Birgitte Lund Nielsen is associate professor at VIA University College, Teacher Education in Aarhus, and is currently working towards a PhD in Science Education at Aarhus University. Her research interest is science teachers' professional learning seen as a continuum from pre-service teacher education to in-service professional development. Birgitte has a background in teaching lower secondary Physics & Chemistry and Geography and she has master degrees in Geology and in Science Education.

BIRGITTE LUND NIELSEN
Centre for Science Education, Aarhus University and VIAUC Teacher Education in Aarhus, Denmark
E-mail address: bln@cse.au.dk

A cohort of novice Danish science teachers: Background in science and argumentation about science teaching

Abstract
A survey on science background and argumentation about science teaching was conducted on a local cohort of newly qualified Danish science teachers. The survey was administered before the novice teachers began their first jobs in primary and lower secondary schools and focused on their reflections on specific scenarios of science teaching and themselves as teachers in various science fields. Three areas of concern were identified: There was evidence of reflection upon and argumentation for the practice of science teaching being stundent centred, but many respondents showed a tendency to focus on students' activities as a goal in themselves, few considered what the students learned through the activities. Results furthermore suggest that the teachers' own assessment of their subject matter knowledge in the physics field may, for a large subgroup in the cohort, affect their approach to teaching science.

Introduction
A decline in young Europeans' interest in science during education and as a career has been widely discussed and recent policy documents recommend reforms in the approach to how science is taught in the school system (Rocard et al., 2007; Osborne and Dillon, 2008). Children's early experiences with science are crucial and teachers play a significant role in determining students' attitudes to school science and their subject choices, in fact teachers are claimed to be *the* single most important factor in relation to the quality of science education (Osborne, Simon and Collins, 2003). In Denmark, as in the other European nations, reforms in the teaching of science are discussed (e.g. Andersen, 2008), but there is a lack of local research that focuses on science teachers' backgrounds and approaches to science teaching. Much of the international research involves university trained secondary science teachers while teachers for Danish primary and lower secondary schools are trained in integrated university college (UC) programs. Students entering the Danish UC teacher education programs have been referred to as having a humanistic profile and concerns have been raised about graduation of too few teachers with a science specialization and that those who graduate have too little science subject matter knowledge (Andersen, 2008). A recent reform aiming to strengthen science led to raised admission requirements in the UC programs, with the immediate result that around 40 % fewer students specialized in science (Kristensen, 2009). There is already a lack of science teachers, so there is definitely a need for further reforms and for more knowledge about Danish UC trained science teachers. What is their background in science and their thinking about science teaching and themselves as science teachers?

Background

Science teachers' knowledge, beliefs and orientations

The work of science teachers is complex, dynamic and requires lots of decision making, as well as knowledge. Pedagogical Content Knowledge (PCK) has for the last 25 years been used as a construct to identify teachers' professional knowledge (e.g. Shulman, 1986, Abell 2007; Berry, Loughran and van Driel, 2008). PCK is highly content and context dependant. The aim of this study is a broad characterization of Danish science teachers' background, not to understand in depth the PCK of a single or a few teachers in reference to a specific science sub-area, as is the case with many studies in the ongoing PCK research. But the fundamental understanding is that learning to teach involves integrating and transforming different kinds of knowledge: Pedagogical Knowledge (PK), Subject Matter Knowledge (SMK) and Knowledge about Context.

It has been suggested that teachers' beliefs may be even more important than knowledge when making decisions in the classroom. Teachers may have similar knowledge, but teach in very different ways, and their beliefs can form a somewhat tacit, but still decisive conceptual map for instructional decision-making (Pajares, 1992). Later research has further investigated the complex relationship between teacher beliefs, which are mental, and their actions in the social arena, for example in relation to using inquiry in science teaching (Wallace and Kang, 2004). A simple causal relationship between beliefs and actions in the classroom cannot be assumed, but the importance of teacher beliefs in relation to their professional decision-making is widely acknowledged, and beliefs are considered a central component of PCK (e.g. Magnusson, Krajcik and Borko, 1999; Friedrichsen and Dana, 2005).

Teachers' approach to students' inquiries

Beliefs about the purposes and goals of teaching science at a particular grade level have been referred to as *orientations* towards science teaching and various orientations have been identified in literature i.e. process, conceptual change, activity-driven, discovery, project based, inquiry and guided inquiry (Magnusson et al., 1999). Research has revealed that prospective and practicing teachers often show a mix of orientations when arguing about various examples of science teaching, so it can be difficult to build up a precise profile for any *individual* teacher (Friedrichsen and Dana, 2003; 2005). But teachers' arguments and reflections about science teaching based in the interplay between their PK, SMK and personal beliefs and experiences might still show an *average* picture of a prevalent *student centred conception* of science teaching versus *a teacher centred conception* and an *activity driven orientation* versus *a transmission orientation* (Abell and McDonald, 2006; Abell, 2007). These orientations can be seen in a continuum where one extreme is the transmission orientation with the teacher as a dispenser of knowledge and students as passive receivers working with teacher specified activities, the other a student centred conception, with the extreme of seeing the teacher as a coach and facilitator and the student as a self-directed learner (Anderson, 2007). A tri-partition is used in other studies: A traditionalist teacher (transmission), a process oriented teacher, who focuses on scientific methods and experimental knowledge, and a constructivist teacher, who helps students construct knowledge (Tsai, 2002).

In contemporary research and policy papers the main challenge for reforming science in school is identified as the widespread use of the transmission orientation meaning that science teachers take a chalk and talk approach instead of a more inquiry-oriented approach (Rocard et al., 2007; Osborne and Dillon, 2008). But focusing only on this challenge might simplify the issue. Studies involving primary science teachers have highlighted a somewhat opposite problem, a purely activity-driven orientation with students spending a lot of time doing science, but little time thinking, talking, posing questions, or constructing explanations, with the goal of making science interesting, enjoyable and fun, but without much focus on what was learned (Abell and McDonald, 2006). Elementary teachers may be convinced of the value of hands-on-activities, but are not always able to develop science content from these exercises and may not even be aware of *what* science students are supposed to learn from the activities (Levitt, 2002). Furthermore there appears to be a widely held lack of confidence among primary science teachers lodged in their own negative experiences as learners and a lack of confidence with their own SMK (Abell, Bryan and Andersson, 1998; Johnston and Ahtee, 2006). Meanwhile secondary Physics and Chemistry teachers seem more confident having typically experienced success themselves in their subject area in the existing educational environment (Tsai, 2002).

