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Science teaching in upper primary school – through the eyes of the practitioners

Abstract

Teachers' own voices have been partially missing in science education research on upper primary school (age 10-12). In order to examine views and experiences of teaching science, we interviewed 14 upper primary teachers. They described science teaching as fun, mainly due to the inherent practical work. The same practical work was also identified by the teachers as the main cause of stress and was therefore conducted less frequently than desired. The data enabled construction of seven teacher roles, closely connected to both their described teaching practices and views on science education. Teachers' accounts of their science teaching speak of a varied practice with emphasis on practical work and facts, and less articulated descriptions of work to develop students' abilities to examine and communicate science. The results provide insights into the interactions between teacher views and teaching practices which could prove valuable for improving upper primary science education.

INTRODUCTION

It has been suggested that students' interest in science peaks at age 10-12 and subsequently fades upon entering secondary school (Lindahl, 2003). In addition, science appears to be more affected by the transition compared to other subjects (Braund, 2008). Recent research proposes that part of the problem may lie in the inability of primary schools to teach science in a way that promotes students' development of understanding and interest from the outset (Anderhag et al., 2016). These somewhat contradictory results increase the need for research on primary science education. Adding to this need is Tytler's (2010) identification of primary school as a crucial time in the formation of positive student conceptions of science. Furthermore, Milner, Sondergeld, Demir, Johnson, and Czerniak (2012) pointed out that an inadequate primary school science education clearly decreases the chances of succeeding in secondary school science. Despite the importance of quality science teaching in upper primary school, it has been a low priority both in research and in school development (Skolinspektionen, 2011; Tytler, 2010). In addition, teacher views are continually ignored by policy makers, who tend to base decisions regarding school development on international test results (Stigler & Hiebert, 2009). This course of action is worth questioning since, for example, Milner et al. (2012), in a large survey study of elementary teachers' beliefs about science teaching, found a strong relationship between teacher views and teaching practices. They further ascertained that a failure to pay adequate attention to teacher views might undermine future attempts to improve science education, something which has also been pointed out by Luft and Wong (2014).

This study was conducted to learn more about improvements needed in science education at a critical stage in students' schooling (Luft & Wong, 2014; Milner et al., 2012; Skolinspektionen, 2011). According to Fraser, Tobin, and Kahle (1992), an understanding of teacher views of practices and teacher roles is a powerful tool in efforts to develop science education. Therefore, we wanted to add to the knowledge base regarding teachers' perceptions of science education, teacher roles and teaching practices. Our study aims to fill some of the gaps regarding *the forgotten stage* (Anderberg, Danelius, & Nordheden, 2010, p. 16) and the invisible science subjects, while also contributing with some upper primary science teachers' own testimonies.

This article seeks to answer the following research questions:

- How do upper primary school teachers describe their experiences of teaching science?
- Which roles and teaching practices emerge from upper primary school teachers' descriptions of their science teaching?

BACKGROUND

Teacher views on science teaching

In many countries, science education has been the domain of secondary school. Perhaps this is one of the reasons that the previously mentioned study by Milner et al. (2012) found that elementary teachers commonly express beliefs that less effort could be put towards science teaching, compared to other subjects, since students are able to *catch up* (p. 128) in secondary school. In the same study it was noted that many teachers feel pressured to focus on mathematics and reading, resulting in lower prioritization of science. The study also found that despite teachers' lack of knowledge and confidence in science, they still reported positive feelings and attitudes towards science. This agrees with recent results from Lidar, Engström, Lundqvist, and Almqvist (2019) which showed that many Grade 6 teachers view science as 'their subject', meaning that they are engaged by and eager to teach the subject content. In another study, early elementary teachers were found to often assume that their students' abilities to engage in science are very limited (Chen, Hand, & Norton-Meier, 2017). Adding to this is the indication that primary teachers tend to have a traditional view of science as a subject filled with *rights* and *wrongs* (Appleton, 2002, p. 402). It is possible that such assumptions and views lead to transmissive teaching practices and factual recall rather than higher-level cognitive thinking among students.

Science teaching practices

Previous research efforts in primary school reveal a complex, inconsistent, and somewhat contradictory image of science teaching practices. Some of these can be explained by differences in study design. Results from a survey of Grade 6 teachers (Lidar et al., 2019) enabled the grouping of teachers into four groups depending on their views of the important elements in science instruction. Lidar et al. (2019) identified these groups as *scientific facts and concept, laboratory work, everyday knowledge, and political and moral questions* (p. 175). However, despite these differences in perceptions of science education, the results implied that the teachers were much less varied in their teaching practices. For example, a majority of them claimed that discussions and expository teaching in whole class setting were most consistent with their own teaching practices. This result does not align with the largest of the four groups consisting of teachers who regard laboratory work as the most important aspect of science teaching. It does, however, support previous findings showing that whole class work is seen as the most effective practice for elementary school science (Fradd & Lee, 1999). A similar conclusion was reached by Appleton (2002) based on primary teachers' claims that practical work is efficient in engaging students, yet this approach is often avoided due to issues surrounding availability and maintenance of materials. In addition, Supovitz and Turner (2000) observed the same phenomenon while also finding a negative relationship between teacher experience and the presence of an investigative classroom culture, which ought to be further explored. Furthermore, Tytler (2010) pointed out that even though science in primary school tends to be more *hands-on* (p. 55) rather than transmissive, the investigative work conducted is often at a lower level of reasoning. The inconsistencies of these previous results raise the need for continued research on primary school science education.

