Laboratory work and a SSI about water quality: is it possible to develop both socially responsible citizens and scientific skills?

PARISE — Promoting Attainment of Responsible Research & Innovation in Science Education

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Background

With limited time to educate students: Does SSI take time from learning scientific facts and scientific skills or will it increase motivation for learning and developing responsible citizens?

Here we follow students (17-18 years) in two classes (N=39) studying chemistry in an upper secondary school in Sweden. The implemented teaching sequence involve a practical laboratory investigation of one quality parameter of their own drinking water: hardiness (concentration of Mg^{2+}/Ca^{2+} ions).

Teaching sequence

INTRODUCTION (70 min)

Digital poll:
Data collection "before".
What do you want to know about your drinking water – and why? What shall society and research do to protect the drinking water?

Videos: Production of drinking water in our city - where does it come from? (own movie) and "Safe-Drink" reserach project (SLU, Uppsala, Sweden).

Activity: Municipal water or own well? Where do you live? Write on Post-it notes!

Review: Water cycle and newspaper headlines about problems in local drinking water.
Chemical analysis, water hardiness, EDTA-titration method, statistical methods.

PLANNING (60 min)

Groups:
Planned by teacher based on post-it notes about students own water sources. Three students each (mix of municipal water and own wells).

Demonstration: Water sampling and the EDTA-titration method.

Student planning: Formulate hypothesis, design your sampling method. One planning per group.

LABORATORY WORK (90+60 min)

Water sampling:
All students brought bottles with water from home to the lab according to their sampling design.

EDTA-titration: Volume of EDTA added corresponds to the amount of Mg2+/ Ca2+ in the water sample.

Data analysis: Calculations of water hardiness (mean °dH, STDEV, diagrams in Excel). Conclusions and evaluations in groups.

GROUP DISCUSSION + WRITING (60 min)

Activity:
Value discussions about "Who is responsible for the ground near where drinking water is coming from? No one? Everybody? Politicians? Companies?

Intergroups: Presentations of hypotheses, results and conclusions. Group discussion about quality of data and consequences of differences in hardiness.

Digital poll: Data collection "after".

Writing: Individual drafts of lab reports.

WHAT´S NEXT? (Autumn 2017)

Activity: Panel discussion with experts.

Writing: Student scientific reports.

Results & Discussion

Increased interest in water analysis project (Fig 1)

- Positive effect on weakly motivated students
- Despite high workload period (reduced general motivation)

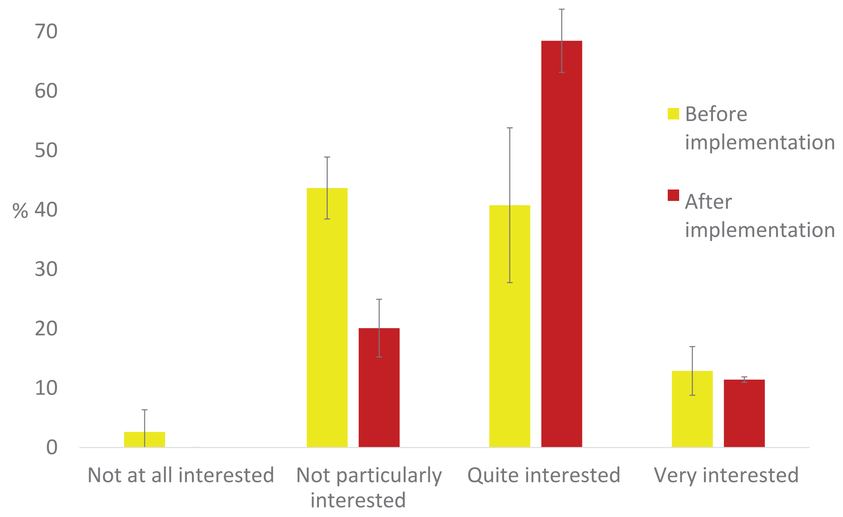


Figure 1. Distribution (in %) of student answers on the question: "*How big or small is your interest right now to work with a project that deals with analysis of drinking water?*" before and after implementation of the teaching sequence.