These results indicate that there might be decisive differences between the orientations toward science teaching and beliefs about yourself as a science teacher held by university educated secondary science teachers, who has been informants in many studies, and UC trained teachers, where less is known. This led to the following research questions:

Research Questions

1. What characterizes new Danish UC trained science teachers' science background?
2. How do new Danish UC trained science teachers reflect on themselves as science teachers?
3. How do new Danish UC trained science teachers reflect on science teaching?

Methods

Sample

Informants constitute the full local cohort of novice science teachers who graduated in June 2009 from a UC teacher education in Denmark (n=110). The training at the UC offers four science specializations: Biology, Physics & Chemistry, Geography and Science & Technology; the three first are identical to subjects taught in lower secondary, grade 7-9, while Science & Technology is integrated primary science, grade 1-6. The cohort in this study entered *before* the reform mentioned above and can be seen to represent a typical cohort of science teachers in the school system at the moment.

Data collection

Data was collected through a semi-structured web-based questionnaire, containing single item questions revealing background information, but with central questions seeking open ended, word based answers due to the exploratory character of the study. The questionnaire was administered at the end of training, but before the informants started their career as teachers. Data include answers about background in science, considerations about themselves as science teachers in various fields and reflections on a range of short *science teaching scenarios* (Friederichsen and Dana, 2003). Friedrichsen and Dana used science teaching scenarios as tools for helping teachers articulate their knowledge and beliefs during interviews. From their range of scenarios for elementary and middle school seven were chosen as central to the Danish curriculum. The scenarios, slightly refined to fit into a Danish context, are shown in table 1. The question following the scenarios was*: Is this an approach you would consider taking? It is very important that you substantiate your arguments and that you write what you think is positive/negative in the scenario compared to your conception of science teaching.*

Responses

The questionnaire was piloted and refined before final data collection. The response rate was 79%; 87 informants completed the full questionnaire. The division on the various specializations are shown in table 4 below. The gender division is 52 % male/48 % female: Physics & Chemistry 70/30, Biology 54/46, Geography 42/58 and Science & Technology 45/55. 'No replies' are distributed over all four specializations and are gender neutral.

Table 1: Science teaching scenarios used in the study. Reference to the Danish curriculum: Undervisningsministeriet, 2009.

Scenario	**Which parts of this scenario might be expected to trigger in reflections?**
1: Students in a 3rd grade Science & Technology class observe earthworms and generate questions and hypotheses about earthworms' behaviour based on their observations. Each group designs and carries out an experiment to test their hypotheses.	○ Phrasing pointing to inquiry based methods in science is used: generate questions, hypotheses, observation, experiment, test ○ Group work ○ Life science ○ Curriculum, Science & Technology: Ways of working and thinking in science: *formulate questions, pose hypotheses* and *animals and plants in the world near to you*
2: Students in a 9th grade Geography class work on a project about clean drinking water, which they are going to present in class. You as a teacher help with various materials, but the groups organize their own work.	○ Phrasing pointing to inquiry based methods in science is not used ○ Project work ○ Teacher as a facilitator ○ Earth science/environmental science ○ Curriculum, Geography, Biology *and* Physics & Chemistry: *describe the water cycle in nature*. Geography: *clean drinking water as a (global) resource*
3: You are teaching a unit about space and the solar system in a 6th grade Science & Technology class. The students read to the class about the various planets in the solar system and you take notes on the whiteboard in the class.	○ Phrasing pointing to inquiry based methods in science is not used ○ Whole class teaching ○ Teacher centred ○ Curriculum, Science & Technology: Ways of working and thinking in science: *reading in science, concepts/language* and the world far from you: *the solar system*
4: Students in an 8th grade Biology class choose a subject to explore according to their own interest. One student uses library books to research information on whales while another student sets up an investigation with experiments to study bread moulds.	○ Phrasing pointing to inquiry based methods in science: Explore ○ Students' individual work ○ Interest based ○ Life science ○ Curriculum, Biology: Ways of working and thinking in science: *design and explore* and *read and understand information*
5: Your students in 7th grade Physics & Chemistry are intrigued with a toy water rocket that a classmate has brought to school. As a group the students identify questions and experiments to explore how the rocket works. You help with the organisation and you investigate along with the students.	○ Phrasing pointing to inquiry based methods in science: identify questions, experiments, explore, investigate ○ Group work ○ Teacher as a co-investigator ○ Physical science ○ Curriculum, Physics & Chemistry: *describe and explain examples of energy-transfer in everyday and technical contexts,* ways of working and thinking in science: *formulate simple problems*
6: In a 2nd grade Science & Technology class you are presenting important information about separation of waste and recycling.	○ Phrasing pointing to inquiry based methods in science is not used ○ Teacher centred ○ Transmission ○ Environmental science ○ Curriculum, Science & Technology: *give examples about recycling and be able to sort waste*
7: In an electricity unit in 4th grade Science & Technology you give students batteries, bulbs and wires. You encourage the students to find all the possible ways to light the bulb.	○ Phrasing pointing to inquiry based methods in science is not used, but inquiry based methods are indicated ○ Teacher as facilitator when students explore ○ Physical science ○ Curriculum, Science & Technology: *Give examples of how we produce electricity, examine and describe everyday issues like electricity*