Regarding traditions, a recent study found that Swedish science teachers ranging from Grade 4 to 9 spontaneously identified different teaching traditions during discussions surrounding contexts for teaching the nature of science (Leden, Hansson, & Ideland, 2019). These traditions stem from three abilities for students to develop which are part of national science syllabi. In short, they state that students should be able to: 1) use scientific knowledge to search for and evaluate information, communicate, and take a stand on scientific issues, 2) conduct systematic studies and, 3) use scientific concepts, models, and theories to describe and explain scientific phenomena (Swedish National Agency for Education, 2018). Even though the abilities are thoroughly described as the objective of each subject, the study participants condensed them into single words: discussion, lab-work, and fact. Whether this is a sign of pragmatic thinking and an attempt to facilitate dialogue, or insufficiencies in teachers' perceptions of the abilities to develop, remains unclear. Furthermore, while the last two traditions were seemingly obvious and dominating parts of science teaching, the teachers considered discussion to be new and more challenging, and possibly even in conflict with practices stemming from the fact-based tradition. A focus on transmission of facts is well established in school science discourse (Mortimer & Scott, 2003; Aikenhead, 2006), and the same applies to practical work, or lab work (Tytler, 2010). Mortimer and Scott (2003) expressed concern that teachers tend to focus on activities, rather than on communicating in a manner which truly involves students in classroom discourse, thereby providing opportunities to develop a variety of abilities. Appleton (2002) found that primary teachers' descriptions of *activities that work* (p. 393) revolved more around what students do and the prospect of clear outcomes, than on which abilities are developed through these activities. This is considered a challenge to the development of conceptual understanding since it tends to fragment the syllabi. One reason for preferring concrete, fact-based practices might be found in the results of Leden et al. (2019), which show an existing reluctance among teachers to conduct classroom discussions, since it is considered a waste of time that could be used to teach facts instead. It is also viewed as a practice involving the risk of having to handle social as well as ethical dilemmas in science, for which teachers feel unprepared.

The roles of science teachers

Primary science teacher roles have mainly been researched through observation studies. For example, a recent multiple-case study examined roles adopted by three experienced elementary teachers,

based on who controls discussions and activities in science classrooms (Chen et al., 2017). Results enabled the construction of a conceptual framework consisting of four roles which together are expedient in guiding students toward higher-level cognitive thinking. It is suggested that alternating between the roles of *dispenser*, *moderator*, *coach*, and *participant* is effective in promoting development of students' abilities to participate in classroom discussion. Similar to this, Zhai and Tan (2015) described how elementary science teachers shuttled between the four key roles of *dispenser of knowledge*, *mentor of learning*, *monitor of students' activities* and *partner in inquiry*. The choice of role depended on, for example, the nature of tasks and teacher preferences. In a study of 4th Grade science teaching, Fradd and Lee (1999) explored the two opposing teacher roles of *teacher-as-knowledge-transmitter* and *teacher-as-facilitator*. The knowledge transmitter used more explicit teaching practices, leading the whole class in simultaneous work on step-by-step tasks. In contrast, the facilitator guided students in their independent work on inquiry-based tasks via exploratory teaching practices. Furthermore, Fradd et al. (1999) proposed that the two, and possibly more, roles complement each other and are both useful for science teachers. The teachers in the study, though recognizing the importance of occasionally adopting the role of facilitator, still *argued that an explicit approach was essential until students acquired basic concepts and skills for engaging in science inquiry* (Fradd et al., 1999, p. 19) implying that transmission of facts came first. In an observation study of one particularly skilled teacher, Crawford (2000) asserted that using only two roles was an oversimplification, and went on to identify ten roles that were adopted during high school science teaching. Results from Tobin's (1993) study on high school science teachers' descriptions of their roles using metaphors, also indicate the existence of a great diversity, including examples like *teacher as preacher*, *teacher as resource*, *teacher as movie director* and *teacher as entertainer*. A comparison with primary school teacher roles may provide interesting insights into how science teaching in different stages of schooling relate to each other.

METHODS

The study was designed as qualitative research enabling the contribution of a deeper understanding of primary teachers' experiences of science teaching. It was inspired by phenomenography which aims to investigate the qualitatively different ways in which people perceive, experience, or think about something (Marton & Booth, 1997). Here, the phenomenon in focus is teacher views of their role in science teaching practices. The research relied on data obtained from first-hand interviews, followed by an inductive thematic analysis (Guest, MacQueen, & Namey, 2012). Since teaching is a cultural activity *learned through informal participation over long periods of time* (Stigler & Hiebert, 2009, p. 86), and research studies about primary science teacher views are limited, we wanted to find science teachers with as much variety in experience as possible. This variety of teaching experience, type of teaching certificate, and type of school provided opportunities to reveal qualitatively different ways teachers perceive or experience the socio-cultural school practice.

