Contemporary science as context for teaching nature of science: teachers’ development of popular science articles as a teaching resource

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Abstract
Most of the physics (as well as the other sciences) taught in school can be described as well-established or consensus science. This is the kind of science knowledge that was mostly developed over a century ago. The inclusion of contemporary science research in compulsory school science teaching could be justified from a variety of reasons: increasing students’ interest and motivation; providing insights into modern research practice; and as a frame for teaching nature of science (NOS) perspectives. The present article focuses on the latter—contemporary science as a means to teach NOS. The article builds on data from an in-service teacher training course that focused on ways to include contemporary science in lower secondary physics education. Each course participant chose a research area, interviewed a scientist, and wrote a popular science article based on the interview. The article was written with secondary students (13–15 years old) as a target audience. By the end of the course the participants designed, implemented and evaluated a teaching unit which was based on the popular science article. The present article analyses what NOS perspectives that have been included in the popular science articles. The results show a high diversity of NOS aspects, which indicate a great potential for taking contemporary science research as a starting point for NOS teaching.
Introduction

There is much evidence from science education research that the teaching of physics, as well as of the other science subjects, is focused on foundational, consensus science. Often, the concepts and models that are presented evolved more than a hundred years ago. However, it has been argued that also contemporary science (or science-in-the-making) needs to be included in science teaching in order to provide meaning and broaden the views of science (e.g. Tytler (2007) and Wong and Hodson (2009)). Research studies have shown that many students view school science as uninteresting, but that the same does not necessarily hold for contemporary science (Jidesjö et al 2009). To include contemporary research in science teaching provides opportunities for students to come to grips with characteristics of research of today. We further argue, that contemporary research is a valuable part in the teaching of nature of science (NOS) perspectives. Science education research has defined NOS as an area that deals with issues that connect to what science is and how scientific knowledge is developed. The importance of including NOS in science teaching has been highlighted from a number of perspectives (see e.g. Lederman (2007)), such as a citizen perspectives (Hodson 2008). Teaching NOS in the context of contemporary science research is directly relevant in relation to a citizen perspective (Hodson 2013, Allchin et al 2014, Tala and Vesterinen 2015) since many socio-scientific issues include aspects related to frontier science. This article explores in-service teachers’ choices of NOS aspects to include in lower secondary science teaching (students aged 13–15 years) in the context of contemporary/frontier science.

NOS and images of science

NOS has been conceptualized in different ways in the science education literature (see e.g. Lederman (2007), Erduran and Daghet (2014) and McComas (2017)). In this article we use a broad definition of NOS that includes characteristics of ‘Scientific knowledge and its Limits’, ‘Tools and Products of Science’, as well as ‘Human elements of science’ (McComas 2017). A point of departure for this article is that NOS should be studied ‘as discussion themes rather than as ‘truths’ to be memorized’ (Tala and Vesterinen, p. 451; see also Leden et al 2015). NOS can be taught in different contexts such as historical cases, students’ own inquiry, or as in the present article, contemporary science. Other publications have provided examples of how NOS teaching could be coupled to specific science content (Hansson and Leden 2016, Hansson et al 2019) and how different approaches can be integrated (Allchin et al 2014). One reason for choosing a contemporary context is its contribution to insights into the messiness of science processes where consensus on certain results may not yet have been reached. In historical contexts we are always provided with hindsight information.

Numerous studies show that myths and different kinds of stereotypical images of science are frequently reproduced in various situations in science teaching and classroom communication and are further reinforced by textbooks as well as media (Frayling 2005, Allchin 2013). These myths include notions of one specific scientific method (McComas 1998, Sismondo 2010), that creativity is not part of the research process and that scientific research is totally objective and independent of both the individual researchers and of society and culture. Myth reproduction in school science often occur, without the teachers’ intent, as part of a science teaching tradition (Hansson 2018). Such a tradition includes a strong focus on science as facts also according to teachers themselves (Leden et al 2015, Leden and Hansson 2017).

To use contemporary science as a context for discussions of NOS opens up for possibilities to add human elements of science, such as creative and socio-cultural aspects, and to challenge images of ‘the scientific method’. Wong et al (2008) show examples of how a broad spectrum of NOS aspects, both aspects that are commonly suggested in science education research (e.g. the theory-laden nature of observations and interpretations, and the impact of social and cultural values on science) and ones that are rarer (e.g. competition in scientific research and the peer-review process), can be treated through teaching material concerned with contemporary research cases that also include interviews with scientists.

