

RESEARCH ARTICLE

How Socio-Scientific Inquiry Based Learning (SSIBL) promotes inquiry in climate issues – An example for enacting socio-scientific issues in science education

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The project “Mobility, Traffic and Renewable Energies” is a joint project between the University of Klagenfurt and the University of Teacher Education in Carinthia. Pre-service science teachers, teachers and school students engage in real-world issues. This participatory project was implemented in two rounds (academic year 2015-2016 and 2016-2017) and was part of the EU-FP7-Project PARRISE (Promoting Attainment of Responsible Research and Innovation in Science Education). An essential goal of PARRISE was to implement the pedagogic framework of Socio-Scientific Inquiry Based Learning – SSIBL. In this paper practical activities at schools are described and selected findings of an evaluation about the learning of school students and pre-service science teachers are presented.

Keywords: Prospective science teachers, science teaching orientations, teacher epistemologies, teacher beliefs, card sorting activity

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Introduction

An overall goal of the multi-agency project “Mobility, Traffic and Renewable Energies” was to implement the pedagogic framework of Socio-Scientific Inquiry Based Learning – SSIBL (Figure 1) developed in the European Project PARRISE (2017). SSIBL draws together three pedagogical approaches, common in schools but often independently pursued – Inquiry Based Science Education (IBSE), Socio-Scientific Issues (SSI) and Citizenship Education (CE) (Levinson, 2016). Teaching SSIBL has three main stages: authentic questions, enactment and actions. Teaching starts with raising meaningful and *authentic questions* about ‘socio-scientific issues’. For exploring

these questions, social and scientific inquiry is used (*enaction*). Finally, students are stimulated to take action: form opinions and formulate solutions (*action*) (Knippels, van Dam & van Harskamp, 2017).

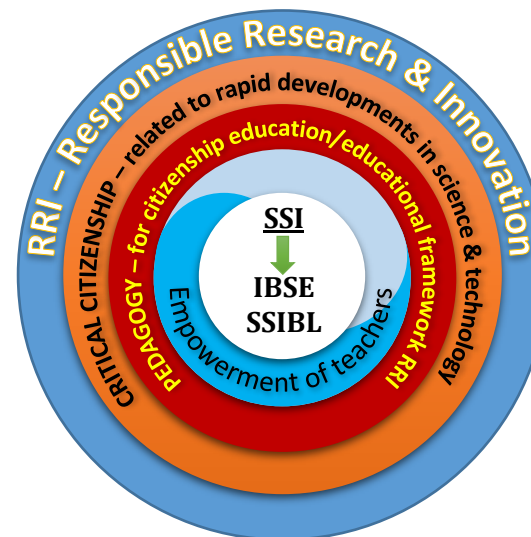


Figure 1. The socio-scientific inquiry-based learning framework (SSIBL)

The more specific goal of the Austrian project “Mobility, Traffic and Renewable Energies” was to engage school students in real-world issues (Sadler, 2009) and to instil long-term awareness of the challenges of climate change in school students, teachers, parents, experts, regional and local authorities, and to encourage sustained engagement with climate and energy issues (Rauch, 2017). The assumption is that climate change offers a fruitful ground for learning about science and environmental issues (Menthe et al., 2013; UN 2015).

In the Austrian project “Mobility, Traffic and Renewable Energies”, a total of two teacher educators, 24 pre-service science teachers, about 250 school students, 44 teachers and three climate region managers were involved.

Practical examples

The following examples illustrate how the SSIBL approach was enacted in the Austrian project. In order to introduce the topic in all participating schools, experts from the Austrian Climate and Energy Fund and the climate region manager, conducted different workshops on climate and energy. They visited together with students, in-service and pre-service teachers various research

institutions and enterprises in Carinthia, as well as a hands-on science centre, recycling centres and installers (to explain the use of solar collectors), a waste incineration plant and a green power plant.

Another initiative which presented in more in detail was a workshop on energy and heat insulation. The one-day workshop was co-designed by pre-service science teachers and in-service teachers and took place at four primary schools in the province of Carinthia for 89 children aged 9-10 years. The use of experiments should foster SSIBL and should nurture the students' interest in renewable energies. Based on everyday experiences, students should gain an understanding of thermal processes, understand and explain terms like heat conduction, heat flow and heat radiation. In the context of responsible research and innovation, students should recognize the importance of thermal energy for living beings and learn to consider thermal energy in a cross-curricular way linked with economic and environmental dimensions. The teaching goal was to use simple and everyday examples. Students should be motivated to think independently and critically and to work together in teams.

At the beginning of the workshop, pre-service teachers presented the issue to the students by letting them elaborate the terms 'hot and cold'. They asked them what they associate with the color red and the color blue. Afterwards, the pre-service teachers showed the students a thermal camera and explained its function and how to use it. For the next learning activity, students took a shot from a thermal camera and were given the task to analyze it in small groups. The students discussed the meanings of the colors in the shot: What could the transition of colors from yellow to green mean? Why are the windows red and the rest of the house blue? The results of the group discussions were presented to the whole class sitting in a circle.