Participants

To examine teacher views and descriptions of their teaching practices, we conducted semi-structured interviews (Kvale, 1997) with 14 upper primary science teachers. The criterion for study participants was that they currently or recently had taught science in Grades 4-6. In addition to this criterion, we tried to diversify our sample by inviting teachers from a variety of schools located in several municipalities. The process of recruiting participants resulted in a convenience sample. Information about the purpose of the study as well as their rights as participants, was e-mailed to all participants (Swedish Research Council, 2017). An overview of the participants with fictitious names is presented in Table 1. Most of the teachers worked as general teachers and taught most or all subjects to the same class, while three of them worked more similarly to subject teachers, teaching science to several classes. The majority were women, which reflects the overall nationwide pattern, with about 75% of Grade 4-6 teachers being women. The sample came from 8 different schools, ranging in size and with students from differing socio-economic areas, located in 4 municipalities. Even though the participants were not purposefully chosen, the sample ended up matching the composition of teaching staff in Swedish

upper primary schools. This includes teachers with a variety of certificates, due to the many reforms in teacher education, and those without teacher education (cf. Skolinspektionen, 2018). Three of the teachers were chosen as empirical examples to be presented as narratives in the results section. In the process of deciding who to choose as examples, the variety of experience and teaching certificate was considered. No incentive was offered for participation in the study.

Table 1. Overview of teachers participating in the study

School (approx. number of students, Grades, location)	Teacher	Teaching experience (yrs)	Teacher education (Grades, focus)	Sex	Length of interview (min)
A (160, F*-5, small town)	Anders	34	4-6, general teacher (incl. science)	M	64
	Alice	14,5	1-7, general teacher (incl. science)	W	67
B (350, F-6, midsize city)	Betty	30	4-6, general teacher (incl. science)	W	57
C (300, F-6, small town)	Catherine	30	4-6, general teacher (incl. science)	W	23
	Charlotte	15	1-7, general teacher (incl. science)	W	34
	Cecilia	4	No teacher education	W	35
D (180, F-5, midsize city)	Daisy	23	1-7, general teacher (incl. science)	W	53
E (45, F-9, rural area)	Eric	22,5	1-7, general teacher (incl. science)	M	64
F (360, F-6, small town)	Felicia	18,5	4-9, math/science	W	23
	Frida	11	1-7, general teacher (excl. science)	W	34
	Fia	10	1-7, general teacher (incl. science)	W	29
	Freja	2	4-6, general teacher (incl. science)	W	19
G (230, F-5, small city)	Gabriella	20	1-7, general teacher (incl. science)	W	64
H (400, F-6, small city)	Henrik	14	1-7, general teacher (incl. science)	M	66

* F = Preschool class (Förskoleklass)

Data collection

Semi-structured interviews were conducted at each participant's workplace and lasted 25-65 minutes, with an average of 45 minutes. Interviews shorter than 30 minutes, 3 in total, were shortened by teachers having to substitute for colleagues on sick leave as well as tend to unexpected events.

The interview guide contained open-ended questions divided into the following areas: background, science teaching in general, planning processes and science teaching practices. Included in the guide was also a theme called wishes, intended to let teachers share their thoughts on possible develop-

ment of science education, and type of support needed. Examples of questions, including supportive questions in parentheses, were *Tell me about the work of teaching science in upper primary school (What is expanding or challenging? What is your role in the classroom?), Tell me about your use of steering documents during lesson planning and student assessment* and *How do you view your work with the three abilities stated in science syllabi?*. The national chemistry syllabus was used for reference. At the beginning of each interview, the teacher was informed that the study emphasis was science teaching. Each interview was audio recorded and transcribed verbatim. All participants also filled out a form to clarify their background, resulting in the information found in Table 1. Interview transcripts containing an anonymization code for each teacher totalled over 100 pages, which formed the basis for thematic analysis using NVivo software.

Analysis

Interviewing and transcribing automatically induces some data analysis, and even though several insights started to form during the work these were not thorough enough to fully interpret the data. Following the transcription, an inductive thematic analysis was performed (Guest et al., 2012) by reading and rereading the transcripts in an exploratory manner *looking for key words, trends, themes, or ideas in the data that [would] help outline the analysis, before any analysis takes place* (p. 6). NVivo 12 Pro was used to organize teacher quotes into themes and corresponding codes (Table 2). This process was repeated from scratch twice, which meant deleting codes and reorganizing themes into new codes. Each processing of the data induced greater familiarity and was done to ensure reliability. The final analytic draft consisted of two themes, along with 8 codes unequally divided between them. Excerpts of teacher utterances are presented in Table 3 and in the result section "Empirical examples".

Table 2 Themes and codes

Themes	Codes
Teachers' views of teaching science	Positive aspects Negative/challenging aspects
Teacher descriptions of their science teaching practices	The teacher role Science themes and specific tasks Assessment Teaching aids Planning and organization Curriculum

The teacher quotes, organized under each code, were summarized to determine aspects frequently mentioned by participants. This process was aimed at identifying similarities among experiences and thoughts indicative of an existing culture transcending upper primary school science teaching. Rarer statements were also noted to illuminate variety within the group. One of the follow-up questions in the interview asked for the teachers' roles in their science classroom and the participants were not offered any previously constructed teacher roles as support while answering this question. The analysis of the answers to this question induced an interest in performing a literature search for previous studies around science teacher roles to compare with those explicitly mentioned by participants. An abductive process, during which teacher quotes were analyzed and compared to roles found in previous research studies, enabled a continued construction of the teacher roles which are introduced in the results section. The results are presented in Table 3, and by using three teachers as empirical examples to reify both common patterns and deviations in teacher descriptions. These teachers were specifically chosen as they vary in terms of experience, teaching certificate and combination of different teaching practices and roles.

