European Early Childhood Education Research Journal

ISSN: (Print) (Online) Journal homepage: https://www.tandfonline.com/loi/recr20

Nature of science in early years science teaching

Lena Hansson, Lotta Leden & Susanne Thulin

To cite this article: Lena Hansson, Lotta Leden & Susanne Thulin (2021): Nature of science in early years science teaching, European Early Childhood Education Research Journal, DOI: 10.1080/1350293X.2021.1968463

To link to this article: https://doi.org/10.1080/1350293X.2021.1968463

Published online: 25 Aug 2021.

EUROPEAN EARLY CHILDHOOD EDUCATION RESEARCH JOURNAL
https://doi.org/10.1080/1350293X.2021.1968463

Nature of science in early years science teaching

Lena Hansson, Lotta Leden and Susanne Thulin

Faculty of Education, Kristianstad University, Kristianstad, Sweden

ABSTRACT
The research field of science education has gathered questions about what science is, how scientific knowledge is developed and in what ways humans are involved in these processes under the umbrella concept 'nature of science' (NOS). Previous research has suggested that teaching ought to focus much more on these issues, but so far the focus has been on older children and students, while there is a lack of research on NOS teaching for the youngest children (up to six years). In this conceptual article, we suggest that NOS should be taught from the outset, and thus be part of science teaching in the early years. We put forward arguments as to *why* this early introduction coupled to the overall values and aims of democracy and social justice is important, and elaborate on the kind of NOS issues that could be included in science teaching aimed at the youngest children.

KEYWORDS
Nature of science; NOS; early years science; social justice; democracy

Introduction

This article positions itself within a line of research that presumes the values and aims of democracy and social justice to be central to ECE (Early Childhood Education) (see e.g. Margrain and Löfdahl Hultman 2019; Mitchell 2018). Such research stresses participation, agency, inclusion, and equity. Mitchell (2018) argues that 'democracy as a primary value for education raises possibilities for critical thinking about educational policy and practices and possibilities for change' (Mitchell 2018, 2). Hence, when the goal is that science in ECE promotes democracy and social justice, it urges us to investigate, and when necessary challenge and suggest alternatives to the practices and traditions of ECE science.

Science education scholars (see Yacoubian and Hansson 2020) have suggested that to serve educational aims and values related to democracy and social justice, science teaching should challenge stereotypical images of science and scientists. This includes providing more diverse images of scientists as well as broader images of the characteristics of science, how scientific knowledge develops, and its role in society. This kind of knowledge has often been labelled 'nature of science' (NOS) (see e.g. Erduran and Dagher 2014; Lederman 2007; McComas 2020).

Despite a large body of NOS research, the strong connection between NOS and democracy, and arguments for the early introduction of NOS by Bell and Clair (2015)

CONTACT Lena Hansson lena.hansson@hkr.se

and Akerson et al. (2011), there remains a lack of research focussing on NOS teaching in the early years. This article aims to promote the importance of such research by elaborating on motivations for introducing NOS in the early years of ECE (children aged two to six years) and suggests NOS issues appropriate for this age group.

The overarching aims and values of democracy and social justice are our points of departure. The article is argumentative and builds on previous NOS research, previous research on ECE traditions and practices, as well as on our own explorative, empirical research on NOS teaching in ECE (Hansson, Leden, and Thulin 2020; Hansson et al. submitted; Leden et al. manuscript; Thulin et al. manuscript).

To understand what an introduction to NOS in ECE might look like, as well as what it might challenge, we begin with a brief look at some common, current traditions and practices of science in ECE.

Traditions and practices in ECE science

Science in ECE has often been described as either focussing on specific phenomena and concepts (the 'facts tradition') and/or on detached, fun and sometimes spectacular experiments (the 'doing tradition'). The facts tradition in ECE borrows from a science teaching tradition that is common in compulsory schools around the world and which is labelled 'traditional school science' (Zacharia and Barton 2004). Such science teaching is teacher centred, regards science as a body of facts, and omits NOS issues such as how the knowledge has been developed and who has been involved in the development. With some adjustments, this tradition, associated with science teaching for older children and students, has also been implemented in ECE. Even though there are many different arguments for science in ECE (see e.g. Eshach and Fried 2005), the facts tradition with its main focus on teaching science as a body of facts primarily serves aims related to preparing children for increased conceptual understanding in the later school years.

