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Pols, C.F.J.; Dekkers, P.J.J.M.; de Vries, M.J.

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Development of a teaching sequence on physics inquiry

C.F.J. Pols, P.J.J.M. Dekkers, M.J. de Vries

Delft University of Technology, *c.f.j.pols@tudelft.nl*

Abstract. Learning to engage in scientific inquiry is an important goal in secondary physics education. However, attaining this learning goal continues to be a challenge. We addressed this problem by devising and testing a teaching sequence that aims at developing students' (aged 14-15) understanding of and adherence to scientific criteria. We observed, that after going through this sequence, the students' critical attitude evolved and they developed basic understandings of how to conduct a physics inquiry. They started to substantiate the decisions made in their inquiries. The teaching sequence thus seems a suitable starting point for engaging young students in scientific inquiry.

1 Enabling students to engage in physics inquiry

One of the main learning goals of secondary school physics education is *learning to engage in scientific inquiry*. However, we do not seem to effectively attain this goal, if at all [1]. What is understood though, is that successfully engaging in physics inquiry requires the development of a substantial amount of procedural and conceptual knowledge and enhancing students' critical attitude [2-4]. This attitude is characterized by continuously asking and evaluating the question '*what decision leads to the best possible result?*

In this intervention study, we developed and tested a teaching sequence in which we give explicit attention to the role of argumentation in scientific inquiry. We simultaneously aim at the development of students' understanding that in physics inquiry one seeks to produce the best available answer to the research question, and the development of inquiry knowledge that allows students to produce such an answer.

The central research question guiding this study was:

> *What does a teaching sequence with a focus on developing students' understandings of doing physics inquiry and use of argumentation look like and what does it yield in terms of acquired knowledge and enhanced critical attitude?*

2 Method

The teaching sequence, consisting of five activities [5], was devised for and carried out by Pre-University students (aged 14-15) in the Netherlands. The first activity involved a contextualized practical work. Once students produced a report, they were questioned whether they would accept the risk of operationalizing the outcomes of their inquiry in real-life. The activity was meant to instigate students to consider the delivered quality and the trustworthiness of their conclusions. After students became aware that the quality of their work is already insufficient by their own standards, they learned in three subsequent activities what scientific criteria entail, what decisions students need to make, where to pay attention to, and why. The last activity involved again a contextualized practical work which was meant to consolidate previous learning.

The development of students' understanding of doing physics inquiry and their enhancement of a critical attitude was established by assigning scores to the quality of their inquiry using the Assessment Rubric for Physics Inquiry [4]. In essence, this rubric provides the means to determine students understandings of physics inquiry and their adherence to the implicit scientific standards by reviewing students' choices and their substation of these (if any).

3 Results

In the first activity – the contextualized inquiry, most students chose for a simple but scientifically unsatisfying methods for collecting their data. The confrontation with the potential severe outcomes of their inquiry made them realise that they could and should have performed better. In the three subsequent activities, students learned why repeating measurements was important, that different methods should be considered – choosing the one that yields the most reliable data, and that they validity of their conclusions is limited due to various constraints. In the final inquiry, students deliberately considered various methods and adequately applied their acquired understanding. They thus made significant progress in the first phases of the inquiry, where they set up their inquiry and collect the data.

Although students considered better ways of collecting data and were more keen on repeating measurements and controlling variables, they often did not substantiate their choices. They lacked the ability to analyse the data in a meaningful way. As a consequence, their conclusions remained often qualitative in nature, where the context of the inquiry required a quantitative relation between the investigated physical quantities.

4 Conclusion

Throughout the teaching sequence, students made progression in developing a deeper understanding of the targeted insights and made a first step in developing the inquiry knowledge that enables them to produce a scientifically acceptable answer to the research question. Where the teaching was not successful in developing students' understanding, i.e. students' ability to analyse data and draw informative conclusions, this study provides direction for extending the sequence. All materials are freely available in English, French and Dutch.

References

1. Hodson, D., *Learning science, learning about science, doing science: Different goals demand different learning methods.* International Journal of Science Education, 2014. **36**(15): p. 2534-2553.
2. Millar, R., *Student's understanding of the procedures of scientific enquiry*, in *Connecting Research in Physics Education with Teacher Education*, A. Tiberghien, E.L. Jossem, and J. Barojas, Editors. 1997, International Commission on Physics Education. p. 65-70.
3. Millar, R., et al., *Investigating in the school science laboratory: conceptual and procedural knowledge and their influence on performance.* Research Papers in Education, 1994. **9**(2): p. 207-248.
4. Pols, C.F.J., P.J.J.M. Dekkers, and M.J. de Vries, *Towards Integration of Argumentation and Inquiry: Defining and Assessing Understandings of Evidence with ARPI* 2021(manuscript submitted).
5. Pols, C.F.J., P.J.J.M. Dekkers, and M.J. de Vries, *Introducing argumentation in inquiry—a combination of five exemplary activities.* Physics education, 2019. **54**(5): p. 055014.