RESULTS

The results section features teacher views on primary school science and is divided into two parts. The teacher views on teaching science are introduced first, and these are followed by descriptions of teaching practices and roles. The results section is concluded by in-depth descriptions of three teachers (Anders, Frida, and Fia) chosen as empirical examples of important findings from the analysis of the full interview data material. The examples are to be considered as views and descriptions shared, in full or in part, by other participants and have been added to the article as a way to bring teacher narratives to life.

Teacher views on teaching science

Most teachers described science and teaching science as *fun*. To some extent, different scientific disciplines were perceived as more fun than others, but there was no obvious agreement on this. The adjective fun was used more frequently than *interesting* or *important*, which were mentioned by a few teachers. Interestingly, the use of the word fun to portray science teaching was one of the few differences found between the more and less experienced teachers in the study. While none of the teachers with 30+ years of experience talked about science teaching as fun, all except one of the other teachers did. Nevertheless, most of the teachers agreed that students consider practical work particularly enjoyable. On further exploration, it became clear that science was considered fun due to the unique variety offered through practical work. The creativity allowed in practical work made science teaching fun to these teachers. Despite this, there was a contradiction in the fact that a clear majority of the teachers identified the planning and organization of practical work as one of the main causes of stress and time pressure in their work. In part, practical work was perceived as challenging because there were many students to instruct and sometimes furniture and materials to be moved around. Purchasing, storing, and maintaining materials also required significant effort. In addition, several teachers talked about a need to test activities in advance to feel safe. Some teachers also emphasized the difficulties of conducting practical work in primary school classrooms, which must be tidy and organized for the next lesson to take place without interruptions caused by lingering odours or soiled desks.

Teachers' descriptions of their science teaching practices

During the analysis, it became clear that views, roles, and practices were closely linked. Some roles were named and described explicitly by the teachers in response to the interview question. Others were more elusive and indefinable, making their presence implied in narratives of views and practices rather than expressed in detail. The analysis resulted in the construction of seven different roles that were more or less present in the teacher narratives. It is important to point out that individual teachers are not believed to adopt only one role, but rather appear to alternate between several roles depending on their suitability for the current teaching situation. Most of the teachers expressed views and described practices that indicated their adherence to 3-4 roles, while some showed preference for five roles. One teacher only expressed views and teaching practices in accordance with the role of The Encyclopaedia, while only one teacher appeared to take on the role of The Participant. In Table 3, the roles are presented in descending order, depending on how many of the teacher statements they could be extrapolated from.

Table 3 Teacher roles and characteristics of teaching

Role	Characteristics of teaching	Example quotes
The Encyclopaedia	Aims to be confident in and able to share scientific facts, theories, and concepts, prefers using textbooks, often refers to core content as very important	*I have to study up on the subjects before I go in. So I know what to say.* (Frida) *Now, they're so young in fourth Grade, so you have to start off by giving them some answers. Teach them a little.* (Felicia)

		I have to give [the student] some knowledge too. (Henrik) *[Secondary school science teachers] have enough knowledge. Which I feel I lack so to speak.* (Catherine) *We rely a lot on the available textbook.* (Daisy) *… you have to be well prepared, because you need to explain concepts.* (Charlotte) *… around plants and animals, one feels a bit shaky sometimes.* (Eric)
The Inspirer	Aims to capture student interest and raise curiosity about science	*In a way, [science] is not demanding, you can easily catch the students' interest, I think.* (Frida) *We do a lot of experiments and stuff which makes them happy and interested.* (Daisy) *Science is the one part of teaching where you have the greatest ability to inspire, I think.* (Anders) *I want children to be interested in science. To feel that 'this is interesting' (*Henrik)
The Enabler	Aims to summarize and draw conclusions for the students rather than expecting them do this on their own, often work thematically to demonstrate connections, attempts to facilitate learning by preparing/structuring/	*It can be difficult to break it down so that these younger children understand it. When you think about textbook authors… all due respect, it's not like they're creating an understanding.* (Fia) *I'm the one who structures the whole thing. I have to sort of prepare, so that it'll be easy for the students to acquire knowledge.* (Daisy)
	supportingg/varying activities /allowing several attempts	*We tried to mix many different ways to benefit everyone, since we know that some are really good at writing and some have a really hard time writing. You try to find some sort of middle road. (Alice)* *You break it down a little for them. (Cecilia)*
The Entertainer	Aims to make it fun for the students, often uses happenings to do this	*If we can determine the species […] they usually think that's fun.* (Eric) *It's really fun with the 'poof' and the 'bang' and all that.* (Frida) *To DO. Then they get happy. When they get to do practical things.* (Betty) *I also need to be the one who makes it fun.* (Henrik)
The Guide	Aims to guide students in their quest for knowledge and understanding, often	*… it's about waking them up in all this, and to teach them where to find facts.* (Felicia)

