group (1.5), mutual responsibility within the group for completing the task (1.4), and autonomy with respect to how to organize the work (1.4) and formulate questions to discuss within the SSI (1.2). Items with intermediary VIP (0.5 – 1) were; influence on presentation forms, teacher support in the form of structuring short whole class lectures during SSI work, and encountering information that conflicts students previous knowledge.

Conclusions and Implications

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 pupils 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* pupils. However, educators should continue to look for ways to promote development of pupils' attitudes and epistemological beliefs.

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