Developing an understanding of the nature of science in preschool primary teachers

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Summary

Introduction

Science plays a vital role in today's increasingly technological world, so much so that it is recognised as an important component of teaching meaningfully at all levels of school education. One key aspect in the learning of science is often referred to as the nature of science (NOS) (Abd-El-Khalick & Lederman, 2000), and in this respect, researchers have identified several key conceptualisations which have importance in science education (Kampourakis, 2016):

(a) scientific knowledge is empirical and tentative;
(b) logic, imagination and creativity play a significant role in the development of science learning;
(c) science perceptions are influenced by the prior knowledge and experiences of scientists, as well as by social and cultural context;
(d) distinguishing between observations and inference, as well as theories and laws of science, is essential in the teaching and learning of science;
(e) there is no universal scientific method.

Research has shown that, in the teaching of science subjects, an understanding of NOS is problematic for both students and teachers (Akerson & Hanuscin, 2007; Dogan & Abd-El-Khalick, 2008). For example, both students and teachers have been shown to hold a naive view that science utilises one universal scientific method (Akerson & Hanuscin, 2007; Dogan & Abd-El-Khalick, 2008), the development of scientific knowledge, as well as the interrelationship of hypotheses, theories and laws, are not understood (Dogan & Abd-El-Khalick, 2008). There has been little research on teachers' and students' conceptualisation of NOS in Estonia.

Studies have shown that three main approaches have been used to develop teacher and student understanding of NOS: a historical approach, an implicit

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approach and an explicit-reflective approach (Khishfe & Abd-El-Khalick, 2002). All three approaches have been shown to have their advantages and disadvantages, but the explicit-reflective approach has been shown to be the most effective (Akerson et al., 2011; Ward & Haigh, 2017). Nevertheless, learners may still have difficulties in terms of the tentativeness of knowledge, distinguishing the nature of theory and law, and appreciating subjectivity and socio-cultural influences (Cofre et al., 2019). This suggests that effective teaching may need to involve a combined use of different approaches.

It has been recognised that it is appropriate to start teaching about NOS as early as possible to facilitate the understanding of NOS (Akerson et al., 2011). However, no previous studies on primary school teachers' understanding of the Nature of Science have been undertaken. Yet, they are the ones who lay the foundation for students' understanding of the Nature of Science.

Aim of the study:

The present study aims to design a compulsory course based on the current understanding of the nature of science for all students studying to become primary school teachers, supporting the development of a meaningful understanding of the nature of science and enabling their readiness to promote aspects related to the nature of science in general education schools.

The research questions are:

1. What are the pre-course perceptions of students studying to become primary school teachers about the nature of science?
2. What attitudes towards teaching components of the nature of science topics within school science teaching do students studying to become primary school teachers hold?
3. What is the feedback from students studying to become primary school teachers towards the value of a subject course designed to develop an understanding of the nature of science?

Methodology

This study involved 27 Master's students in their 5th year of the University of Tartu primary school teacher education programme. At the beginning of the NOS course, all participants completed a questionnaire seeking their prior NOS understanding, and the course was adjusted according to the outcomes of the questionnaire. In total, 22 participants completed a final feedback questionnaire.

The study was conducted in the following stages.

(a) In the first stage of the study, the pre-course questionnaire was analysed to identify perceptions of the various aspects of NOS.
(b) In the second stage of the study, the course in the primary school teacher's curriculum was modified based on the outcomes of the questionnaire.
(c) In the third stage of the study, the adapted subject was implemented. The course lasted one whole semester (one seminar per week), and the learning activities carried out were of different durations (15 minutes to 1 hour).

The course covered the following NOS topics:

(I) the nature of observations,
(II) conceptualisation of the scientific method,
(III) the formation and nature of scientific knowledge,
(IV) the use of imagination, objectivity and subjectivity in science.

In addition, activities were included focusing on misconceptions.

(d) At the end of the course, the participants completed a feedback questionnaire prepared by the researchers. This questionnaire aimed to gather information on the usefulness of the course and activities in the learners' estimation of understanding different aspects of NOS.

Results and discussion

The students' responses to the initial questionnaire revealed that they had a limited understanding of many aspects of NOS or that their views did not correspond to those presented in contemporary research. For example, students thought that theories were not as certain as the laws, and theories had less supporting evidence. The study confirmed that there was a misconception among prospective primary school teachers about the existence of a universal scientific method, i.e. the knowledge that "all scientists follow certain steps in their work" (McComas, 1998). The persistence of a misunderstanding of the universal scientific method was alleviated by promoting the importance of inquiry learning and its stages in teaching related to the natural science curricula developed for general education schools (Ainevaldkond "Loodusained", 2011ab) and within teacher training programmes (Klassiõpetaja, 2022). The findings and activities of researchers in different fields were introduced, and reference to additional research studies was given to facilitate an understanding of the diverse methods promoted during the studies. It was also pointed out that a historical approach could be justified during which stories about scientists and scientific discoveries were read (Fouad et al., 2015) or meetings with scientists were organised.

Although the study revealed several gaps in the students' understanding of NOS, they were supportive of the teaching aspects of the nature of science in school. There was clear support for the view that the school should teach that scientific knowledge may be tentative, because then students understand better the development of science. This was seen as a positive result because if school students understood that science was continuously developing, they would hopefully trust the opinions of scientists more, seek ways to find solutions to their everyday problems and make scientifically based decisions with the welfare of both themselves and the whole of society in mind (e.g. in the field of nutrition, vaccination, health behaviours).

The study revealed that the students evaluated the adapted course positively. Participants rated learning about the nature of observations as the most useful activity, while learning activities related to theories, laws, and models turned out to be less useful and the most difficult for the participants to understand. This did not come as a surprise, as the complexity of this aspect of NOS was already revealed in the analysis of the answers to the questionnaire. The study also revealed that students had a general lack of understanding of what were theories, laws, models, etc. This implied that the topic should be initiated by developing such concepts.

The study confirmed that it was not essential to create a separate NOS subject course in the curriculum to facilitate students' NOS understanding but that it was sufficient to adapt the existing course by introducing NOS aspects. Previous studies also showed that with only three hours of effective NOS learning, it was possible to significantly improve students' understanding (Valencia Narbona et al., 2022). Therefore, it was most important to identify the most suitable learning activities. In this respect, this research provided important insights. Based on the experiences gained, additional activities could be added to the course (e.g. stories illustrating the development of science, further practical tasks), and less effective activities could be removed or modified/supplemented (e.g. reading scientific articles). It would be desirable to introduce an even more reflective aspect to follow-up courses, which was emphasised in previous research (Adibelli-Sahin & Deniz, 2017). For example, in addition to oral discussions used for all activities during this course, written reflections (e.g. short essays) could also be added.

Keywords: nature of science, teachers' training, primary school teachers' understanding