	uses discussion as an activity	*You walk around from group to group, discussing with them and you, the students get to tell each other.* (Alice) *They get to examine their own answers and the reasons for them.* (Cecilia) *I try to stay a bit more 'listen, walk around, pep talking and supporting' but perhaps not always be the one to, it's good not to give away ALL courses of events. Especially in science where you're supposed to discover.* (Anders)
The Flexible Opportunist	Aims to pick up on current events or things that students talk about, often lets random events direct classroom activities or topics, prefers informal talk as a tool for communication	*I very often take side-tracks. There's always someone who asks the question 'What would this be like?' and then we end up discussing that.* (Frida) *Then we fell into the issue of people believing that the earth is flat. So, today we worked on what kind of arguments one has when claiming that the earth is flat, and what that says compared to current research.* (Felicia) *It happens in the moment. No, but you always have to be so well prepared and know what to bring [to the classroom] all the time. I think that's boring.* (Charlotte)
The Participant	Aims to learn in cooperation with students, heavily focuses on students' doings and discoveries	*I am certified in all science subjects up to Grade 6, but I have studied very little. I graduated in 2006 and in my degree there was a tiny, tiny bit of science. Or, really as an elective course. So, I'm very, I always thought it was fun and interesting myself, but I can't stand there and present all the results without being part of discovering them for myself.* (Fia)

According to the teacher narratives, The Encyclopaedia is by far the most common role to adopt in upper primary school science class, while the role of The Participant only seems to be practiced by one of the teachers. The roles are accompanied by different teaching practices. For example, a teacher adopting the role of The Encyclopaedia is more likely to offer students activities and tools such as lectures and reading textbooks, while The Entertainer might resort to practical work more often since students enjoy it.

Practical work and talking were the most frequently mentioned teaching practices, followed by the use of teaching materials. Activities involving talk were less explicitly described but spoken of almost as much as practical work, often in passing when teachers described talking *to* students about scientific concepts and/or science related issues. *Talking*, *discussing*, *reasoning*, and *conversing* were all terms more or less frequently used by the teachers. Whether these interactions were shaped to enable students to practice and develop their ability to investigate and discuss scientific issues was unclear. Use of teaching materials was the third most commonly mentioned practice. Reading, individually or aloud in a whole-class setting, and answering questions or finishing chapter assignments summarizes the teachers' descriptions of textbook use in science class. One common teaching practice appeared to be starting a task with individual work and concluding it with teacher-led discussions or reviews of correct answers. The practice of reading and writing in science class was viewed, among some of the teachers, as preparation for students transitioning to secondary school. A few even expressed remorse over not preparing the students enough by enabling development of these skills.

Empirical examples

In order to bring the study results to life, some empirical examples are provided here. The three teachers presented below displayed a variety of experience, teaching certificate and roles expressed.

Anders – the experienced teacher

Anders had been a teacher for 34 years and said it was a sheer coincidence that he ended up as a teacher to begin with. As a certified general teacher, he taught his class in every subject except sloyd and physical education. He believed that the teaching profession is both important and complex and pointed out that many changes had taken place during his career. Anders' science teaching was based on a rough subject plan which was available to all schools in the municipality.

Regarding planning for students to develop the three abilities presented in science syllabi, Anders described the ability to understand and use concepts and scientific models, as well as the ability to conduct systematic studies, as easier to work with in Grade 4-6 than the ability referred to as discussion (cf. Leden et al., 2019). He suspected that students at these ages struggle with discussions due to limitations in their prior knowledge and even suggested that perhaps this ability ought to be completely omitted from primary school science:

> *After all, one could, and I don't know if this is explicitly stated, but one could look at it like this, this [ability] is part of an overall purpose and is more appropriate in Grade 7-9 than the rest [of the three abilities]. I don't know if you could make that statement, but you certainly could interpret it like that. There's a great deal of leeway in these [syllabi] and I find it quite frustrating from time to time.*

Anders described the role he adopted during science lessons as a variable depending on classroom work. Sometimes he was what he refered to as *the traditional lecturer who, perhaps, displays something at the front of the classroom to the whole class* implying that the role of The Encyclopaedia was in his repertoire. He preferred, however, to be The Inspirer who encourages students to make discoveries on their own. According to Anders, science differs from other subjects by offering the greatest opportunity to teach in such a way thanks to the curiosity aroused in students through practical work, including trial and error. During practical work, which permeated Anders' account, he seemed to prefer the role of The Guide who leads students through joyful discoveries:

> *Well, the joy of discovery. Most kids really enjoy investigating and finding out, hypothesizing. They think it's great fun.*

Frida – the general teacher

Frida had worked as a teacher for 11 years. She was certified but lacked science courses in her degree. Despite this, she taught science since *the teacher who used to teach science in this class left and [Frida] was sort of left with the task*. She described science as fun although her lack of training meant she had to spend a great deal of time studying up on subject content before entering the classroom. This was important to Frida, who wanted to feel confident in what to say and do in class, suggesting that the role of The Encyclopaedia was included in her practice. Frida said that working as a general teacher in upper primary school was stressful, and in her case, involved planning and teaching all subjects in her class. She explained that the lack of time often made her opt out of practical work in favour of less time-consuming activities. Unlike most study participants, Frida and her colleagues had access to an equipped lab in an adjoining school building. However, Frida seldom used it, since bringing her students across the schoolyard to reach it was more complicated than remaining in their classroom.