Related to stereotypical images of science are stereotypical images of scientists. Such images of scientists are present in children’s drawings (e.g. Barman (1999), Finson (2002),
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Rodari (2007) and Sjøberg (2010)). Frequent characteristics in children’s drawings are labcoats, glasses, and test tubes. Furthermore the scientist is often a male with messy hair who is involved in dangerous activities such as explosions. These images are often reinforced in media (see above) and are also sometimes communicated by the scientific community itself (Andrée and Hansson 2014). Thus, the scientist is often positioned as someone who is different from most people. Sometimes the picture in media is one of the mad scientist, or of an individual who harms society, and sometimes the scientist is presented as a super hero. Stereotypical images could be challenged through providing possibilities for students’ to meet with real scientists and show that scientists are men and women with different cultural backgrounds, individual personalities, and with varying interests and driving forces. Thus, to include contemporary science and its contemporary scientists in science teaching, becomes a means to challenge frequently held images.

However, previous Nordic studies (see Svennebeck (2003), Hedrén and Jidesjö (2010) and Vesterinen et al (2013)) show that science textbooks highlight historical episodes and scientists rather than contemporary science and scientists or research conditions of today. Thus, if students are to encounter contemporary science and scientists it must often has to be arranged for in other ways, for instance through real life meetings with scientists as suggested by Woods-Townsend et al (2016). Other ways could be through written material (e.g. webpages, popular articles) or films. An example of the latter is the short e-lectures on contemporary physics aimed at high-school students, described in Kapon et al (2009). Meeting scientists in real life, through media or textbooks during science class, could mean that richer images of contemporary science practices and contemporary scientists are opened up to students. As a consequence the possibilities for different student groups (e.g. girls) to participate and identify with scientists and science could be improved (see e.g. Henriksen et al (2015)). Contemporary scientists could more easily than historical scientists serve as role models for students.

Teachers’ role in providing broader images of science

‘teachers’ professional identities are forged through their experiences of school and university science, with very few having practiced science in a research or professional sense. If we are serious about having school and university science reflect the nature of science as it is practiced in contemporary society, then we need to interrogate directly the nature of contemporary science and how it might differ from schooling versions’ (Tytler 2007, p. 23).

As Tytler (2007) argues in the above quotation, teachers often have little experience of their own regarding contemporary science. There are, however, different possibilities to achieve experiences of contemporary science and scientists. Profound meetings between teachers and scientists were arranged with positive result in a study by Anderson and Moed (2017). In their study teachers followed a scientist for half a year. Another, less resource-demanding approach, is described in Tala and Vesterinen (2015) where teacher students interviewed practicing scientists as a way to start examining contemporary science practices. The authors argue that ‘the abstract NOS ideas could be better understood by listening to such exemplary voices in the mixed choir of scientists’ (p. 440). It is also important that teachers’ own acquired NOS insights are followed by reflections on how these insights can be translated into compulsory school practice (Leden et al 2015). Tala and Vesterinen (2015) further suggest that ‘the contextualized interview method can be used to create authentic examples about science also for science classes’. These examples do not have to be constructed by people outside school. Instead Tala and Vesterinen (2015) suggest that teachers and students can be involved in the production of these examples (this was, however, not done in their study).

The present article builds directly on the above suggestion by Tala and Vesterinen (2015). Thus, this article describes a case study where science teachers, during an in-service training course, developed and implemented teaching sequences focusing on contemporary physics. The teaching sequence was built around a popular
science article that was written by the teachers after they had interviewed a scientist.

We know from previous research that teachers’ own knowledge about NOS is not necessarily reflected in their teaching (Lederman 2007). This discrepancy depend on different factors such as teaching traditions and views regarding what is viewed suitable for the students (Popkewitz 2004, Leden et al 2015). Due to this possible discrepancy between knowledge and teaching this article focuses directly on the NOS aspects that in-service science teachers choose to include in the popular science articles about contemporary science and scientists, aimed at their students (ages 13–15 years).