The doing tradition in ECE builds on the rhetoric that 'children are constantly learning from everything' (Pramling Samuelsson and Pramling 2008, 158, our translation) and an assumption that doing automatically leads to learning. In ECE science, the doing tradition often takes the shape of fun, detached experiments (Areljung 2017) that are frequently used only as 'wow moments' (Eley and Martin 2019) or 'poof and bang experiences' (Larsson 2016, 69, [our translation]) with learning objects seldom specified. Such spectacular experiments that aim to create interest and fascination have a background and a long history in scientists' encounters with the public, including children (see e.g. Andrée and Hansson 2014). In this way, the doing tradition is often associated with activities that aim to contribute to the development of positive attitudes towards science among children.

Against this background, the next section is devoted to our argument for why NOS is an important element in early science teaching aimed at promoting democratic and social justice values.

Why teach NOS in the early years?

There are many arguments for NOS teaching (e.g. Driver et al. 1996; Hodson 2014; McComas 2020) ranging from NOS being beneficial for the learning of scientific concepts and models to NOS being an important part of science teaching that contributes to democracy, citizenship and social justice. These arguments are, however, general and have previously not received a detailed elaboration in relation to the youngest of children.

In line with Akerson et al. (2011), we argue for introducing NOS simultaneously with the introduction of science in ECE. In the Swedish context, this means for children at preschool level (children aged one to six[1] years). As indicated above, our main argument is that NOS can contribute to an ECE science that prioritises the aims and values of democracy and social justice. More specifically, we claim that NOS teaching enables children's agency in science-related issues and that NOS teaching can interrupt the reproduction of stereotypical images that may prevent children from perceiving science as relevant and participation in science as possible.

Both arguments are elaborated in the following sections.

NOS teaching enabling agency in science-related issues

We argue that NOS teaching can contribute to democracy and social justice through increasing children's agency in science-related issues, both now and in the long run. Here and now, NOS can inspire children's curiosity, their desire to know and to explore. Thus, teachers and children can make use of their NOS knowledge when they engage in investigations and critical examination of ideas in everyday life at the preschool. One example from our own research that indicates what this can mean and how NOS teaching can contribute to agency, inquiry and critical thinking, was when a group of five-year-old children shared their view that the eyes of boys and girls look different. In this situation, the teachers made use of NOS aspects that had previously been discussed with the children (e.g. that empirical investigations are central in science) and involved them in an investigation that critically examined this view.

Long-term aims related to agency and critical thinking regard NOS as an element of education for citizenship. In many complex societal and everyday issues knowledge about specific science phenomena, concepts and models is not enough. In such cases, you also need knowledge about issues such as how science knowledge is constructed, the intertwinement of science and society, the limits of science, and why some knowledge can be uncertain (Yacoubian and Hansson 2020; Kolstø 2000). In a time when 'knowledge resistance', 'fake news', and 'alternative facts' are common expressions in the societal debate, it is important that very young children are provided with rich opportunities to discuss and learn about NOS and that they feel confident about participating in science-related debates.

NOS teaching enabling children to identify with science and find science meaningful

Here and now, NOS teaching can contribute with more diverse images of science and scientists and challenge stereotypical images that are frequently communicated in the media and through science teaching. Such images often show scientists as Western males who appear to be either superheroes or weirdos who work alone in a laboratory (see e.g. Adúriz-Bravo and Pujalte (2020); Allchin 2013). Stereotypical images have found their way into ECE science through the teaching traditions described above, as well as through children's trade books (see e.g. Dagher and Ford 2005; Kelly 2018; Zarnowski and Turkel 2012). Stereotypes can be reinforced either through omission of the humans involved in science, as in the facts tradition, or through only showing one-sided caricatures of scientists. These stereotypes leave minimal room for women and non-western nationalities, collaborations/networks, or a variety of science fields and activities beyond the laboratory. Furthermore, the detached, often spectacular experiments of the doing tradition risk conveying images of science and scientists that are unequivocally associated with specific values, aesthetics and interests. These connotations need to be problematised (see Andrée and Hansson 2014). The inclusion of NOS can provide more diverse images of science and scientists and thus increase the opportunities for more children to identify with science and perceive science as meaningful and relevant for them. This includes children of different genders, as well as children with different ethnic, social and cultural backgrounds who for different reasons have often been marginalised in science teaching (see Archer 2012). Furthermore, more diverse images provide room for children who are not attracted by spectacular experiments or the idea of working alone but instead prefer discussing and collaborating with others. It can also include different driving forces where fascination for the spectacular is only one possible starting point for an interest in science. If stereotypical images of science and scientists are not problematised from the very beginning there is a risk that these images become cemented ways of thinking about science and scientists (see e.g. Sharkawy 2012) – ways of thinking that exclude a great deal of individuals. Thus, NOS teaching could lead to more inclusive teaching that expands children's possibilities right here and now. However, introducing NOS in ECE can also be an important foundation for long-term aims and goals of social justice and can contribute to breaking patterns of marginalisation where certain groups are engaged in science-related citizens' issues to a lesser extent than others. It may also contribute to changing preconceptions of who can and who will become scientists.