Frida did not cooperate with any other teacher in organizing and planning science classes and said that she was on her own, at least for the moment. She relied on the textbooks selected by the school, rather than syllabi, to cover the curricular content in science classes. The ability to reason and take

a stand on certain issues (discussion) seemed less important during planning, but Frida claimed to work together with her students on that ability in a spur-of-the-moment-mode:

> *… now that you asked about it, it was like 'Oh, we actually touched on that [ability]'. I think we probably do that more than we realize.*

Frida's ambition was to base classroom conversations on students' interest, and she claimed to take *side-tracks very often* indicating the presence of the role of The Flexible Opportunist in her teaching practice. A wish to capture her students' interest as well as inspire was expressed throughout Frida's account, suggesting an intention to act as The Inspirer. Her experience from teaching in lower primary school allowed her to compare science teaching at the different Grade levels. She claimed that the older students *lose some of the urge to find out more*. This resulted in a heavier workload as it put pressure on her to *constantly try to determine 'How can I capture student interest in this topic? And in this topic?'*. Frida's desire to make science fun for her students, in accordance with The Entertainer, was hampered by her insecurity about science in general. It all boiled down to the following summary of her science teaching practices:

> *We talk, we read, we use the workbook, we watch movies.*

Fia – the participating teacher

Fia had worked as a teacher for about 10 years and described science teaching as enjoyable. She attributed this positive feeling to a strong tendency among 10-12-year-olds to want to explore things and said that it makes the subject very creative. The creative aspect, she said, came from her belief that:

> *… you can kind of interpret the curriculum as you wish, in a way. It says a lot about, it emphasizes inquiry-based practices and that is really my passion.*

Fia described herself as The Guide when asked about her role in the classroom. Through her account it appeared that she also occasionally took on the role of The Participant, which made her unique among the teachers in the study. In addition to the quote which is included in the description of The Participant (Table 3), she described an instance where she and her students buried a wooden board with different materials attached to it in the schoolyard. The students had hypothesized which items would be decomposed, and Fia expressed how she was curious to see the results as well since she wasn't sure of them. When asked if she discovers things together with her students she answered:

> *Yes, actually. And I'm thinking that we should be able to be on that level.*

DISCUSSION

Almost thirty years ago, Fraser et al. (1992) pointed out the importance of teacher views of their science teacher roles as powerful knowledge in efforts to develop science education. In the present article, the science teacher roles were constructed and considered as possible manifestations of teacher perceptions of science education and teaching practices. These roles add another perspective to those presented in previous studies based on classroom observations. While generalizations are difficult to make using a limited sample of 14 participants, the results give interesting insights into the views of a diverse group of upper primary science teachers. Hopefully this contribution will be useful for further research on teacher roles and their interplay with science teaching practices.

Teachers' experiences of teaching science

Most of the teachers shared a view of science teaching as fun. For example, Frida and Fia identified the variety offered by practical work as the main source of this positive attribute. An interesting observation was that the most experienced teachers appeared less excited about the creative opportunities

offered by practical work. Like Supovitz and Turner (2000), we were unable to find specific causes for this phenomenon. Several teachers seemed to view practical work as a valuable break and a welcome interruption in daily classroom routines, rather than emphasizing it as an essential aspect of science. This contrasts with Appleton's (2002) finding that primary teachers tend to portray practical work as an activity which must always produce correct or incorrect results, thereby including scientific correctness as an important feature. Whether the teachers actually use practical work in class, or rather like the idea of doing so or at least talk about doing so, remains unclear since interviews and surveys provide one piece of the puzzle but do not offer detailed information about actual classroom teaching practices (cf. Lidar et al., 2019).

Most of the teachers agreed with Anders that a large proportion of work-related stress is caused by the same practical work that many considered to be what made science fun. While a majority of the teachers called for opportunities offered by laboratory rooms, it was notable that Frida and the other teachers with access to such facilities seldom used them due to pragmatic reasons. The difficulties of establishing and maintaining the necessary equipment in upper primary school remain despite being a well-known problem (Milner et al., 2012; Appleton, 2002). Primary schools' current conditions stand in stark contrast to those in secondary school, and there is a risk that the stress brought on by lack of time, equipment and suitable facilities contributes to reducing practical work. This was also expressed by many of the teachers who claimed to be willing to do practical work but lacked the time to do it properly. Since practical work simultaneously constituted the main reason why the teachers considered science fun to teach, this course of events could prove unfortunate. The persistent lack of time invested in primary school science indicates that previous research pointing to science education suffering from low prioritization (Skolinspektionen, 2011; Tytler, 2010) has had little impact.