Design of the study

Context of the study

The Swedish curriculum states that ‘Current research areas in physics, such as elementary particle physics and nanotechnology’ (Swedish National Agency for Education 2011) should be included in the physics core content knowledge for school year 7–9. Similar formulations exist in the biology and chemistry curriculum. However, this is something that is often overlooked in the science teaching. Since there are no strong traditions of teaching contemporary science, there is a need to develop resources to support teachers (Tytler 2007). There is also a need to develop strategies and teaching materials to teach NOS in the context of contemporary science. The teachers in this study took part in developing such a teaching material, and tested it in their own science classes.

Participants

The teachers (N = 9) were, as mentioned above, taking an in-service teaching course in physics and physics education, spanning three semesters. The reported project was the final part of the course. For ethical purposes, the teachers were only asked whether we could use their texts for research purposes after they had been graded and had finished the course.

Various aspects of NOS teaching had been taught and evaluated earlier during the course and the teachers had tried different NOS activities with their students. Thus, although the NOS training the teachers took part in was limited, these teachers had more experience of explicit NOS and NOS-teaching discussions than most teachers in Sweden.

Data material

Each teacher identified an area of current physics research and interviewed a scientist in that area. After the interview the course participants wrote a popular science article aimed at secondary students (13–15 years old). There are several advantages when teachers write their own texts, for instance, their robust knowledge of their student group and their needs, and the teachers’ own opportunity to gain deeper knowledge about a subject before teaching it. The instructions for the article were to: write a text (approximately 1500 words) on the chosen research area. The text should be aimed at lower secondary students as a way to raise their interest as well as to increase their knowledge about contemporary research processes. The teachers were also instructed that ‘The text should aim to describe both the general research field and the details of the particular research of the interviewee. Apart from describing the physics, the article should also describe driving forces, funding, research questions, and how the research is conducted (e.g. individually/group, university/company/inside/outside, equipment…etc)’.

Furthermore, the teachers designed, implemented and evaluated a teaching unit built around the article, and finally wrote a short report where they described their experiences from implementing the teaching sequence in their classroom. The present article analyses the popular science articles that were written by the teachers. The teachers used their own article in their lower secondary science class in ways that they found suitable. In some classes this meant that they read parts of the text jointly and in others individually at home or in school. The teachers prepared for expected challenges in relation to students’ varying reading skills.

The present article builds on data from nine popular science articles written by the same number of teachers. The articles were examined for different NOS aspects. The teachers mainly based their articles on the interviews with scientists. The
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Interview questions were prepared by the teachers and revised after feedback from other course participants and the course leaders (the authors of this article). Even if the interview guides were individual, most of them contained questions about the research field, the specific research project(s) that the scientist was engaged in, the working day schedule, the scientist’s personal interests, and structural issues such as research funding. Thus the focus of the articles were the individual scientists’ perspective, of course filtered through the teachers’ own understanding of NOS, as well as what they considered suitable for their students.

Previous research shows that scientists’ views of NOS depend less on the research discipline than on the specific individual context (Schwartz and Lederman 2008, Wong and Hodson 2010). However, Tala and Vesterinen (2015) argue that ‘Every field of science highlights and explains some NOS ideas more than others’ (p. 444). Therefore, both individual and discipline-specific perspectives and contexts are relevant as starting points for discussions on a broad range of NOS aspects. In the present study the research areas represent different physics-related disciplines including astrobiology, astrophysics, medical radiation physics, nanophysics, nuclear physics, particle physics, photonics, and solid state physics.

Analysis

The analysis was based on a framework described in McComas (2017). This framework organizes NOS aspects according to whether they concern ‘Scientific knowledge and its Limits’, ‘Tools and Products of Science’, or ‘Human elements of science’ (McComas 2017). For the purpose of this article we use a slightly different title of the second category: ‘Tools and Processes of Science’. In our analysis different aspects of research processes are categorized here. However, differentiation between e.g. theories and laws (mentioned by McComas (2017)) as part of ‘Tools and Products of Science’ is in the revised categories used as part of ‘Scientific knowledge and its Limits’, since we view understanding of models, theories and laws and their relation to reality as part of what characterizes ‘Scientific knowledge’.

Our use of these three categories are founded in a broad definition of NOS, inspired by somewhat diverging sources such as Lederman (2007), Allchin (2011), Erduran and Dagher (2014) and McComas (2017). The three categories are large and partly overlapping. As an example, research presentations in conferences are part of the research process, but can also be seen as a human aspect of science since research is discussed among scientists in the field. We searched the popular science articles, written by the course participants for NOS references, which then were categorized in one of these overall categories.