Developed scientific skills (Fig 2)

- Students feel confident with planning including hypothesis formulation.
- Students (and teacher!) are satisfied with their performance in the lab.
- Correct analyses and reasonable conclusions are made.

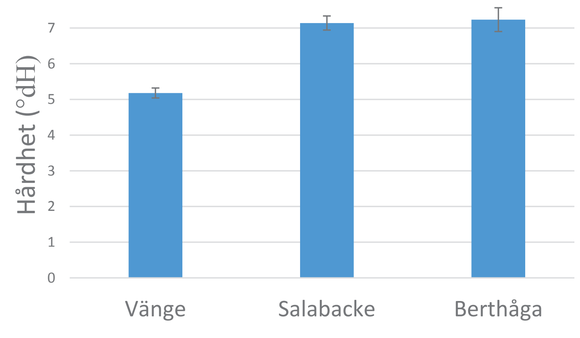


Figure 2. Example of results from analysis of water hardiness from one student group. Students use basic statistical tools (mean values, STDEV) to draw their conlusions.

Changed focus in student questions (Table 1, 2)

- Increased interest in health aspects
- Sparked interest in economic issues
- Maintained personal involvement, increased connection with society and expressed needs for information to complete the school assignment

Table 1: Thematic content analysis of student responses to question "*What would you like to know about drinking water and why do you want to know it?*".

	Theme	Natural variation	Environment	Health	Daily life	Technical	No questions	Economy	Other
Before	(% of 46 scores)	39	17	26	2	4	11	0	0
After	(% of 34 scores)	21	9	47	0	6	0	9	9

Table 2: Distribution (in %) of student perspectives interpreted in the expression of their questions about drinking water (same question as described in Table 1).

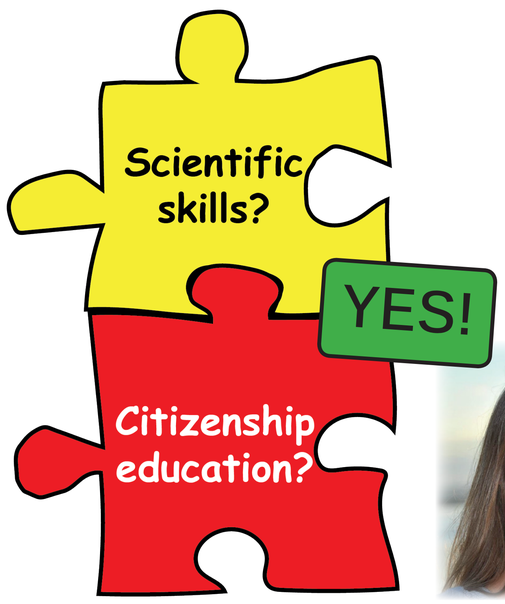
	Perspective	Facts	Personal	Society	Global	School
Before	(% of 38 scores)	45	29	21	5	0
After	(% of 30 scores)	30	27	33	0	10

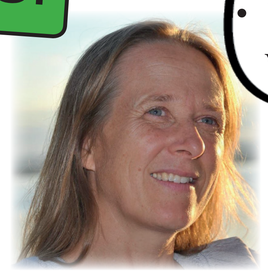
One of the most important things is that we conserve the resources of drinking water, because water shortages can also occur in a rich country like Sweden. Another important thing is to keep the drinking water hygienic and work to improve water purification to avoid diseases, etc. It also includes the fact that we should not dump toxic material in nature as it is likely to get into the groundwater.

Students ideas about what society and research shall focus on (Fig 3)

- Control and investigate eventual health aspects
- Develop techniques
- Ensure access to clean drinking water for all

Figure 3. Example of answer on the poll question: "*In your opinion - What is most important for society and research to do, to protect the drinking water in the future?*" after the implementation of the teaching sequence.





Teacher reflections

- Avoid intensive test periods for students when planning to run this lab project
- Use value discussions and interactive methods earlier (introduction phase)
- Focus more on background facts about water hardiness in introduction and/or planning phase.

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