Table 2: Data-based categories and codes

Category	Description	Codes	Quotations
Teachers' argumentation about teaching in a certain science field			
Subject specialization	Argumentation is about their science specialization in teacher training	Positive because of specialization (PSS)	*Yes-this is my subject specialization*
		Negative because of lack of specialization (NSS)	*I do not have biology as a subject specialization*
Interest	Argumentation is about their personal interest in this field of science	Positive because of personal interest (PI)	*The best subject in the world! A subject where I am really burning.* *I find this subject interesting*
		Negative because of lack of personal interest (NI)	*This is a subject which since my own school time did not appeal to me*
Student Age	Argumentation is about the age of the children who have this subject in the school system	Positive because they would like to teach this age-group (PSA)	*I will look forward to teaching students of this age group*
		Negative because they would not like to teach this age-group (NSA)	*I would like to avoid teaching children below 6^{th} grade*
Subject Matter Knowledge	Argumentation is about their own subject matter knowledge	Positive because they think they know something in this field of science (PSMK)	*I think I have a fair amount of knowledge to teach this subject*
		Negative because of lack of subject matter knowledge (NSMK)	*I know nothing about Physics.* *This is my weak side, and I would fail as a teacher if I had to teach it.*
Teachers' reflections and argumentation on the scenarios			
Students' motivation	The main argumentation surrounds whether students are motivated and interested or not.	Positive about students' motivation	*This is a really motivating approach*
		Doubtful if this is motivating for students	*This depend on whether the group is motivated by the work*
		Negative about students' motivation	*You could work with this in a much more interesting way*
Students' self-regulation	The main argumentation is about if – and to what degree the school students are able to regulate their own work	Positive about students' self-regulation	*They are going to find the results themselves* *9^{th} grade know how to work on their own*
		Doubtful about students' self-regulation	*I would use such an approach to a certain degree being aware that some students have problem with self motivation*
		Negative about students' self-regulation	*It would be dangerous to take such a free approach*
Students' activity	The main argumentation is about students being active or passive	Positive because students are active	*It is good to have active students*
		Doubtful because students are too passive	*This I would consider doing but I would supplement with letting students sort real garbage*
		Negative because students are too passive	*Students are not active themselves in this case* *Students should not read about it, they have to go out and do*
Nature of Science	The main argumentation refer to students' experiments, hypotheses and scientific methods	Positive arguments	*Good with the scientific approach, that they have to pose a hypothesis*
		Doubtful arguments	*Students need an introduction so they know the concepts hypothesis and experiment*
		Negative arguments	*Students are too young to be able to pose a hypothesis*
Pedagogical theory	Arguments which refer to specific pedagogical theories, 'Bildung' or democracy in education	Positive arguments	*'Bildung' is a part of this* *A project oriented approach* *This is good democratic learning*
		Doubtful arguments	*I would take a project-oriented approach instead of group-work*
		Negative arguments	*I do not believe in this learning style*
Teachers' (lack of) subject matter knowledge	Arguments which refer to their own level of subject matter knowledge in this field of science	Positive	(no examples)
		Doubtful to consider this because of their lack of knowledge	*In principle I do not know much about this, but*
		Negative because of their lack of knowledge	*This sounds dangerous, I have no subject matter background to answer the question* *No I do not feel competent enough*

Analysis

Open answers were approached as qualitative data using methods from content analysis and open coding (Cohen, Manion and Morrison, 2007). The arguments about teaching a certain science field were coded as either positive or negative and according to the following four categories (table 2):

- Teachers' subject specialization
- Teachers' personal interest
- Students' age
- Teachers' subject matter knowledge

Through the same procedure of open coding six categories were developed to describe the teachers' reflections and argumentation on the scenarios (table 2):

- Students' motivation
- Students' self-regulation
- Students' activity
- Nature of Science (NoS): students' experiments and hypotheses and scientific methods
- Pedagogical theory of a general character (not from the field of science education)
- Teachers' subject matter knowledge

Each category was subdivided into positive, doubtful and negative. Coding was done separately by two researchers, inter coder reliability was more than 80% from the beginning and afterwards coding with incongruence was refined. There are examples of arguments referring to more than one category, but in the final coding all reflections could be coded in one of the categories in a reliable way referring to the *main* argumentation.

Acknowledging the diffuse character of teacher orientations the open coding of the scenarios was supplemented with two kinds of theory-informed coding (table 3).
Firstly, reflections were separated in process-oriented arguments, constructivist oriented arguments and arguments pointing to a traditionalist approach (Tsai, 2002). Through this analysis a category describing argumentation with *both* 'hands on' (process-oriented) and 'heads on' (constructivist) reference was separated, arguments which refer to inquiry as including the learners scientifically oriented questions, explanations, communication and justification (Abell and McDonald, 2006; Bybee, 2006).

Secondly, student-centred and teacher-centred arguments were identified to underpin a discussion of how reflections may be seen in reference to the continuum of orientations (Anderson, 2007). Student-centred reflections were sub-divided into arguments referring to students' learning and other student-centred arguments. Reflections referring to what students may learn through a certain teaching-approach were seen to differ from arguments for example being backed by something being a good idea while students were active. This subdivision acknowledges that a teacher's focus on how and what students learn is seen as decisive in contemporary research on teachers' professional development (e.g. Borko, 2004). In these two coding procedures some of the reflections were coded as 'other arguments' as it was not possible to place them in a particular category.

Table 3: Theory-informed codes

Codes		Description	Quotations
Teacher orientations I			
Process-oriented		Science is best taught by focusing on the processes of science or problem-solving procedures. Descriptors: teaching the scientific method; following problem-solving procedures; experiencing the processes of (self) discovery; working on the processes of verification (Tsai, 2002, p.774)	*It is motivating to take an…experimenting approach* *Good with the practical element and the scientific approach* *The scientific method is decisive and exemplary*
Constructivist		Science is best taught by helping students construct knowledge Descriptors: Helping students make interpretations; providing authentic experiences; interacting with students; encouraging discussion and cooperative learning; paying attention to students prior knowledge or misconceptions (Tsai, 2002, p.774)	*This is a good constructivist approach where students construct their knowledge* *It is important that students pose their own questions and starts their investigation from there* *I presume focus will be on students' pre-conceptions*
Traditionalist		Science is best taught by transferring knowledge from teacher to students (Tsai, 2002, p.774)	(no examples)
Integrated (hands on & heads on)		Integrated inquiry involves learners in the collaborative social practice of doing science and communicating about their doing and thinking (Abell and McDonald, 2006, p.250)	*students are using their hands and you can add theory while they are working and afterwards* *a good approach where the foundation is the student's experiments. The teacher of course has to follow up on students' experiences*
Teacher orientations II			
Teacher-centred		A focus on what the teacher does in the argumentation. The extreme is teacher as dispenser of knowledge and students as passive receivers (Anderson, 2007)	*I think it is important to tell student how the society works*
Student-centred	Students' learning	A focus on how the students learn in the argumentation. (an important part of teachers learning: e.g. Borko, 2004)	*Students learn by posing hypotheses and trying them out*
	Student centred	A focus on what the students do in the argumentation. The extreme is seeing students as self-directed learners (Anderson, 2007)	*Students at this level can organize such a work themselves*

Results

Science background

Based on information given about upper secondary education the cohort can be divided into two groups: High level background before teacher training or low level background. This is based upon *how much* science they took in upper secondary: A, B or C level, not on their marks (table 4).

