Challenging stereotypical images of science: Suggestions for the reading of science trade books* in the early years

● Lena Hansson ● Lotta Leden

Abstract

Previous research in science education shows that science and scientists are frequently described in stereotypical ways. Stereotypical images of science and scientists can be found in science teaching as well as in different forms of media and children's books. In this article, we suggest scaffolding themes and topics for discussion when reading science trade books to children. These suggestions can help in directing children's attention towards different issues related to Nature of Science (NOS). Concrete examples from science trade books are discussed with the aim of providing ideas for how stereotypical images of science and scientists can be challenged as soon as from early childhood education.

** The definition of the term 'trade books' in this article is: 'books published for the general public and not primarily aimed to be used as educational material'.*

Keywords: Emergent science, nature of science, scientists, stereotypical images, trade books

Introduction

Science education research emphasises the importance of not only focusing on specific science phenomena in the teaching of science, but also on the Nature of Science (NOS) (Allchin, 2011; Leden *et al*, 2015; Erduran & Dagher, 2014; Lederman, 2007; McComas, 2017). To include NOS perspectives means challenging a tradition that has mainly focused on ready-made facts, and instead also deals with issues such as: *What processes have led to science knowledge (facts)? What is the relation between empirical data and theoretical reasoning? How do human elements influence science? Are there limits to science or will science be able to answer all kinds of questions?*

The inclusion of such issues can enhance children's interest and enjoyment in science and science education (Aikenhead, 2006; Allchin, 2014; Clough & Olson, 2012; McComas, 1998) and provide a basis for increased scientific literacy (Allchin, 2014; Driver *et al*, 1996; Hodson, 2008; 2009).

Previous research shows that stereotypical images of science and scientists are common in school science as well as in different forms of media. Stereotypical images can also be found in media aimed at young children, such as picture books and television programmes. One example of a stereotypical image is when scientific knowledge is presented as indisputable facts, without mentioning the knowledge processes and the scientists involved. When scientists are mentioned, they are often pictured in stereotypical ways. Further, stereotypical images of scientists are frequently expressed among children in, for example, their drawings (Barman, 1999; Finson, 2002; Rodari, 2007). Such drawings, by children of all ages, often show images of the scientist as a white lab-coated man who wears glasses and carries a test tube.

One way in which young children meet science is through science trade books (books published for the general public and not primarily aimed to be used as educational material). For the youngest children, these books take the form of picture books. NOS is often not addressed in an explicit way in such books. A study by Schroeder *et al* (2009) shows that only 21% of the 116 science trade books aimed at 8 year-olds analysed addressed NOS. Similarly, Brunner and Abd-El-Khalick (2017) found that only two of the 50 analysed science trade books aimed at children aged 11 included explicit references to NOS. Furthermore, previous research has shown that children's trade books contain many of the above mentioned stereotypical images of science and

scientists (e.g. Dagher & Ford, 2005; Zarnowski & Turkel, 2012). In a recent study of 28 science picture books aimed at elementary students, Kelly (2018) shows that most scientists in books are white males, and that the extent to which NOS is represented varies widely between books. However, the images are sometimes broadened, especially when it comes to books that describe contemporary science. Still, even though books about contemporary scientists' work more often provide detailed descriptions of tools and equipment, or describe scientists who are engaged in collaborations, they often over-emphasise observations and seldom describe how theories are developed (Dagher & Ford, 2005).

It has been suggested that teachers should be provided with tools in order to be able to choose books more wisely (Zarnowski & Turkel, 2012; Ford, 2004) and that teachers need to develop skills to scaffold discussions connected to book reading so that children's images of science and scientists can be broadened (Dagher & Ford, 2005; Sharkawy, 2009; Zarnowski & Turkel, 2012). Most of the above mentioned studies have focused on science and literature in primary and middle school and very few have investigated books for the younger audience. Other studies have focused on the extra textual talk (i.e. discussions) that surrounds book readings (not specifically focused on science) for younger children (e.g. Andersson *et al,* 2012 and Price *et al,* 2009).