Suggesting NOS themes appropriate for ECE

As formerly mentioned, NOS research focussed on children younger than six years is very scarce and NOS teaching frameworks (see e.g. Erduran and Dagher 2014; Lederman 2007; McComas 2017, 2020) have not been specifically developed for the teaching of very young children. Here, we have chosen to use McComas's framework (2017, 2020) since it includes three broad NOS categories/themes that we believe can be useful for structuring NOS issues appropriate for ECE. The three themes that we use as starting points for our suggestions are: characteristics and limits of scientific knowledge, human elements of science, and scientific processes and tools (see Hansson, Leden, and Thulin 2020). They have been slightly modified[2] from McComas' original themes. The suggestions build on previous NOS literature and our own empirical explorative research done in close collaboration with preschool teachers in Sweden (see Hansson, Leden, and Thulin 2000). Transcripts from conversations between teachers and children at a Swedish preschool are used as illustrations of sub-themes for the three different NOS themes.

What can NOS mean in the ECE context?

We elaborate on our suggestions in relation to each of the three themes above and intend this to be regarded as a proposal for the first building blocks of a NOS progression.

Scientific processes and tools

The unpacking of 'scientific processes' (the seeking of evidence through a variety of scientific methods and activities) is in one way or another integral to most conceptualisations and suggestions for the teaching of appropriate NOS (see e.g. Erduran and Dagher 2014; McComas 2020). Suggesting a very first building block for this theme, we argue that the main issue for the teaching of NOS in ECE is to highlight that there *are* scientific processes. By focussing on the question: 'How do we know this?', children are offered opportunities to learn that the 'facts' of science, described, for example, in children's books, are not something that just exists, but are something that people have been engaged in finding out, in various ways. For example, if teachers and children work with dinosaurs, the teacher can ask questions about how it is possible to know where dinosaurs lived. In other words, the major issue is to pinpoint the scientific processes that often have remained hidden in a teaching focussed on scientific facts (cf. the 'facts tradition'). In line with the argument in Erduran and Dagher (2014) and Kelly (2018) that a broad, diverse, and complex picture should be provided, the above question is preferably revisited and explored in relation to different scientific areas. That way NOS can become contextualised from the very beginning and become a natural part of science.

In addition, we suggest that the focus on scientific processes in ECE can involve directing attention to the diversity of tools and methods that are used in science. This diversity between various scientific disciplines has been emphasised as an important issue in the NOS framework of Erduran and Dagher (2014) and can become visible for children already in the early years, when diverse contexts and subject areas are explored. Diverse and detailed contexts also help clarifying, from the start, that there is no specific universal 'step-by-step method' (McComas 2020, 46). An excerpt from a dialogue between a teacher and a group of 5–6-year-old children about elephants illustrates how attention is directed towards tools and methods that might be used in elephant research:

> Child A: Have they [the scientists] been taking pictures?
> Teacher: Yes, they probably have, they might have taken …
> Child A: Have they been that close to elephants?
> Teacher: Yes, that is something you might wonder about too, how close to an elephant you can get, that is …
> Child B: But elephants are dangerous.
> Child A: Maybe they [the researchers] hid.
> Teacher: Exactly.
> Child C: But there is almost nothing …
> Child D: When the elephants weren't looking.
> Teacher: That's how it might be. A person has hidden themself and looked and taken pictures, just so we would be able to get to know [about elephants] and so that they would get to know even more. Then they compared elephants living in different places around the globe.

Here the conversation concerns how we know things about elephants, and what methods can be used when researching elephants. Previous research has shown that when trade books (Dagher and Ford 2005; Brunner and Abd-El-Khalick 2017) and textbooks (Abd-el-Khalick et al. 2017) highlight scientific processes they often emphasise tools and methods related to observations and experiments (empirical aspects of science), while theoretical aspects of science such as how the observations are used to draw conclusions are seldom mentioned. Even though it might be natural to focus on empirical aspects of science in ECE, as in the example about elephants above, previous research has suggested that theoretical elements (such as theoretical methods and tools) are also important (e.g. Dagher and Ford 2005; Brunner and Abd-El-Khalick 2017). Our suggestions about theoretical elements of science are modest since, in relation to young children, previous research as well as our own empirical data lack relevant, rich examples. Even so, based on our own experiences from preschool teachers' work we argue that a first step can be taken at the ECE level. Teachers might direct children's attention towards theoretical methods and show how scientists, in addition to observing the natural world, also think, read, calculate and so on. Tools, such as computers and books, can be pinpointed in relation to these processes.