In Danish upper secondary school (gymnasium) an A level is 3 years, a B level 2 years and a C level is 1 year of a particular subject. Combinations of levels of science subjects coded as high level are AA, AB, ACC, BBC or BCC. The % is based on the 87 teachers who completed the full questionnaire. The division across the four specializations is shown in numbers. Eleven of the teachers have opted for two science specializations in teacher training.

The result of making this rough division shows that 30% of the cohort had a high level background. 63 % of the teachers specializing in Physics & Chemistry in teacher training have a high level background, while the majority of the new teachers with Geography, Biology and Science & Technology specializations have only basic mandatory background in science from upper sec-

Table 4: Background in science from upper secondary school before beginning teacher training.

Specialization in teacher training → / **Background in science** ↓	**Physics & Chemistry** (21 teachers)	**Science & Technology** (19 teachers)	**Biology** (21 teachers)	**Geography** (37 teachers)	**Average**
High level science from secondary school	63 %	31 %	24 %	21 %	30 %
Low level science from secondary school	37 %	69 %	76 %	79 %	70 %

ondary school. This result is supported by the fact that nearly half of the informants specifically emphasize their humanistic background in an open category at the end of the questionnaire. 57% of the respondents reported their teacher identity attached to other areas than science. Physics & Chemistry teachers dominated when it came to identity as science teachers and also in relation to interest in science from their own school background. Some teachers, especially Biology teachers referred to interest in the nature/outdoor part of science in particular.
The gender division in high/low level background nearly follows the general gender division in the various specializations, for example 30 % of the ones who have high level background and Physics & Chemistry are female: so in each specific specialization high/low level background is gender neutral.

Reflections on themselves as science teachers

When asked if they want to teach in a certain science field all the teachers obviously expressed a preference to teach their own specialization, but more teachers were prepared to teach Science & Technology, Geography and Biology without having a specialization in contrast to Physics & Chemistry (table 5 a). 25.9 % state that they will say yes if asked to teach Physics & Chemistry, which is more or less the same percentage (24%) as those specialized, whereas 64.7 % would say no.

When analyzing what kind of argumentation the teachers use to back why they do or do not want to teach in the various fields, two kinds of representations are used in table 5. 67.3 % of the arguments for not wanting to teach Physics & Chemistry refer to lack of SMK (table 5 a). This is also the main category for Biology. Those without a specific background in Biology, but who would be prepared to teach it refer to personal interest (26.9 %). The same kinds of comments are made for Geography. Students' age is an issue especially when arguing about Science & Technology (primary science); 19.5 % are negative because of students' age, while 9.8 % are positive with reference to students' age. Table 5 c confirms significant difference between arguments used about wanting or not wanting to teach in the four science fields.

When looking into how teachers with various specializations argue on *all* fields summed (table 5 b) there is a partition in the cohort where arguments grounded in lack of SMK are expressed most by teachers with Geography (37.2 %) and Science & Technology (36.0 %), to a lesser degree by teachers with Biology (9.6 %) and only occasionally by teachers with a Physics & Chemistry specialization (2.3 %). There is significant difference between teachers with Physics & Chemistry versus Geography and Science & Technology, and also between teachers with Biology versus Science & Technology (table 5 c).

Table 5: Arguments used when reflecting on whether you want to teach various science subjects. P is positive arguments, N is negative arguments. SS=Subject Specialization, I=Interest, SA= Students Age, SMK=own Subject Matter Knowledge. All numbers are in %. Table 5 a: Results from asking all teachers what their answer would be if asked to teach the various science subjects and why they gave this answer. Table 5 b: Results from summing the kind of argumentation (overall) used by teachers with each of the four specializations. The three dominant types of argumentation are shown in various grade of shading in both tables. Table 5 c: Chi-square test, p<0.05 is highlighted.

Table 5 a	**Teach Physics & Chemistry?** (24 % specialized)			**Teach Biology?** (24 % specialized)			**Teach Geography?** (43 % specialized)			**Teach Science & Technology?** (22 % specialized)		
Arguments used ↓	Yes	Maybe	No	Yes	Maybe	No	Yes	Maybe	No	Yes	Maybe	No
	25.9%	8.2%	64.7%	32.5%	33.7%	30.1%	56.1%	26.8%	14.6%	53.1%	35.8%	11.1%
PSS	14.3 %			13.5 %			37.3 %			29.3 %		
PI	10.2 %			26.9 %			39.2 %			7.3 %		
PSA	-			-			-			9.8 %		
PSMK	-			7.7 %			3.9 %			24.4 %		
NSS	4.1 %			7.7 %			2.0 %			2.4 %		
NI	2.0 %			7.7 %			3.9 %			-		
NSA	2.0 %			1.9 %			2.0 %			19.5 %		
NSMK	67.3 %			34.6 %			11.8 %			7.3 %		
	100 %			100 %			100 %			100 %		

Table 5 b	Teachers with Physics & Chemistry specialization	Teachers with Biology specialization	Teachers with Geography specialization	Teachers with Science & Technology specialization
PSS	27.3	23.9	24.5	28.0
PI	41.0	34.8	17.0	10.0
PSA	2.3	4.3	3.2	4.0
PSMK	13.6	8.7	7.4	6.1
NSS	6.7	2.2	2.1	8.0
NI	4.5	4.3	3.2	2.0
NSA	2.3	2.2	5.3	6.1
NSMK	2.3	9.6	37.2	36.0
	100	100	100	100

Table 5 c			
Chi-square (df=7) From 5 a (*to teach*)		Chi-square (df=7) from 5 b (*teachers with*)	
P&C Bio	χ^2= 14.12 ρ=0.028	P&C Bio	χ^2= 9.996 ρ=0.996
P&C Geo	χ^2=33.34 ρ=0.000009	P&C Geo	χ^2= 15.525 ρ=0.029
P&C S&T	χ^2= 45.46 ρ=0.0000001	P&C S&T	χ^2= 20.044 ρ=0.005
Bio Geo	χ^2= 16.18 ρ=0.013	Bio Geo	χ^2=10.056 ρ=0.185
Bio S&T	χ^2= 36.99 ρ=0.000005	Bio S&T	χ^2= 14.482 ρ=0.043
Geo S&T	χ^2= 30.96 ρ=0.00006	Geo S&T	χ^2= 3.173 ρ=0.868

The teachers with Physics & Chemistry seem to feel more confident in teaching life and earth science as well. If they argue for not wanting to do it, their arguments are not about lack of SMK like examples from other teachers when referring to Physics & Chemistry:

> *"How could I possibly teach something I do not understand at all myself.*"

or about Science & Technology:

> *"I am not good in the physics part."*

When teachers with Physics & Chemistry do not argue about lack of SMK it might be due to their higher background from upper secondary (above), *but* Biology teachers do *not* have a similar background from upper secondary.