This article suggests themes for teachers and children to discuss in connection with the reading of science trade books. The focus is on suggestions for NOS teaching aimed at the youngest children (aged 1 to 9 years). Since picture trade books are a common way through which young children are exposed to scientific knowledge, the images of NOS in these books need to be scrutinised and strategies developed to challenge stereotypical images when they appear. Furthermore, this article suggests ways to focus on NOS issues suitable for the youngest children, since most of the research in this area has focused on older students (Akerson *et al,* 2010; Bell & Clair, 2015).

Design of the study

As discussed above, NOS is most often implicit in science trade books and, when NOS-related issues *are* mentioned, this is frequently done in stereotypical ways. In this article we elaborate on suggestions for how teachers might direct attention to different NOS issues in connection to the reading of science trade books *and,* when necessary, how to problematise the images provided in the books.

The research literature provides different suggestions concerning what NOS aspects to address in the teaching of science (Erduran & Dagher, 2014; Lederman, 2007; McComas, 2017). Despite taking a different focus, all frameworks highlight: characteristics of scientific knowledge (e.g. that it is open for change, and has limitations); how scientific knowledge is developed (e.g. the central role of empirical work); and science as a human activity (e.g. creativity and subjectivity is part of the scientific processes). In this article, we have used the overarching themes: *Scientific knowledge*; *Scientific processes*; and *Scientists* to organise the suggestions of NOS themes. These themes were inspired by the three categories described in McComas (2017): 'Science knowledge and its limits', 'Tools and products of science' and 'Human aspects of science'.

Our suggestions for how to direct attention towards NOS take science picture books as starting points. The excerpts are chosen from a collection of picture trade books (n=36) aimed at young children (ages 1 to 9 years). The books were not chosen as a representative collection, but rather aimed at including examples of books relating to *different* science areas (astronomy, biology, chemistry, geology, physics), as well as representing different genres (non-fiction and fiction with a content related to science). Thus, the themes we suggest are broad and can be connected to a wide range of issues common in children's trade books. All books mentioned in this article are published in Swedish (sometimes translated to Swedish from other languages). All excerpts from the books have been translated from Swedish into English by the authors of this article. The excerpts are labelled according to the target group, based on our own evaluation and the evaluation from online bookstores.

Suggestions of NOS topics in connection to book reading

This section illustrates ideas of how images of science and scientists can be broadened through directing attention towards different NOS issues in

relation to texts and/or images in the picture trade books. The section is organised around three themes: *Images of scientific knowledge; Images of scientific processes;* and *Images of scientists* and suggests issues to focus on during book readings.

Images of scientific knowledge

Picture trade books often carry messages about scientific knowledge that are in line with the stereotypical and mythical images described above. For example, science knowledge is frequently presented as a bulk of facts and no reference is made to the limitations of science (neither concerning the knowledge we have today, nor concerning the principal scope of science).

Yet, there are examples in the material analysed where these stereotypical images are challenged. One example is a non-fiction book about astronomy (aimed at ages 3 to 6), where the surface of the moon is described as follows: *'This dark surface on the moon is actually not a sea. It is a large plain, but previously astronomers thought that it might be a sea. This was where the first moon rockets landed'* (Martin & Sanders, 2016). This example communicates that scientific knowledge about the moon has changed, and is different today to what it was before. Other examples from non-fiction books communicate that there are still things not known by science: *'We know that dinosaurs had scales. But were dinosaurs grey, green, red or all colours at once? Were they spotted or striped? One wonders…'* (Rolland, 2002, flap book aimed at children aged 3-6).

These two examples illustrate how science knowledge can be communicated as open to change, and limited in meaning, and that science does not have answers to every question. As a way to broaden the image of science, teachers can purposely direct children's attention towards such instances whenever they appear in a book. One way of highlighting uncertainty could also be by emphasising certain words that highlight uncertainty (e.g. 'scientists *believe*'), or changes in scientific knowledge (e.g. '*previously* we thought') and focus the discussion explicitly on uncertainties or changes. Such words are otherwise often lost to the reader (see Ford, 2006 for a discussion on the extent to which children grasp subtly-formulated statements).

However, as previously mentioned, most books only tell *how things are*. In Swedish everyday talk, such books are often labelled as 'fact books'. Some of the books are also titled 'Facts about…'. Facts are presented as statements of how things are. The following is from a book about elephants (aimed at ages 6 to 9 years):

'Elephants talk to each other with very low sound – which we cannot hear' (Maclaine, 2012).