We also highlight that it is possible and important to teach the difference between observations and conclusions (that data do not speak for themselves) early on. This means finding ways to take a first step in the progression towards understanding that '(f)acts do not lie scattered on the beach like seashells, merely waiting, preformed, to be collected' (Allchin 2013, 37). A first building block in this domain can be illustrated by an example where a teacher and a group of 5–6-year-old children read a book about dinosaurs that provides information about what dinosaurs ate and that some dinosaurs were good runners (see Hansson, Leden, and Thulin 2020). In this case, it led to a discussion about how palaeontologists can draw conclusions from what can be 'seen on the skeletons' or on the teeth. Directing attention towards the complex nature of empirical evidence and to the fact that conclusions can be drawn about things that no living individual has actually seen in action (e.g. running dinosaurs) can be a first step towards understanding the relationship between observations, inferences and conclusions. One way to render this issue meaningful and make it concrete for the children is to offer them the experience of observation and of drawing conclusions in their everyday life (see in-depth descriptions in Hansson et al. [submitted]). We illustrate what this might mean by an example involving very young children (2–3 years old). The children and their teacher offered different kinds of food to a snail kept in a container. When the children observed what kind of food was missing the following day, they could draw conclusions about what the snail had eaten:

> Child A: They have eaten the dandelions [several of children repeat this statement].
> Teacher: / … / Yes, the dandelions are gone, but the other, look at the red [stuff] here; look, what's the red [stuff]?
> Child B: Melon.
> Teacher: Yes, what's happened to that?
> Child C: Nothing [several of children repeat this statement].

Comparing such experiences to the work of scientists might be a promising way to approach the complex relationship between previous knowledge, empirical observations, and the creative process of drawing conclusions.

Characteristics and limits of scientific knowledge

In a similar vein, 'characteristics of scientific knowledge' is part of most NOS frameworks. This theme highlights the boundaries of science and issues concerned with the characteristics of scientific knowledge — for example, that science has limits and is open to change. It also includes the complex relationship between science and technology. In our research on NOS in ECE this has been the most trying theme. The teachers and researcher jointly struggled to figure out issues and approaches that might make sense to the children and catch their attention (Leden et al. manuscript). The suggestions here are therefore more modest than those made for the other themes.

We identify a few main NOS issues that might constitute the first step in a progression for the theme *Characteristics and limits of scientific knowledge.* One issue that might be important for this theme is that science does not know everything. Such a claim challenges the common view that science has no limits with regards to its scope. Similar issues are also highlighted in the framework by McComas (2020). It may also be relevant to talk about scientific knowledge as something that has not always existed, but has been created and might be revised, and to talk about research as an ongoing activity. That scientific knowledge is long-lasting yet tentative has been emphasised in several NOS frameworks (e.g. Lederman 2007; McComas 2020). It seems reasonable to include all these issues as the basis of discussions on generic principles for the characteristics and limits of science. They might also be a way to challenge stereotypical images of science knowledge as static and readymade.

We suggest that the issues presented above (limitations to the scope of science, science as uncertain, ongoing, and open to change) constitute main topics for the youngest children (up to six) to explore. These issues can be discussed in fairly concrete ways, as suggested in Akerson et al. (2010), close to the science content. For example, when discussing thunderstorms, the teacher might provide examples of how scientific explanations for thunder have not always existed but have been developed by humans over time. There is, however, a risk that historical descriptions are presented in a non-complex way that reinforces myths about science (see e.g. Allchin 2013). Oversimplified descriptions can, for example, appear when teachers and children discuss how previous beliefs about thunder, from the perspective of Norse mythology, are exchanged for scientific knowledge. Still, such conversations might serve as a first step towards questioning science knowledge as static. As a complement to historical descriptions of how knowledge changes, we suggest that children are invited to take part in conversations about ongoing research, as in the following example (with children 4–6):

> Teacher: In Sweden, research is done about all sorts of things, all, all, all possible things are researched.
> Child A: Even scrap [in Swedish ‘skrot’, in English scrap/junk].
> Teacher: I’m sure there are those who do research about scrap, yes, and, for example, about what happens in nature if you throw scrap in nature / … /and there are probably many who do research / … / about different medicines and different diseases, because research is going on all, all the time.
> Child B: Research about dinosaurs and how they eat and so on?
> Teacher: Yes, there are still those who research that, because we don’t know everything yet.