Teachers' descriptions of their science teaching practice

All the teachers expressed views and described practices indicative of The Encyclopaedia being a common role in upper primary science. The Encyclopaedia harbours a traditional view of science accompanied by a feeling of necessity to master all factual content beforehand. It is not necessarily manifested in class through the expository teaching previously observed in the roles of transmitter (Fradd et al., 1999), preacher (Tobin, 1993) and dispenser (Chen et al., 2017; Zhai et al., 2015). Nevertheless, this traditional view of science was strikingly well established among these upper primary teachers. An emphasis on students' development of the fact ability (cf. Leden et al., 2019) seemed just as important as it has traditionally been in secondary school science. Whether this view is expressed through presentational-style teaching or other practices remains unclear, but it raises some concern regarding the quality of hands-on tasks in primary school as pointed out by Tytler (2010). Perhaps Lidar et al. (2019) are closer to reality in their finding that Grade 6 science is mostly taught through whole-class seatwork. This would partly explain why teacher descriptions revolved around talk almost as much as practical work. It was not apparent how the teachers organize activities involving talk. However, repeated mention of talk as a way to ensure students' understanding of terms provided a hint about the purpose being clarification and consolidation of facts rather than to offer opportunities to practice discussing scientific issues in order to develop the discussion ability (cf. Leden et al., 2019). Anders described the latter as difficult, if not impossible, with younger students. In accordance with elementary teachers surveyed by Milner et al. (2012) he suggested that this might be better suited for secondary school. Grade 6 teachers claimed to have changed their science teaching practices by including more activities to help students develop the discussion ability (Lidar et al., 2019). In the present study, however, many of the teachers seemed to either find this ability too difficult at these Grade levels or assume that development of reasoning skills does not require much planning. It rather just happens as part of other classroom work. For example, facilitated through the role of The Flexible Opportunist, which Frida appears to use occasionally. A possible reason for this discrepancy is that the teachers' view of the importance of upholding the role of The Encyclopaedia reduces their willingness to conduct discussions, since these risk leading the students into areas where the factual content is perceived as too difficult.

Several teachers conveyed the same insecurity around science content that has previously been expressed by elementary teachers (Milner et al., 2012). Combined with the view of teachers as Encyclopaedias, it paves the way for an unfavourable development of upper primary school science. The frequently mentioned use of textbooks suggests that fact-based practices may already be established. Relying on textbooks for support, rather than introducing uncertainty into the classroom by acting as The Flexible Opportunist or The Participant, is a more secure alternative for classroom management as proposed by Tobin (1993) and Leden et al. (2019). This could, however, result in failure to offer opportunities for students' interest to fully develop, further reducing the prospects for future success in science, as feared by both Anderhag et al. (2016) and Tytler (2010). In accordance with findings from Chen et al. (2017), we believe that this might be especially true if teachers simultaneously include the role of The Enabler, hence inadvertently preventing students' engagement in higher-level cognitive thinking.

Three of the roles found in this study connect particularly well with practical work but in different ways. A teacher acting as The Inspirer uses practical work to appeal to and increase student interest in science. This role has not been noted in previous observation studies and one might ask if this is a role that teachers wish to adopt, and if so, how could they work in the classroom to actually fulfil the role of The Inspirer? The Entertainer, previously described by Tobin (1993), prefers using happenings to offer students something fun. The difference between these two might seem obvious, but observations are required to examine if the accompanying teaching practices differ, and if so how. In comparison, The Participant stands out and proved to be as rare in this study as previously described by Chen et al. (2017). In fact, the only teacher to express views and practices associated with it was Fia. Joining the students in their quest by being a true novice is a practice that might slightly separate The Participant from similar roles defined in previous observations studies (cf. Chen et al., 2017; Zhai et al., 2015). Both Chen et al. (2017) and Zhai et al. (2015) describe a teacher who deliberately withholds information from students to elicit engagement. As opposed to that, Fia distinctly stated that she doesn't know the result and is just as curious as her students while conducting certain tasks. This slight divergence in role interpretation may indicate substantially different teaching practices, and The Participant could possibly be a suitable teacher role for increasing students' higher-order cognitive thinking by allowing greater agency (cf. Andersson & Gullberg, 2014).

In this study we examined teacher views on science teaching and listened to their own descriptions of their practices. Practical work and difficult content were at the heart of their split view of science as both fun and demanding. In agreement with both Milner et al. (2012) and Tobin (1993), we believe that the findings of this study on views of teaching practices and accompanying teacher roles have strong potential as a tool to bring about significant changes in science education. For this to happen the roles, as manifested in classroom practice, need to be further investigated and, above all, introduced and discussed among teachers.

REFERENCES

Aikenhead, G. S. (2006). *Science education for everyday life: evidence-based practice*. New York: Teachers College Press.

Anderberg, E., Danelius, L., & Nordheden, I. (2010). *Skolans mellanår: språkutveckling, undervisning och ledarskap*. Lund: Studentlitteratur AB.

Anderhag, P., Wickman, P., Bergqvist, K., Jakobson, B., Hamza, K., & Säljö, R. (2016). Why Do Secondary School Students Lose Their Interest in Science? Or Does it Never Emerge? A Possible and Overlooked Explanation. *Science Education (Salem, Mass.)*, *100*(5), 791–813. https://doi.org/10.1002/sce.21231

Andersson, K. & Gullberg, A. (2014). What is science in pre-school and what do teachers have to know to empower children? *Cultural Studies of Science Education, 9*(2), 275-296.