Similarly, in a fiction book (aimed at ages 1 to 5 years), a tree is telling the reader/listener about different animals. In the example below, the tree is telling the listener about squirrels:

'The squirrel is climbing and scratching my neck and looks for the dry mushrooms. Furthest down in a forked branch I can feel a hazelnut that she has forgotten. But, I won't say anything!' (Bengtsson, 2006).

Thus, when these books are read to children, the listeners are exposed to a great deal of knowledge about elephants and squirrels and their ways of living. What is left out, however, is when, how and by whom this knowledge has been developed – the book only tells the reader or listener how things are. When books communicate science as facts, the teacher can pause the reading and start a discussion centred around the issue of how we know these 'facts'. With respect to the books about elephants and squirrels, the teacher can discuss with the children issues such as: *How do we know these things about the life of elephants/squirrels? Have we always known? Who has found out? Are people doing research on the life of elephants/ squirrels today?* Raising such issues could lead to discussions about how science knowledge is developed by humans. It could also lead to an interest to learn more about the research process in science (discussed below).

Challenging the notion of 'science-as-facts' can also mean taking opportunities to direct attention to ongoing research, uncertain knowledge, and to principal limits concerning the scientific method in science, even if this is not a topic in the book. Teachers could, for instance, with respect to the multitude of space books aimed at young children, pause their reading and start a discussion on ongoing research, and things into which science does not yet provide insight.

Similarly, considering the following extract from a book about dinosaurs, it is possible for the teacher to challenge the notion of 'science-as-facts'. The extract describes reasons as to why the dinosaurs disappeared:

'Continents drifted apart and weather changed /.../ There were also several eruptions that let out poisonous gases /.../ and as if that was not enough a large stone from space, a meteorite, crashed on earth! /.../The crash led to earthquakes, tidal waves, and further eruptions' (Sheppard, 2008, aimed at ages 3 to 6 years).

Despite the ongoing discussion in the scientific community about the significance of different explanations (meteors vs. volcanoes), the book presents a collapsed explanation as a 'fact'. Nevertheless, a teacher could use this example to raise the issue of different or conflicting explanations.

Images of scientific processes

When science is communicated as 'facts', the process of science becomes hidden. As exemplified above, books communicate knowledge about, for example, elephants, squirrels, space and dinosaurs without providing any detail concerning the processes that have led to the development of this knowledge.

Yet, one can find examples where scientific processes are highlighted. Such examples are common in non-fiction books about space: *'Scientists at a space station do experiments. They investigate how plants and crystals grow when they are weightless and what happens to small animals like mice and spiders when they are in space'* (Nelson & Harper, 2000, aimed at ages 3 to 6 years).

Here, the teacher can pause the reading and focus on the issues of research questions and processes. Issues for discussion could be: *What are the scientists interested in? Why? How do they investigate this? Do they need some equipment?* Related to the latter question, books do sometimes show examples of tools used by scientists, such as a microscope, telescope, spade, computer, test tube, all of which could be discussed from the points of *why* and *how* scientists use these tools.

The scientific processes that are mentioned in science trade books aimed at young children almost exclusively target empirical aspects of the process of science – it is all about experiments and observations (c.f. Dagher & Ford, 2005). The theoretical aspects of the processes are very seldom mentioned, even though some examples do draw attention to the thinking processes (in the example below, the discoverer in shape of a turtle, Professor Shellback [Swedish: Skalman], is thinking and counting):

'Can you figure out where on the Earth it will land? Shellback was standing quiet with closed eyes /.../ – I am counting, said Shellback, and a minute later, – Now I have figured it out' (Andréasson, 2000, aimed at ages 3 to 6 years).

Similarly, human elements of the research process such as discussions, argumentations or publishing are rarely mentioned (see next section). A way to expand the meaning of scientific processes further could be by posing questions such as: *What do you think the scientists did before the investigation? What do you think they did after the observation?* In this way, the teacher adds to the information provided in the books by directing attention to the theoretical and human elements of the research process.