This conversation shows a joint focus on examples of ongoing research. At the end of conversation, the teacher responds to the child’s question by directing their attention to the fact that there are things science has not been able to answer.

Another issue that has been frequently suggested in the NOS literature is the relationship between science and technology. This can be discussed with young children by highlighting the role of science in technological development (e.g. development of medical treatments) and vice-versa – the role of technological development in science. We suggest that directing children's attention to the utility-driven interests in science could lay a sound foundation for such discussions. This suggestion overlaps with the theme of human elements of science dealing with driving forces and is further discussed below.

Human elements of science

Human elements of science deal with issues connected 'to the reality that humans do science' and is 'concerned with human strengths, frailties and associations' (McComas 2020, 51). As a first age-group-appropriate building block, we suggest discussions regarding human involvement in science. Such discussions are important since they can serve as a way of diversifying and challenging the images of scientists and thus humanising science. This means directing attention to the individuals behind the science concepts and explanations that the children encounter in the teaching. Teachers and children can discuss that being a scientist is a profession — doing science is a job. They can also discuss that scientists might have families, needs and interests outside work. Furthermore, teachers can direct attention towards the variety of people from different backgrounds that may be involved in science. An example from our research shows how a teacher and a group of children aged 4–6 discuss the work of astronauts using as a starting point a book they read together:

> Child A: Can we open the flap? [the book has flaps that can be opened].
> Teacher: Do you think we should?
> Child B: It's a girl.
> Teacher: It's a girl who is an astronaut.
> Child C: There are girls.
> Teacher: Can boys also work as astronauts?
> Children [More than one]: Yes!
> Child C: Yes, they have worked hard. And girls.
> Teacher: What do you think they need to know when they are going up in a space craft?
> / … ./
> Child D: To be good [competent] and not be alone or say 'I can do it myself', then they will get lost.
> Teacher: You have to be more than one then, yes.
> Child C: More than one.
> Teacher: What do you do then?
> Child C: You have to be two.
> Teacher: You have to be two, but how do you work then?
> Child C: How do you work then? I don't know.
> Teacher: What does the one do and what does the other do?
> Child D: One watches the hatch, and one searches if someone is lost.

In this dialogue, both gender issues and the fact that being an astronaut is a profession are highlighted. However, a balance is needed between showing possibilities for a variety of people to take part in science and making children prepared to engage with injustice in the shape of cultural and social habits and structures. Cultural and social structures are part of most NOS frameworks. Examples include McComas (2020) who emphasises links between science, society and culture in his NOS framework and Erduran and Dagher (2014, 146) who highlight 'political power structures, such as issues of gender, and ideology. We argue that even very young children can take part in discussions about cultural and social injustices. We have seen examples of how the first step towards such discussions was made in an uncomplicated manner when a group of children (3–5 years old) and their teacher talked about Marie Curie. A child noticed that 'it's unfair' when the teacher told them that Marie Curie was not able to go to school and that people at that time thought that women should not do research, but stay home with their families.

As can be seen in the above transcript, the teacher and children also refer to the need for specific competences, where collaborative competences are specifically highlighted. An emphasis on collaboration might be a way to challenge common images of the lone scientist. However, in the above dialogue, other stereotypes (the scientist as an extraordinary person or a hero) might be reinforced when scientists are highlighted as persons who 'worked hard', and that the scientists have to be 'good'. Thus, in many cases, it can be a balance between challenging or avoiding the reproduction of stereotypes (the scientist as an extraordinary person) and being true to actual circumstances (astronauts need to be well trained and scientists normally have many years of studies behind them). The important issue is to avoid communicating the idea that becoming a scientist is out of reach for the children.

In many conceptualisations of NOS, the importance of creativity as well as the scientist's perspective and previous knowledge are highlighted (see e.g. McComas 2020). Teachers can address these issues by directing attention towards researchers' use of imagination and the need to use previous knowledge when they draw conclusions from, for instance, observations. We suggest that the first building block can be very concrete by providing children with experiences from their own scientific investigations. Teachers can preferably connect such experiences of creativity (e.g. when children engage in planning an investigation or in interpreting observations) to the work of scientists. Creativity is also related to the formerly discussed theme of processes and tools where we suggest that the complex relation between observations and conclusions can be dealt with on a basic level. In the process of drawing conclusions, the scientists' previous knowledge and creativity are both important.