Appleton, K. (2002). Science Activities That Work: Perceptions of Primary School Teachers. *Research in Science Education (Australasian Science Education Research Association)*, *32*(3), 393–410. https://doi.org/10.1023/A:1020878121184

Braund, M. (2008). *Starting science – again? Making progress in science learning*. Los Angeles, Calif.: SAGE. dx.doi.org/10.4135/9781446220542.n2

Chen, Y., Hand, B., & Norton-Meier, L. (2017). Teacher Roles of Questioning in Early Elementary Science Classrooms: A Framework Promoting Student Cognitive Complexities in Argumentation. *Research in Science Education*, *47*(2), 373–405. https://doi.org/10.1007/s11165-015-9506-6

Crawford, B. (2000). Embracing the essence of inquiry: New roles for science teachers. *Journal of Research in Science Teaching*, *37*(9), 916–937.

Fradd, S., & Lee, O. (1999). Research news and Comment: Teachers' Roles in Promoting Science Inquiry With Students From Diverse Language Backgrounds. *Educational Researcher*, *28*(6), 14–42. https://doi.org/10.3102/0013189X028006014

Fraser, B. J., Tobin, K., & Kahle, J. B. (1992). Learning Science with Understanding: in search of the Holy Grail?. *Research in Science & Technological Education*, *10*(1), 65-81.

Guest, G., MacQueen, K.M., & Namey, E.E. (2012). *Applied Thematic Analysis*. Thousand Oaks, California: SAGE Publications. https://dx.doi.org/10.4135/9781483384436

Kvale, S. (1997). *Den kvalitativa forskningsintervjun*. Lund: Studentlitteratur.

Leden, L., Hansson, L., & Ideland, M. (2019). The mangle of school science practice: Teachers' negotiations of two nature of science activities at different levels of contextualization. *Science education (Salem, Mass.), 104*(1), 5-26. doi:10.1002/sce.21553

Lidar, M., Engström, S., Lundqvist, E., & Almqvist, J. (2019). Undervisningstraditioner i naturvetenskaplig undervisning i relation till svenska utbildningsreformer i skolår 6. *Nordina: Nordic studies in science education, 15*(2). https://doi.org/10.5617/nordina.5893

Lindahl, B. (2003). *Lust att lära naturvetenskap och teknik? En longitudinell studie om vägen till gymnasiet*. Göteborg: Acta Universitatis Gothoburgensis. https://gupea.ub.gu.se/handle/2077/9599?locale=sv

Luft, J., & Wong, S. (2014). Connecting teacher beliefs research and policy an overview and potential approaches. In *The Role of Science Teachers' Beliefs in International Classrooms: From Teacher Actions to Student Learning*. https://doi.org/10.1007/978-94-6209-557-1_9

Marton, F., & Booth, S. (1997). Learning and awareness. Mahwah, N.J. Erlbaum.

Milner, A., Sondergeld, T., Demir, A., Johnson, C., & Czerniak, C. (2012). Elementary Teachers' Beliefs About Teaching Science and Classroom Practice: An Examination of Pre/Post NCLB Testing in Science. *Journal of Science Teacher Education*, *23*(2), 111–132. https://doi.org/10.1007/s10972-011-9230-7

Mortimer, E., & Scott, P. (2003). *Meaning making in secondary science classrooms*. Open University Press.

Skolinspektionen. (2011). *Fysik i mellanåren: bortgömt men inte bortglömt. Rapport om undervisningen i fysik i de mellersta grundskoleåren*. Stockholm: Skolinspektionen. https://www.skolinspektionen.se/beslut-rapporter-statistik/publikationer/kvalitetsgranskning/2011/fysik-i-mellanaren--bortgomt-men-inte-bortglomt/

Skolinspektionen (2018). *Årsrapport 2017. Strategier för kvalitet och helhet i utbildningen*. Stockholm: Skolinspektionen. https://www.skolinspektionen.se/beslut-rapporter-statistik/publikationer/regeringsrapporter/2018/arsrapport-2017---strategier-for-kvalitet-och-helhet-i-utbildningen/

Stigler, J. W., & Hiebert, J. (2009). *The teaching gap: best ideas from the world's teachers for improving education in the classroom*. New York: Free Press.

Supovitz, J. A., & Turner, H. M. (2000). The effects of professional development on scienceteaching practices and classroom culture. *Journal of Research in Science Teaching, 37*(9), 963-980. doi:10.1002/1098-2736(200011)37:9<963::AID-TEA6>3.0.CO;2-0

Swedish National Agency for Education (2018). *Curriculum for the compulsory school, preschool class and school-age educare 2011: revised 2018*. Stockholm: Swedish National Agency for Education (Skolverket).

Swedish Research Council. (2017). *Good Research Practice*. VR1710. Stockholm: SwedishResearch Council.

Tobin, K. (1993). Metaphors and images in teaching. In B.J. Fraser (Ed), *Research Implications for Science and Mathematics Teachers. Volume 1. Key Centre Monograph Number 5*. National Key Centre for School Science and Mathematics, Curtin University of Technology, Perth, Western Australia, Australia.

Tytler, R. (2010). *Ways forward for primary science education: a review commissioned by the Swedish National Agency for Education*. Deakin University, Melbourne, Vic. http://dro.deakin.edu.au/eserv/DU:30032184/tytler-primaryscience-2010.pdf

Zhai, J., & Tan, A. L. (2015). Roles of teachers in orchestrating learning in elementary science classrooms. *Research in science education*, *45*(6), 907-926.