In a second step, the NOS aspects in each of the three categories were organized into subcategories based on an empirically grounded analysis. Thus, the results of this article describe the variety of NOS aspects that were included in the popular science articles.

Results

The popular science articles written by the course participants all included a presentation of the overall research area, the specific scientist, and more specifically the scientist’s own research. A number of different NOS perspectives are raised that can be related to the three overall categories described above. Below, NOS aspects from the articles are described and exemplified.

Scientific knowledge and its limits

Primarily, four sub categories emerge related to the category scientific knowledge and its limits. These are:

- Knowledge changes
- Uncertainty/things not known
- Basic research and applied science
- Demarcation of science from ‘bad’ science and pseudoscience

The articles exemplify, in different ways and from different contexts, that scientific knowledge can change. This is clear from descriptions of the historical development of a research area—things we know today which were previously not known. The changes in the scientific knowledge is often communicated as a progression—today we have more and/or better knowledge than we had before. The tentative character of scientific knowledge is also evident from descriptions of science in the making—research that is going on
at this moment. Some articles illustrate the recent development of entire new areas of research. As an example, one of the articles describe how scientists come together at conferences and discuss directions for continued work:

In conferences, you present your research to others and discuss what is known and how to proceed. There you can get inspiration for new research questions.

From this, and other examples, the students who read the articles get the opportunity to learn that frontier science is about asking new questions, and develop new knowledge. Students also get the opportunity to meet different reasons as to why scientific knowledge develops and sometimes changes. For example an article about medical radiation physics describes how the development of new and better methods and equipment (in this case MRI (magnetic resonance imaging camera) is part of the knowledge development:

You use the MRI in order to scan the function of, for instance, the brain /.../ This means that you might have to take a fresh look at brain function

Related to examples of changes in knowledge/development are examples concerned with things not known today, or things that are uncertain. For example, an article about particle physics says that ‘It is believed that equal amounts of matter and anti-matter were developed in the beginning’, and an article about nanotechnology states that we still lack knowledge concerning possible risks with nanoparticles. Another article discusses that sometimes many different models for describing the same thing can exist at the same time (e.g. concerning the forces inside the nucleus).

The collection of articles also shows that the relative emphasis on basic and applied research differs between research areas. An article about medical radiation physics describes research in the following way:

A large part of her work meant building and calibrating the equipment that was needed to carry out the experiment.

In contrast, another article, about particle physics, describes the time between new knowledge and possible future use as much longer:

There are decades passing before you find a new area of use and there are no guarantees you will find them.

The fourth subcategory related to the overall NOS category scientific knowledge and its limits is concerned with the delimitation of science from ‘bad’ science and pseudoscience. These issues are discussed in the context of nuclear physics and cold fusion, and through an individual scientist’s engagement in opposing pseudoscientific claims.

Tools and processes of science

The popular science articles that the teachers wrote contain a great deal of references to different tools and different kinds of scientific processes. Below, four subcategories are described:

- Empirical aspects of science
- Theoretical aspects of science
- Research tools and equipment
- Presenting and publishing research.

Empirical aspects of science are described in all of the articles. It is evident from the articles that experiments and observations are an important part of the research process. This is shown by descriptions of empirical work and the use of different research facilities. The collection of articles show that scientists are involved in planning the experiments they later perform, and that the development of methods (including developing, building and calibrating equipment) sometimes is viewed as an important part of the research process:

A large part of her work meant building and calibrating the equipment that was needed to carry out the experiment.

One of his ongoing research projects is to develop methods for combining optical telescopes over distances up to some kilometers in order to get extremely high resolution.

However, also theoretical aspects of science are described in some of the articles. In one of the articles the scientist ‘pondered over’ if interpretations ‘are in line with theoretical calculations’ The article describes that the aim of the research is to distinguish between the many possible models that describe the forces inside the nucleus of
an atom. Another article describes the relation between theoretical and empirical work:

both experiments and calculations drive the understanding of what is observed and lead to new ideas

Other related aspects in the articles are scientists who are involved in analyzing the empirical data, and scientists that make use of calculations and computer modelling as part of the research process. Furthermore, scientists’ discussions about their research with other scientists as part of the work is highlighted in some of the articles.