Reflections on science teaching

Results from analyzing teachers' reflections and arguments on the seven scenarios are shown in table 6. The results about arguments used most frequently, by *all* teachers for *all* seven scenarios are highlighted in the bottom row.

16 % of the argumentation is about students' motivation:

> *"A problem based approach is an excellent motivating factor."*

and 18 % about their self-regulation:

Table 6: Teachers' reflections on the seven scenarios. The coding of the type of main argumentation showing columns with the six categories, each category sub-divided into Positive (P), Doubtful (D) or Negative (S) and in a separate row summed % of argumentation in this category. In the last column the average is shown for each scenario. The most frequent argumentation is bold. In the last row the average for all teachers on all scenarios is shown. All numbers are in %.

Scenarios	P positive D doubtful N negative	Motivation	Self regulation	Activity	Pedagogy	Nature of Science	Subject Matter Knowledge	Average
Scen. 1 Earthworms	P D N	7.8 - -	4.3 - 4.3	15.5 - -	7.3 2.6 -	44.9 9.0 1.8	- - 2.5	**P 79.8** D 11.6 N 8.6
	Summed	7.8	8.6	15.5	9.9	**55.7**	2.5	100
Scen. 2 Drinking water	P D N	6.6 1.7 -	47.2 15.7 5.0	4.3 - -	16.1 - 1.7	- 1.7 -	- - -	**P 74.2** D 29.1 N 6.7
	Summed	8.3	**67.9**	4.3	17.8	1.7	-	100
Scen. 3 Solar system	P D N	- - 23.4	- - 2.5	- - 39.1	5.3 3.1 18.9	1.5 1.5 4.3	- - -	P 6.8 D 4.6 **N 88.6**
	Summed	23.4	2.5	**39.1**	28.1	6.9	-	100
Scen. 4 Biology project	P D N	11.5 2.6 -	32.4 11.7 -	- - -	14.3 19.6 1.8	1.8 3.5 1.8	- - -	**P 59.0** D 37.4 N 3.6
	Summed	13.1	**44.1**	-	35.7	7.1	-	100
Scen. 5 Water rocket	P D N	53.4 2.4 -	2.4 2.4 -	1.7 - -	13.6 3.9 -	10.5 - -	- 1.9 7.8	**P 81.6** D 10.6 N 7.8
	Summed	**55.8**	4.8	1.7	17.5	10.5	9.7	100
Scen. 6 Recycling	P D N	- - -	- - -	- 12.7 19.6	53.6 8.9 3.6	- - -	- 1.6 -	**P 53.6** D 23.2 N 23.2
	Summed	-	-	32.3	**66.1**	-	1.6	100
Scen. 7 Light the bulb	P D N	10.2 - -	3.7 0.9 -	41.1 - -	5.5 0.9 -	10.4 5.8 1.9	- - 19.3	**P 71.2** D 7.6 N 21.2
	Summed	10.2	4.6	**41.1**	6.7	18.1	19.3	100
All teachers on all scenarios	P+D+N	**16**	**18**	**22**	**25**	**14**	**5**	**100**

"Students at this level can organize such a work themselves."
Students' level of activity is used as a warrant in 22 % of the argumentation. Positive arguments in this category are about active school students whereas negative and doubtful arguments are about students being too passive. Main argumentation referring to NoS:
"Posing hypothesis and trying them out."
comprises 14 %.

Table 7 and 8 show analyses for all arguments on all scenarios coded according to table 3.

Table 7: Type of argumentation, all teachers on all scenarios, divided in teacher-centred versus student-centred argumentation.

Teacher-centred	Student-centred		Other (cannot be categorized)
	Students' learning	Other student-centred	
29 %	9 %	45 %	17 %

Table 8: Type of reflections, all teachers on all scenarios

Process-oriented	Constructivist	Traditionalist	Integrated (hands on + heads on)	Other (can not be categorized)
21 %	41 %	0 %	5 %	33 %

More than half the arguments indicate a student-centred focus (table 7), but positive arguments about students' activity or negative arguments about passive students are not often associated with students' learning or lack of learning, only 9 %.

In table 8 referring to Tsai (2002) the main part of the argumentation, 41 %, indicates a constructivist view either explicit:

> *"This is a good constructivist approach where students construct their knowledge."*

or implicit according to the descriptors in the codebook in table 3:

> *"The special focus on posing questions can be used to clear up the students' prior knowledge and their pre-conceptions and support the students."*

29 % is coded as process-oriented. This sort of argumentation focuses on scientific methods and problem solving. A small fraction of the process-oriented arguments explicitly mention what they call *the* scientific method, emphasizing one particular specific scientific method, one of the frequently mentioned misconceptions in the area of NoS. These teachers all have a Physics & Chemistry specialization and a high level background. 5 % of the arguments indicate an integrated approach to inquiry, where there is a reference to hands on as well as heads on:

> *"Students are using their hands and you can add theory while they are working and afterwards."*
>
> *"A good approach where the foundation is the student's experiments. The teacher of course has to follow up on students' experiences."*

Students formulating explanations from evidence, as in the contemporary understanding of integrated inquiry (Bybee, 2006; Abell and McDonald, 2006), is not mentioned but still, these arguments are different from arguments just referring to hands on activities.
There were no reflections indicating a transmission orientation (Tsai, 2002).

When looking further into the kind of argumentation used for the separate scenarios (table 6) in the case of scenario 1 (*students observe earthworms, generate questions and design an experiment*) 55.7 % of the teachers refer to NoS in their argumentation. This could be expected, while words like observation, hypothesis and experiment are explicitly used in the phrasing of the scenario. It might be more interesting that 32 % of the arguments refer to active, motivated, self-regulated students *without* mentioning hypothesis, inquiry or scientific methods. When comparing with scenario 7 *(find possible ways to light the bulb)*, where such phrasing is not as explicit, a smaller percentage of the arguments, 18.1 %, are categorized as referring to NoS. This scenario plus the earthworm scenario are where a small group of teachers with a specialization in Physics & Chemistry refer to *the* scientific method.