Finally, driving forces is also part of this theme and can be discussed in different ways. Science can be discussed as curiosity driven — highlighting knowledge for its own sake (e.g. about space or dinosaurs). Science can also be discussed as utility-oriented, such as rescuing elephants, making weather forecasts, or developing new medicines. We want to emphasise the need for communicating different driving forces and orientations in the early years NOS teaching to acknowledge the relevance of different interests and driving forces among the children. In our empirical work we have seen teachers and children directing attention towards curiosity driven, basic research, as well as towards technical knowledge interests by, for instance, referring to research concerned with new medical treatments and medicines. It is also important to understand that different interests are involved in science when it comes to financial issues, such as research funding. The first step here can be to provide opportunities to discuss how expensive research is (e.g. equipment and salaries).

Discussion and conclusion

In this article we have, in line with what has been suggested by Akerson (2011) and Bell and Clair (2015), argued for an early introduction of NOS. We have proposed that NOS should be included as an important part of science education from the outset. In the Swedish context, this means at preschool level. Our arguments for such an early introduction of NOS are based on the need for children to encounter and challenge stereotypical images of science and scientists before they become cemented (c.f. Sharkawy 2012), thus creating the possibility for more children to identify with science. We also argue that NOS can contribute to children's agency, both here and now and in the future, which is a reason to also involve young children in NOS teaching. These arguments are directly relevant to overall aims and values associated with democracy and social justice (Yacoubian and Hansson 2020).

Since previous research lacks concrete, detailed suggestions of what NOS could look like in the earliest years, this article suggests NOS issues that may be appropriate for an ECE that embraces the values and aims of democracy and social justice. The NOS issues summarised in Figure 1, below, are suggested as the first steps in a NOS progression that should be continued in primary school and beyond.

Familiarity with the main issue: 'How do we know this?' can contribute to children's agency here and now, as well as in a long-term citizen's perspective — both in relation to performing investigations of their own and in relation to understanding the benefits and shortcomings of investigations performed by others. Our suggestions about theme *Characteristics and limits of science* deal with the first building blocks towards a more nuanced view of the scope and limits of science, as well as towards a view of science as ongoing and open for revision. That everyone, from the outset, has access to nuanced and realistic ideas of what can be expected from science is important from democracy and social justice perspective. It is particularly important that everybody is able to navigate the terrain and take a stance at a time when science is both downplayed and put on a pedestal in societal debates. Finally, the issues suggested in the theme 'human elements of science' can serve as a first step to normalise and humanise science and scientists and thereby make science available to more children.

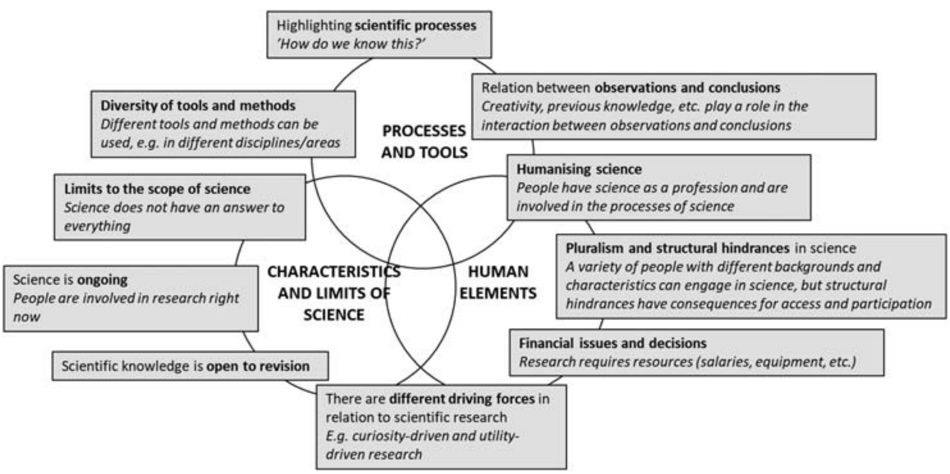

Figure 1. Suggestion for NOS issues appropriate as first building blocks for NOS teaching aimed at children two to six years old. The three overall themes are slightly adapted from McComas (2017; 2020).

This is a first tentative suggestion of NOS issues rooted in the overall values and aims of democracy and social justice that can be taught to very young children. This suggestion is primarily meant as a tool that can be used by teachers in their didactic analysis (Klafki, 1995) and decisions about what NOS issues to teach in the early years. However, the suggestions might also serve as a basis for discussions among other actors (policy makers, authors, etc.) that are important for shaping science in ECE. More research is needed to further scrutinise what NOS issues are important and how they can be meaningfully taught to young children, and, more specifically, the extent to which different NOS issues contribute to children's agency in science and their access to science. Thus, the appropriateness of the suggested NOS issues, and possibly other issues, needs to be confirmed by further studies, in different contexts. In addition, there is a need for more research on NOS teaching approaches appropriate for the youngest children. We hope that the preliminary model put forth here will inspire others to join us in theoretical and empirical explorations of what is, for the ECE context, a new area.