In connection with the descriptions of the research processes, the articles also mention different research tools such as: computer, accelerator, detector, spectroscope, gamma camera, magnetic camera, telescope, tokamak, scanning tunneling microscope, electron microscope. In some cases the equipment is described as available in local laboratories, but a number of the interviewed scientists also talk about visits to large research facilities (such a CERN) or using equipment in other countries:

There are thousands of scientists from all over the world and experiments are constantly ongoing. You are there and offer help on the spot, but most of the work is done when you are back in Sweden. Then results from experiments are analysed—experiments which you yourself or others have agreed that you should perform.

Even if the individual articles only provide examples from one specific research area, the collection of articles highlight a high level of diversity related to the research tools used in the different contemporary physics areas. Moreover local laboratories as well as large, international research facilities and collaboration and cooperation are present in the articles. Most articles include descriptions of publishing and presenting research in journals and conferences as part of the work as a scientist.

**Human aspects of science**

Four subcategories emerge related to the category *human aspects of science*. These are:

- Interest and driving forces
- Collaboration and competition
- Research funding
- Characteristics of a scientist

The articles show that *interests and driving forces* can differ between individual scientists as well as research fields. Sometimes the driving forces are related to whether the research is applied or basic. An article about particle physics gives voice to a scientist who describes driving forces as a ‘want to know where we are from and where we are going’. Another article says ‘This is what most scientists in this area dream of—finding a cure for cancer’. Thus, the collection of articles contain descriptions of scientists emphasizing usefulness and curiosity as important factors. One article highlights the interest in problem solving as central:

I do not think most people become scientists because they are interested in a particular question, but because they are interested in problem-solving, and science in general.

Human aspects of science are also present in the articles through descriptions of a quest for personal glory and status:

If you have really interesting results you can hope for publishing in Science or Nature—these are journals that everyone in the research world knows of and dream of publishing in.

Another very pragmatic way to view driving forces is presented in one article—emphasizing practical and economic circumstances, rather than the scientist’s own interest.

Concerning the research question, there are a great deal of driving forces: competence, experimental resources, possibilities to get funded. Most research needs external funding, which you apply for. You cannot only consider your own interest but also those of others.

In the above example it becomes obvious that scientists often have to apply for funding—and thus are not entirely free to follow their own interests. The collection of articles provide opportunities for students to understand that different actors are involved in funding research, such as governmental research councils, EU, private foundations, non-profit organizations, and private companies.

Other human aspects that are mentioned in the articles are *collaboration and competition*. One example is an article where the interviewed scientist highlights collaboration as a great aspect of research:
What I like is that you collaborate so much because all the time you find so much that you need help to explain.

Another article instead describes competition as part of research:

it is very competitive. For sure, no idea is entirely unique in research. If I have an idea there will surely be others in this field of research who have the same idea.

Competition can, however also be described as something that the scientist enjoys:

[The scientist] likes to compete. She enjoys when she is able to publish her article before any of her competitors, but it is so depressing to be defeated.

In the latter example the competition is coupled to publications.

The above examples also include other characteristics of the scientist that are used to describe them and their work. These include things like getting ideas, having fun, getting depressed, and dreaming of success. In the collection of articles written by the teachers, scientists are to various extents portrayed as creative, passionate, and fascinated about their work. Some articles also flirt with images of scientists as geeks (mostly in an appreciative way). In one of the articles a teacher describes a scientist who looks back at the time before she started her own research. Here, the scientist shows an appreciation for the ‘‘crazy physicists’’ at the university who ‘looked so passionate’ and ‘did not care how they were dressed’. Another article gives voice to a scientist saying that:

All since high school I have had the feeling that, deep down, I might be one of those crazy scientists…

The articles provide diverging pictures of scientists who can be very preoccupied with their work while others have hobbies that engage them in their leisure time.

Discussion and conclusion

Tala and Vesterinen (2015) has shown that interviews with scientists could be a way for teachers to work with NOS. Their study focused on teacher students, but they suggest that written material based on interviews with scientists could be used as a resource in secondary school. They further suggest that written material about contemporary science and scientists do not have to be constructed by people outside school. In line with these suggestions, the present article explores the NOS aspects that were included by teachers in popular science articles about contemporary science. Their articles are based on interviews with scientists, and has lower secondary students as target audience. The popular science articles become a way to communicate NOS to the students—and thus the content analysis provide information about the kind of NOS that might become available to the students.