The bulb scenario and another referring to physics SMK (scenario 5: *the water toy rocket)* are where the reflections about lack of own SMK are concentrated, contrary to the scenarios referring to life science or earth science. 19.3 % of the teachers spontaneously refer to a lack of own SMK as a limitation when arguing about the bulb scenario. Except for the references to a lack of SMK, the argumentation about the water toy rocket scenario is mainly positive (81.6 %). Many positive reflections is about the teacher acknowledging the students' ideas, but the fact that the scenario refers to physics subject matter urges some of the informants to make certain reservations:

> *"This is a clear example of teaching starting where the students are interested, if only it was not about Physics & Chemistry!"*

In argumentation about scenarios 2 and 4 reference to students' self-regulation is frequently used (67.9 % /44.1 %). Most teachers are positive, but there are doubtful and negative arguments questioning whether students can handle the free approach. There are not many NoS arguments regarding these two scenarios, but some teachers argue that all students ought to include some kind of experiment in their projects.

In the scenario about recycling many arguments are about this being an important issue:

"Bildung in an early age."

"It is important to take care of nature."

"Bildung to global citizenship."

These arguments are coded as pedagogical arguments. This kind of argumentation refers to the so-called 'German didaktik tradition' (Duit, Niedderer and Schecker, 2007; Westbury, Hopmann and Riquarts, 2000). 'Bildung' stands for the formation of the learner as a whole person, and in this tradition content chosen must represent some general ideas, for example what the German educator Wolfgang Klafki calls epochal key problems: *the general as that which concerns us all in our epoch* (Westbury, Hopmann and Riquarts, 2000 p.104). 32.3 % of the reflections on this scenario are about the need for students' activity, not just the teacher telling, these arguments contribute to the doubtful and negative statements about the scenario. The reflections include concrete ideas for activities to teach recycling not just by telling.

The scenario gaining most negative responses (88.6 %) is the one about the solar system. 39.1 % back the argumentation on the fact that the students are not active, 23.4 % felt it was not motivating and 18.9 % pedagogical arguments suggesting other pedagogical approaches:

"This I would make project-oriented and it could be a cooperative project with arts."

To sum up, particular types of arguments are used more frequently in the argumentation about each of the scenarios, when it comes to whether the teachers are dominantly positive or negative, and the kind of argumentation used to back it. This confirms prior findings, that a single label cannot describe teachers' orientations (Friedrichsen and Dana, 2005). The 7 scenarios trigger in various ways the teachers' reflections, but there is an average picture of the main part of the argumentation being student-centred and about student activity, self-regulation and motivation. The lack of (positive) reference to own SMK, and what can be seen as relatively few arguments referring to NoS even when central in the phrasing of some scenarios is also interesting. The latter is further elucidated below where reflections are separated according to various specializations.

Variation between the specializations

The summed argumentation about scenarios is divided across the four specializations in table 9.

Table 9: Arguments used by the teachers in reflections on scenarios (summed) divided on specialization in teacher training. All numbers %. Average is calculated based on number of teachers with each specialization. Some results referred to are highlighted.

	Specia-lization ↓	Motivation	Self regulation	Activity	Pedagogy	Nature of Science	Subject Matter Knowledge	
Summed argumen-tation	P & C	19.4	19.4	16.1	24.7	20.4	0	100
	Bio	17.5	21.4	16.6	27.2	13.6	3.9	100
	Geo	15.9	18.1	21.8	25.4	11.3	7.5	100
	S & T	13.1	15.0	23.6	24.8	19.6	3.9	100

A Chi-square test shows significant difference in argumentation between Geography and Physics & Chemistry teachers (χ^2=11.71, df=5, ρ=0.038). Physics & Chemistry teachers never use the argument about lack of SMK and are more likely to ground their arguments in the field of NoS. The average above in table 6 is relatively much influenced by Geography teachers who comprise nearly double the number of Physics teachers in the cohort. Science & Technology teachers, besides having most reflections about activity, also seem to back their arguments in NoS more than Geography and Biology teachers. This is not significant (Geo/S&T: χ^2=10.06, df=5, ρ=0.071) but when dividing the analysis according to the Tsai categories (table 8) there is a significant difference between Geography and Science & Technology teachers (χ^2=13.79, df=3, ρ=0.003) and Geography and Physics & Chemistry teachers (χ^2=17.28 , df=3, ρ=0.0006). Physics & Chemistry and Science & Technology teachers use more process-oriented argumentation than Geography and Biology teachers (P & C: 41 %, S & T: 30 %, Bio: 27 %, Geo: 18 %).

Discussion and conclusions

The discussion will be organized starting with exploring the significance and going behind the results referring to the science teachers' background and reflections on themselves as science teachers and on science teaching, and from there move on to the great variation found in the cohort.

Science background and reflections on themselves as science teachers

The indications of *low efficacy beliefs* in many of the reflections may raise some concern (Bandura, 1997). Research suggests that SMK is an issue for being an effective science teacher, not more important for teacher effectiveness than knowledge of how to teach (e.g. Darling-Hammond and Youngs, 2002), but low self-efficacy might very well affect the way the teachers will teach primary science, and in the Danish schools a teacher is normally 'counted as' trained to teach primary science with *any* of the science specializations (the full cohort). Having low self-efficacy in the physics area they might try to navigate around letting primary school students experiment with simple electrical circuits, as made probably by some of the teachers' comments about the bulb scenario:

> *"This sounds dangerous."*
> *"I have no subject matter background to answer the question."*
> *"No I do not feel competent enough."*

A lack of belief in their own SMK in physics might therefore hinder these teachers in teaching primary science as it is described in the Danish curriculum; their PCK for teaching simple electrical circuits is affected. Furthermore low efficacy-beliefs about own SMK in the physics and chemistry area might potentially affect biology and geography teachers when teaching in some parts of *their own* specialisation, as indicated when a biology teacher states:

> *"My limitation in biology is connected to my lack of knowledge in the chemistry area."*