Images of scientists

Scientists tend to become invisible as a consequence of neglecting the scientific processes in the picture books (see previous section). On the other hand, in books where scientists are visible, there are stereotypical images of scientists as well as instances in which such images are challenged in different ways. Teachers can direct students' attention to non-stereotypical images, such as in the example below where collaboration between different scientists is highlighted:

'A palaeontologist has found bones from a dinosaur in the desert. He removes sand and clay with his tools. To protect the bones he plasters them, just like you do with broken legs. Then, the bones are put in crates and transported, first in a truck and then by aeroplane. Other scientists study the bones and try to figure out what the dinosaur looked like' (Rolland, 2002, flap book aimed at children aged 3 to 6 years).

Trying to emphasise such instances in books could broaden the images of science and scientists that children hold. However, it is important for the

teacher to also problematise stereotypical images when they appear in the books. For example, when scientists are only displayed in books as male white scientists, the teacher can ask: *Can everyone become a scientist? Why is it that most pictures in the book show males?* Furthermore, many books contain stereotypical images where scientists are characterised as wearing lab coats and using test tubes, even in science topics where such equipment is seldom used (e.g. astronomy). In such cases, the teacher could ask questions such as: *Do scientists always wear lab coats? Why are they sometimes wearing lab coats? Are scientists normally wearing lab coats when studying the stars?* Similar questions can also be raised in relation to other stereotypes, such as test tubes: *What tools and equipment do scientists need? Is it always the same?* In cases where the books alter and broaden these characteristics, by for instance showing other kinds of outfits and accessories such as cargo pants, pencils and computers, the teacher can take the opportunity and pinpoint these differences.

Highlighting the human element of science also forms part of discussing and problematising the image of scientists. For example, in astronomy books you sometimes find examples of situations where the personal and human needs of astronauts are made evident, e.g. that they need food, rest and leisure time. Other human elements of science, such as creativity and socio-cultural aspects of science, can be harder to find in science trade books. However, by highlighting issues such as *Why are people interested in this? Who pays their salary? Why are the books showing a flag on the moon?*, as well as focusing on what happens before and after the experiment/observation, such aspects of science can be made visible.

Conclusions

A teacher who wants to teach NOS by using science trade books can get some support from the book itself, but often to a rather limited extent. As has been previously discussed, some science trade books challenge the notion of 'science-as-facts' to different extents. If teachers want to problematise stereotypical images of science and scientists, they need to direct the students' attention to these instances in the books, by emphasising certain words or passages or by posing additional questions or making statements: *Look at the astronauts; I wonder how it feels to sleep like that in a space station*.

In almost every case, the teacher also has to add information and/or challenge the already existing information. In some books, the notion of 'science-as-facts' is challenged by showing that scientific knowledge is not just 'there', but has been developed by humans. However, overall, rather simplified images of the science processes are provided. For instance, only strictly empirical parts of the knowledge processes are mentioned, and discussions of theoretical aspects are missing.

In cases when science trade books communicate stereotypical images, the teacher needs strategies to challenge and question them. One way we have suggested in this article is to raise questions or start discussions on what characterises science and scientists. Such questions or discussions could be:

Why are there only male scientists in the pictures? or *Do all scientists wear lab coats?* Many universities have portraits of researchers on their web pages (often including pictures); these could be used as a way to broaden the images of what characterises scientists.

When only 'facts' are described, NOS-related issues can still be discussed. In a book with facts about elephants, the teachers add important issues and messages by asking: *If we cannot hear the elephants speak, how can we know that they speak? Have we always known? Who has found out? What did people do to gain this knowledge? What equipment is needed to gain the knowledge? Are there also people who do research about elephants today?* The suggestions provided here have to be adapted to the age and experience of the children.

Finally, it is highlighted that the reflections presented are related to a project that we recently started in collaboration with a pre-school (children aged 1 to 6 years) where, together with a colleague, we are empirically investigating how reading books can be used to raise NOS learning situations. The idea of the project is for teachers to find ways to direct attention towards NOS issues during reading, in line with the suggestions made in this paper.

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Lena Hansson and **Lotta Leden,**
Kristianstad University, Sweden.
E-mails: Lena.hansson@hkr.se and Lotta.leden@hkr.se