The analysis of the NOS that has been included in the articles, shows a broad spectrum of NOS aspects. This is in line with the study by Wong et al (2008) that shows that many NOS aspects, both ones that are commonly suggested for school science and others more rarely suggested, could be covered through contemporary research cases based on interviews with scientists. In line with Wong et al (2008) the present study shows many examples of NOS aspects that have been frequently suggested for compulsory school such as the empirical and tentative NOS. However, the collection of articles also include NOS aspects that are less frequently suggested, such as research funding, competition and collaboration (see however Wong and Hodson (2010), Allchin (2011) and Erduran and Dagher (2014)).

In the present article, the teachers’ articles represent different physics related disciplines. It is evident that some NOS aspects, such as empirical aspects of science, the tentative NOS (mostly that science is progressing) are highlighted in all or most of the popular science articles. Note, however, that the specificities of the empirical knowledge processes (such as certain equipment) vary for the different articles which means that it is beneficial if a teacher can use more than one case in their science teaching. The same is valid for aspects such as publishing and research funding. On the other hand there are other aspects, such as basic and applied science, that are highlighted to different extents in different articles, possibly depending on different disciplines. In addition, the scientists describe their driving forces in very different ways. Here, plausibly, both individual and discipline dependent explanations are
relevant. There are for instance examples in the teachers’ articles where driving forces and interests are highly coupled to applied versus basic research, while other examples show interests of a more personal character. Consequently, we want to once again emphasize that it might be highly valuable for students to encounter different contemporary research disciplines, as well as different individual scientists as a means to get broad and varied images of NOS. It must also be emphasized that even though there is a high value for students to, in this way, get the possibility to learn about scientists’ own perspectives of NOS, a combination of perspectives from inside as well as from outside science (e.g. history, sociology, and philosophy of science) are valuable to develop a NOS understanding that is useful for students as citizens.

Many of the NOS aspects included in the popular science articles challenge stereotypical images of science and scientists. The different research environments and equipment problematize and complement the frequent image of a standardized ‘scientific method’. In the same way, encounters with on-going research, balances the frequent image of ‘science-as-non-changing-facts’. That the research process as well as the humans involved are visible makes other images of science available to students. Even though some of the aspects that are discussed are both unsurprising and uncontroversial, such as the empirical focus and the presentation of various tools, it still becomes a more nuanced picture than the average focus on facts. Another aspect that becomes more or less explicit in the teachers’ articles is the notion of a progressive science, a notion that rather cements the traditional narrative of science textbooks, but one that has been up for discussion at least since Thomas Kuhn entered the philosophical discussion in the 1960s. There are gains to be made if students could be provided broader perspectives also on these aspects.

To include now living scientists has also been suggested as a way to provide students with role models within science. The present analysis shows that, through the collection of articles, the students get to meet different scientists, with different interests and personalities. However, as the results show, the articles also refer to instances in the interviews where scientists relate to the ‘scientists-as-geeks’ image—and even identify themselves as ‘geeks’ or ‘crazy physicists’. As a consequence there might be a need discuss the geek-image of scientists in science class and discuss what this image could mean for the described scientist. There is a possible challenge in relation to student-scientist meetings if scientists picture themselves as ‘geeks’—and different from most people—since such images easily become hindrances for some (most?) students to identify with science and scientists. Previous research shows examples of how values of the scientific community are reproduced in meetings between scientists and students (Andrée and Hansson 2014). However, depending on how the geek-image is interpreted by the students some students could also possibly appreciate the passionate individuals that are associated with them. There is a need for further studies on how students relate to various images of scientists’ personalities, and how it can be handled and discussed in science class. Such studies have to focus directly on the classrooms and how teachers and compulsory students work with contemporary science and scientists.

In this article we describe how popular science articles were developed by secondary teachers with the starting point in an interview. This is a possibility for in-service teacher training, but might not be feasible for the busy secondary teacher within the frame of ordinary practice. Another possible way is to let students meet contemporary science and scientists through interviews with scientists (perhaps in small groups). Inspirations for interview questions could be found in this article and in different NOS frameworks. The students could use the interviews to write short popular science articles that are shared with their classmates. Recommendations for teachers who want to try such a design would be to choose scientists from different research disciplines since, as have been illustrated in this study, scientists’ descriptions of NOS are both individual and discipline dependent. A further recommendation is that the teacher initiates explicit discussions on similarities and differences in respect of how NOS is described in the various articles. Such a design should be explored in future research studies.
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