Variance in background in science before starting teacher training may play a role in the results showing that teachers with Physics & Chemistry are more prepared to teach out of specialization. *But* Biology and Physics & Chemistry teachers are the ones most alike in their way of arguing about teaching out of specialization (table 5 c) though they differ in background level, and when looking at the reflections on the scenarios it is notable that *none* of the teachers with Physics & Chemistry use NSMK arguments, *independent of background level, gender etc*. A clear conclusion on reasons for this pattern goes beyond the empirical background in this study, but self-efficacy as stated seem to be an issue, beside science background. The teachers' low efficacy beliefs attached to physics might go back to how they themselves have experienced different content fields when at school. Negative experiences as learners can result in negative attitudes and apprehension about especially physics teaching, as it is seen in other studies (Abell et al, 1998; Johnston and Ahtee, 2006). Such deeply founded (tacit) experiences might affect student teachers' choice of specialization, so those having negative experiences as learners do not choose 'hard science' (Physics

& Chemistry and apparently to some degree also Biology). This might also explain the need to explicitly specify, even when not being asked (in an open category) that they have a humanistic background.

Reflections on science teaching

The physics content is clearly seen as especially complicated and difficult, and earth science as easier to cope with. The nature of physics is according to Duit et al. (2007) partly the reason for this being experienced as difficult, counterintuitive and incomprehensible by learners. Physics thinking does not originate from observation of the world around us, but from the reconstruction of this world under the assumption of theoretical principles, this means a very high level of abstraction and idealization (Duit et al, 2007, p.605). In Duit et al. (2007) it is mentioned that especially girls perceive physics as complicated. Gender has only briefly been included in the discussion in this paper, while results have shown no clear differences. Female teachers are overrepresented among those that refer to lack of SMK, when reasoning about the scenarios; 40 % male/60 % female, compared to 52/48 in the cohort, but if taking teachers with Physics and Chemistry out, since none of them use this argument (male or female), it is nearly gender neutral as there are more male Physics and Chemistry specialists. Male teachers with Geography, Biology or Science & Technology use argumentation indicating low efficacy beliefs as much as female teachers, and those female teachers that have Physics and Chemistry seem to argue more like male teacher with this specializations than as female teachers with for example Geography.

To sum up: The teachers in this cohort are not alone in having experiences of physics as a complicated science field, but a large subgroup seems to have *so* low confidence in this area that it affects how they see scenarios of science teaching, even scenarios related to relatively simple physics subject matter.

In relation to orientations towards science teaching none of the novice Danish science teachers showed indications of a traditionalist transmission orientation in their reflections on the scenarios (Tsai, 2002; Anderson 2007). It is however important that what is seen is the newly qualified teachers' ideals (*what they say they want to do*), what they actually are going to do in complex and sometimes confusing classroom situations is beyond the scope of the study. Examples where teachers use a transmission approach though expressing a constructivist orientation are well known. Nevertheless the results confirm the hypothesis that the activity-driven extreme (Abell et al, 1998) is prevalent. In many of the reflections activities are assumed to make science interesting and motivating, with reference to what the students can *do*, not so often how the students *learn*; activities is seen as 'the sugar on the pill' (Zahorik, 1996). Science activities surely *are* important ingredients in contemporary science teaching, but talking science and using science related argumentation is *as* important *and* so is a specific focus on students learning of science, which is only seen to a small degree (Bybee, 2006, Abell and Mc Donald, 2006). In Andersons' continuum of orientations the average novice Danish science teacher is placed as having a student-centred conception, seeing the student as self-directed learner. This widespread tendency to consider students' motivation can in many ways be seen as a strength in this UC-cohort compared to the teacher-centred thinking about transmission of science seen in some research (e.g. Tsai, 2002), but the continuum of orientations might be better illustrated as a two- dimensional landscape where most Danish UC educated science teachers express student-centred beliefs, but focused on activity not learning.

To sum up: The results point to at least three important issues of concern when looking at the cohort in average: 1) the newly qualified teachers' reference to science subject matter, especially physics, 2) their expression of student-centred beliefs with hands on activities being *the* issue and 3) their (lack of) considerations about students learning.

Variation in the cohort

When discussing confidence as science teacher in as well physical science as earth and life science expressed indirectly in the readiness to teach out of specialization, rather clear patterns were found as stated above. Physics & Chemistry teachers in the cohort seem to be more alike the secondary teachers in the study of Tsai (2002) in the sense of feeling confident, while Geography and Science & Technology teachers are more alike the primary teachers referred to in other studies (e.g. Abell and McDonald, 2006).

To supplement these conclusions another way to illustrate the *great variation* found in the cohort is to use the thinking from Max Weber's ideal types: *idea-constructs* that can help put the chaos of social reality in order (Weber, 1997) to highlight some *extremes*:

- Teachers who have a high level background in science and identify themselves as *science teachers in particular*. They have mathematics as another specialization beside Physics and Chemistry. They state that their interest developed from their own school experiences and some explicitly express that they love physics. They mainly express a process orientation in the way they argue and some use the expression *the* scientific method.
- Teachers with a low level background in science, who typically use arguments about students' activities being *the* important thing in *primary science*, including process-oriented arguments with phrasings about students posing hypotheses etc. They might have chosen Science & Technology specialization, not so much to become a science teacher, but to be able to include science perspectives when working with primary school students and they emphasize activities especially useful in primary science teaching.
- Teachers with a low level background in science and an explicitly formulated *humanistic profile* as the background for choosing Geography. They do not *at all* see their teacher identity attached to being a science teacher and several express a lack of SMK in the physics area. They often use constructivist-oriented arguments, emphasize "bildung" in their argumentation and refer to students' motivation as backing in argumentation about self-regulated activities. They might have chosen Geography as a specialization based on interest in cultural and global issues.
- Teachers who value *outdoor activity* for themselves and as a pedagogical approach. Students' self-regulated activities are seen as important and many have sports as another specialization beside Biology. They might always have been interested in science, but not necessarily science in the school system, rather an interest in the 'nature part' of Biology, not 'the chemical part'.

It must once again be emphasized that such ideal-types are used to illustrate *the wide range* of science background and expressed beliefs about teaching and learning science. Many teachers in the cohort are somewhere in between these extremes.