Notes

1. In the Swedish context, children can start preschool ('förskola' — a voluntary form of ECE which a large majority of the children attend) from the age of one, and they leave in August the year they turn six.
2. In McComas (2020) the names of the themes are: *Domain of science and its limitations; Human elements of science;* and *Tools, processes and products of science* (McComas 2020, 40).

Disclosure statement

No potential conflict of interest was reported by the author(s).

Funding

This work was supported by the research platform 'Collaboration for Learning' at Kristianstad University, Sweden [2017-2312-519, 2018-2312-557 and 2019-2312-590].

ORCID

Lena Hansson http://orcid.org/0000-0003-3175-5185
Lotta Leden http://orcid.org/0000-0002-8255-3607
Susanne Thulin http://orcid.org/0000-0001-7276-5422

References

Abd-el-Khalick, F., J. Y. Myers, R. Summers, J. Brunner, N. Waight, N. Wahbeh, A. A. Zeineddin, and J. Belarmino. 2017. "A Longitudinal Analysis of the Extent and Manner of Representations of Nature of Science in U.S. High School Biology and Physics Textbooks." *Journal of Research in Science Teaching* 54 (1): 82–120. doi:10.1002/tea.21339.

Adúriz-Bravo, A., and A. P. Pujalte. 2020. "Social Images of Science and of Scientists, and the Imperative of Science Education for All." In *Nature of Science for Social Justice*, edited by H. A. Yacoubian, and L. Hansson, 201–224. Cham: Springer.

Akerson, V. L., G. A. Buck, L. A. Donnelly, V. Nargund-Joshi, and I. S. Weiland. 2011. "The Importance of Teaching and Learning Nature of Science in the Early Childhood

Years." *Journal of Science Education and Technology* 20 (5): 537–549. doi: 10.1007/s10956-011-9312-5.
Allchin, D. 2013. *Teaching the Nature of Science: Perspectives & Resources*. Minneapolis: SHiPS Education Press.
Andrée, M., and L. Hansson. 2014. "Recruitment Campaigns as a Tool for Social and Cultural Reproduction of Scientific Communities – A Case Study on How Scientists Invite Young People to Science." *International Journal of Science Education* 36 (12): 1985–2008. doi: 10.1080/09500693.2014.888598.
Archer, L. 2012. "'Between Authenticity and Pretension': Parents', Pupils' and Young Professionals' Negotiations of Minority Ethnic Middle-Class Identity." *The Sociological Review* 60: 129–148. doi: 10.1111/j.1467-954x.2011.02042.x.
Areljung, S. 2017. *Utanför Experimentlådan: Kunskapsproduktion, tid och Materia i Förskolans Naturvetenskapsundervisning [Outside the Science Box: Knowledge Production, Time, and Matter in Preschool Science Teaching]*. Dissertation Umeå, Umeå university.
Bell, R. L., and T. L. S. Clair. 2015. "Too Little, Too Late: Addressing Nature of Science in Early Childhood Education." In *Research in Early Childhood Science Education*, edited by K. C. Trundle, and M. Sackes, 125–141. Dordrecht: Springer.
Brunner, J. L., and F. Abd-El-Khalick. 2017. "Representations of Nature of Science in U.S. Elementary Trade Books." In *Representations of Nature of Science in School Science Textbooks: a Global Perspective*, edited by C. V. McDonald, and F. Abd-El-Khalick, 135–151. New York: Routledge.
Dagher, Z. R., and D. J. Ford. 2005. "How are Scientists Portrayed in Children's Science Biographies?" *Science & Education* 14 (3-5): 377–393. doi: 10.1007/s11191-004-7933-2.
Driver, R., J. Leach, R. Millar, and P. Scott. 1996. *Young People's Images of Science*. Bristol, PA: Open University Press.
Eley, A., and S. Martin. 2019. "Moving a Wow to an Understanding: Demystifying Science." *Primary Science* 159: 9–13.
Erduran, S., and Z. R. Dagher. 2014. *Reconceptualizing the Nature of Science for Science Education: Scientific Knowledge, Practices and Other Family Categories*. Dordrecht: Springer.
Eshach, H., and M. N. Fried. 2005. "Should Science be Taught in Early Childhood?" *Journal of Science Education and Technology* 14 (3): 315–336. doi: 10.1007/s10956-005-7198-9.
Hansson, L., L. Leden, and S. Thulin. 2020. "Book Talks as an Approach to Nature of Science Teaching in Early Childhood Education." *International Journal of Science Education* 42 (12): 2095–2111. doi: 10.1080/09500693.2020.1812011.
Hansson, L., L. Leden, and S. Thulin. accepted. "Working with Nature of Science in Early Childhood Education: Inspiring Children's Curiosity, Inquiry and Play". In *Children's Creative Inquiry in STEM*, edited by K. Murcia, C.Campbell, M. Joubert and S. Wilson. Springer.
Hodson, D. 2014. "Nature of Science in the Science Curriculum: Origin, Development, Implications and Shifting Emphases." In *International Handbook of Research in History, Philosophy and Science Teaching*, edited by M. R. Matthews, 911–970. Dordrecht: Springer.
Kelly, L. B. 2018. "An Analysis of Award-Winning Science Trade Books for Children: Who are the Scientists, and What is Science?" *Journal of Research in Science Teaching* 55 (8): 1188–1210. doi: 10.1002/tea.21447.
Klafki, W. 1995. "Didactic Analysis as the Core of Preparation of Instruction." *Journal of Curriculum Studies* 27 (1): 13–30. doi: 10.1080/0022027950270103.
Kolstø, S. D. 2001. "Scientific Literacy for Citizenship: Tools for Dealing With the Science Dimension of Controversial Socioscientific Issues." *Science Education* 85 (3): 291–310. doi: 10.1002/sce.1011.
Larsson, J. 2016. "Barns Lek Och Aktivitet När Fysik Sätts i Förgrunden [Children's Play and Activity When Physics is Placed in the Foreground]." In *Naturvetenskap i Föreskoleperspektiv. Kreativa Lärandeprocesser [Science in a Preschool Perspective. Creative Learning Processes]*, edited by S. Thulin, 67–81. Malmö: Gleerups Utbildning AB.