Next, the students got a shot with a blue and yellow house and were asked to explain the meanings of the colors yellow/red and blue. They thought about questions like: "In which of the houses is it warmer?" "What can be done to make it warmer in the houses?" "Why does it matter that so much heat is 'lost'?" To foster students' participation in class, the students were given the opportunity to try to use a thermal camera. As energy detectives, they investigated the heat state of their own school building. Each child worked with the thermal camera and explored whether the schoolhouse was well-insulated and where energy was lost. Using thermal camera images, students and pre-service science teachers discussed how well the schoolhouse was insulated. The pre-service science teachers explained to the students which materials are used to insulate a house to save energy. They used questions like: "Why is it important to keep a house well-insulated?" "What are energy costs?" and "Why should they be low?" "How do you heat or cool your home?"

Evaluation

The following questions guided the evaluation process: What do students and pre-service science teachers learn while teaching the SSIBL approach in the context of the Austrian project "Mobility,

traffic and renewable energies"? What do the other involved parties (teacher educators, in-service teachers, climate region managers) learn?

To answer the evaluation questions, triangulated data from different participants were cross-examined and discussed (Flick, 2014). The respondents' data were categorized using the method of qualitative content analysis. The material obtained from the questionnaire was condensed and a consensus created. (Mayring, 2015). **Table 1** below gives an overview of the evaluation data collected in two rounds.

Table 1. Examples of scenario texts.

1 st round (academic year 2015-2016)	2 nd round (academic year 2016-2017)
A guided focus group discussion with 3 teacher educators	1 interview with the teacher educator
2 interviews with in-service teachers	2 interviews with in-service teachers
2 interviews with pre-service teachers	A guided focus group discussion with 7 pre-service teachers
10 qualitative questionnaires for pre-service teachers	1 interview with the climate region manager
2 interviews with climate region managers	Field data gathered during the project
Field data gathered during the project	

Selected results on the learning of students and pre-service students

With a focus on pre-service science teachers and school students, the evaluation data offer the following results. Pre-service science teachers developed the self-confidence necessary to implement SSIBL in classrooms. They used inquiry-based learning (IBL) through collaboration and critical examination of evidence. In this context, they learned thinking outside the box, to initiate and manage discussions on important issues and to prompt critical thinking.

Through enacting SSIBL activities in schools, pre-service science teachers

"... had the possibility to try out a new teaching concept, which is in contrast to regular school settings. The students showed a keen interest in nature phenomena in particular on environment and climate." (Focus group discussion with pre-service teachers)

For the majority of the pre-service science teachers (80%), the time-consuming nature of SSIBL in designing and teaching SSIBL-workshops was a challenge; however, this encouraged them to think strategically about planning:

"The planning of the project should take place sufficiently in advance, and the project should be positioned in the annual plan for the class. Further, timely arrangements with all colleagues and regular team meetings are important for successful planning." (In-service teacher)

The following comments illustrate the benefit of the SSIBL approach for school students:

"The lesson planning was designed in a cross-curricular way and linked with environmental and social impacts of technological innovations to make the school students aware of these relationships and then to discuss them. Beyond the understanding of physical-scientific processes they also focused on social impacts of technological developments and innovations and their relation to the struggle for justice." (Teacher educator)

School student learning was stimulated by investigating questions originated by the experts, which were relevant for them and the region in which they live in. School students took on active roles in preparing and carrying out experiments which fostered their own learning and reasoning through reflection and discussion.

"We have had the impression that students learn more easily if they can carry out experiments, perform measurements by themselves." (Focus group discussion with pre-service teachers)

The use of experiments during the workshop on energy and heat isolation fostered inquiry-based learning:

- Eliciting ideas about hot and cold.
- Interpreting images from thermal imaging cameras.
- Understanding how heat is distributed in our school.
- Collecting and discussing the evidence in relation to broader social issues.
- Discussing how to act on the evidence they gathered.

Moreover, school students' capacity for critical thinking was encouraged:

"The school students learned not to take all kinds of information for granted and to reflect critically on questions such as: 'What has thermal insulation to do with climate protection?' 'How ecological is electromobility?'" (Focus group discussion with pre-service teachers)

"Students learned to contrast the knowledge they have acquired in climate and environmental issues with the knowledge spread by media." (In-service teacher)

Summary

The innovative and open teaching and learning design of the SSIBL framework motivated both teachers and students. The framework has made it possible to integrate social and ethical issues such as climate and the environment into science education related to the students' everyday lives and the region in which they live in. The SSIBL approach brings innovation to teaching and

learning in traditional subject matters. 90% of the pre-service science teachers who took part in the project regarded the implementation of SSIBL in classroom as a fruitful learning experience although challenging.

The SSIBL-related topic 'Mobility, Traffic and Renewable Energies' is now a permanent part of the curriculum at the University of Teacher Education in Carinthia. Based upon the evaluation data and the gathered experiences careful support and scaffolding of pre-service teachers is part of the curriculum.

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