Limitations, implications and perspectives

The present study has its limitations. The nature of the study has been highly explorative due to absence of existing research about Danish UC educated science teachers. In retrospect it might have been helpful to use additional cases/scenarios and qualitative in depth studies may be better suited to study teachers' beliefs and orientations. But regarding the aim to get an average picture, the findings have significant implications both in relation to pre-service and in-service training.

There is no easy way to meet the challenges concerning relatively low background in science and negative beliefs about own SMK, which can create a tension in the development of PCK. Raising admission requirements as in the reforms mentioned above is a reasonable political step, but there might be other ways. We might be able to support development of confidence alongside understanding of subject matter and development of (science specific) pedagogical skills building upon the competences and strengths shown for example in the basic student-centred thinking about teaching and learning science. A clearer understanding of the great variation among science teachers, and their associated needs, might also be used to understand how different student teachers and novice teachers might have different learning trajectories in developing PCK for science teaching.

References

Abell, S.K. & McDonald, J.T. (2006). Envisioning a curriculum of inquiry in the elementary school. In L.B. Flick, & N.G. Lederman (Eds) *Scientific inquiry and the nature of science*. Dordrecht: Klüwer Academic Publishers.

Abell, S.K. (2007). Research on science teacher knowledge. In S. Abell & N. Lederman (Eds) *Handbook of research on science education*. London: Lawrence Erlbaum Ass.

Abell, S.K., Bryan, L.A. & Anderson, M.A. (1998). Investigating preservice elementary science teachers reflective thinking using integrated media case-based instruction in elementary science teacher preparation. *Science Education,* 82*(4),* 491-510.

Andersen, N.O. (Ed.)(2008). *Et fælles løft - rapport fra arbejdsgruppen til forberedelse af en national strategi for natur, teknik og sundhed*. Undervisningsministeriet.

Anderson, R.D. (2007). Inquiry as an organizing theme for science curricula. In S. Abell & N. Lederman (Eds) *Handbook of research on science education*. London: Lawrence Erlbaum Ass.

Bandura, A. (1997). *Self-efficacy: The exercise of control*. New York: Freeman.

Berry, A, Loughran, J. & van Driel, J.H. (2008). Revisiting the Roots of Pedagogical Content Knowledge. *International Journal of Science Education,* 30*(10)*, 1271-1279.

Borko, H. (2004). Professional development and teacher learning: Mapping the terrain. *Educational Researcher,* 33*(8)*, 3-15.

Bybee, R. W. (2006). Scientific inquiry and science teaching. In L.B. Flick & N.G. Lederman (Eds) *Scientific inquiry and the nature of science*. Dordrecht: Klüwer Academic Publishers.

Cohen, L., Manion, L and Morrison, K. (2007). *Research Methods in Education*. New York: Routledge.

Darling-Hammond, L. & Youngs, P. (2002). Defining highly qualified teachers: What does "scientifically-based research" actually tell us? *Educational Researcher,* 31*(9)*, 13-25.

Duit, R., Niedderer, H. & Schecher, H. (2007). Teaching physics. In S. Abell & N. Lederman (Eds) *Handbook of research on science education*. London: Lawrence Erlbaum Ass.

Friedrichsen, P.M. & Dana, T.M. (2003). Using a card sorting task to elicit and clarify science-teaching orientations. *Journal on Science Teacher Education,* 14*(4),* 291-309.

Friedrichsen, P.M. & Dana, T.M. (2005). Substantive-level theory of highly regarded secondary biology teachers' science teaching orientations. *Journal of Research in Science Teaching.* 42*(2),* 218-244.

Johnston, J. & Ahtee, M. (2006). Comparing primary student teachers' attitudes, subject knowledge and pedagogical content knowledge needs in a physics activity. *Teacher and Teacher Education,* 22*(4)*, 503-512.

Kristensen, P. (2009). *Sammenfatning og perspektivering af resultater fra undersøgelse af naturfagenes situation på læreruddannelserne*. Foreningen af lærere i Naturfag ved Læreruddannelsen

Levitt, K.E. (2002). An analysis of elementary teachers' beliefs regarding the teaching and learning of science. *Science Education,* 86*(1),* 1-22.

Magnusson, S; Krajcik, J. & Borko, H (1999). Nature, Sources and development of Pedagogical Content Knowledge for Science teaching. In J. Gess-Newsome& N.G. Lederman(Eds.). *Examining Pedagogical Content Knowledge – The Construct and its Implications for Science Education*. 95-133. Dordrecht: Kluwer Academic Publishers.

Osborne, J.; Simon, S. & Collins, S. (2003). Attitudes towards science: a review of the literature and its implications. *International Journal of Science Education*, 25*(9)*, 1049-1079

Osborne, J. & Dillon, J. (2008). *Science education in Europe: Critical reflections.* Report to the Nuffield foundation.

Pajares, M.F.(1992).Teachers' beliefs and educational research: Cleaning up a messy construct. *Review of Educational Research,* 62*(3)*, 307-332.

Rocard, M. (Chair); Csermely, P.; Jorde, D.; Lenzen, D.; Walberg-Henriksson, H.; Hemmo, V. (2007). *Science education NOW: A renewed pedagogy for the future of Europe*. Brussels: European Commision Directorate-General for Research, Science, Economy and Society

Shulman, L.S. (1986). Those who understand: Knowledge growth in teaching. *Educational Researcher* 15*(2),* 4-14.

Tsai, C.C. (2002). Nested epistemologies: science teachers´ beliefs of teaching, learning and science. *International Journal of Science Education,* 24*(8),* 771-783.

Undervisningsministeriet (2009): Fælles Mål (curriculum): http://www.uvm.dk/Uddannelse/Folkeskolen/Fag%20proever%20og%20evaluering/Faelles%20Maal%202009.aspx (link 230311)

Wallace C. S. & Kang, N. H. (2004). An investigation of experienced secondary science teachers' beliefs about inquiry: An examination of competing belief sets. *Journal of Research in Science Teaching,* 41*(9),* 936-960.

Weber, M. (reprint 1997). *The theory of social and economic organization*. New York: Free Press.

Westbury, I.; Hopmann, S. and Riquarts, K (eds.) (2000). *Teaching as a Reflective Practice: The German Didaktik Tradition*. Mahwah, NJ: Lawrence Erlbaum Associates.

Zahorik, J.A. (1996). Elementary and secondary teachers' reports of how they make learning interesting. *The Elementary School Journal,* 96*(5),* 551-564.