Leden, L., L. Hansson, and S. Thulin. (manuscript). Characteristics of Book-Talks about 'Nature of Science' in Early Childhood Education.

Lederman, N. G. 2007. "Nature of Science: Past, Present, and Future." In *Handbook of Research on Science Education*, edited by S. K. Abell, and N. G. Lederman, 831–879. Mahwah, NJ: Lawrence Erlbaum Associates, Publishers.

Margrain, V., and A. Löfdahl Hultman. 2019. *Challenging Democracy in Early Childhood Education: Engagement in Changing Global Contexts* (Vol. 28). Singapore: Springer.

McComas, W. F. 2017. "Understanding How Science Works: the Nature of Science as the Foundation for Science Teaching and Learning." *School Science Review* 98 (365): 71–76.

McComas, W. F. 2020. "Principle Elements of Nature of Science: Informing Science Teaching While Dispelling the Myths." In *Nature of Science in Science Instruction*, edited by W. F. McComas, 35–65. Cham: Springer.

Mitchell, L. 2018. *Democratic Policies and Practices in Early Childhood Education: An Aotearoa New Zealand Case Study* (Vol. 24). Singapore: Springer.

Pramling Samuelsson, I. P., and N. Pramling. 2008. "Erfarenheter Från Genomförande i Praktiken. [Experiences from Practice]." In *Didaktiska Studier Från Förskola och Skola [Didactical Studies in School and Preschool]*, edited by I. Pramling Samuelsson, and N. Pramling, 153–168. Malmö: Gleerups.

Sharkawy, A. 2012. "Exploring the Potential of Using Stories About Diverse Scientists and Reflective Activities to Enrich Primary Students' Images of Scientists and Scientific Work." *Cultural Studies of Science Education* 7 (2): 307–340. doi: 10.1007/s11422-012-9386-2.

Thulin, S., L. Hansson, and L. Leden. (manuscript). Preschool Teachers' Experiences of Benefits from Teaching Nature of Science through Book-Talks in Early Childhood Education.

Yacoubian, H. A., and L. Hansson, eds. 2020. *Nature of Science for Social Justice*. Cham: Springer.

Zacharia, Z., and A. C. Barton. 2004. "Urban Middle-School Students' Attitudes Toward a Defined Science." *Science Education* 88 (2): 197–222. doi: 10.1002/sce.10110.

Zarnowski, M., and S. Turkel. 2012. "Creating New Knowledge: Books That Demystify the Process." *Journal of Children's Literature* 38 (1): 28–34.