Proceedings of the 13th Nordic Research Symposium on Science Education

June 1st - 2nd 2021 Aarhus, Denmark

Science education in the light of Global Sustainable Development

- trends and possibilies

Editors: Søren W. Clausen, Peer Daugbjerg, Birgitte L. Nielsen, Martin K. Sillasen & Simon O. Rebsdorf

NFSUN

Nordiskt Forskarsymposium om Undervisning i Naturvetenskap

Science Education in the light of Global Sustainable Development: - trends and possibilities

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Hosted by VIA University College, Aarhus, Denmark

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October 2021

ISBN: 978-87-995920-4-3

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Content

Introduction

The 13th Nordic Research Symposium on Science Education (NFSUN) was arranged by VIA University College, Aarhus, Denmark. The symposium was first scheduled for June 2020, but due to the Covid-19 pandemic it was twice postponed and finally arranged as an online symposium June 1.-2., 2021. This journey of ups and downs for the arranging committee is presented in the graphic novel following this introduction.

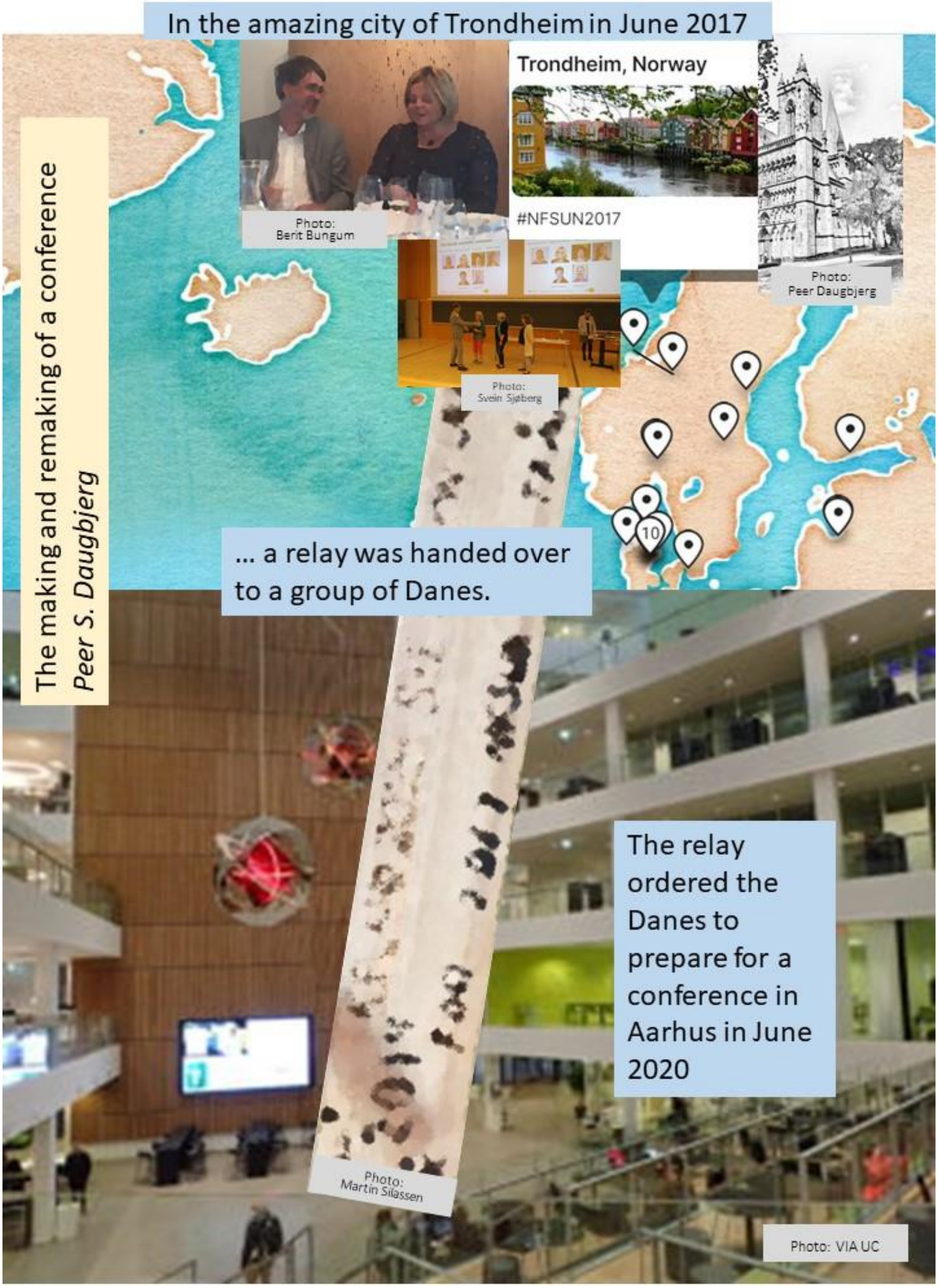
The conference theme "*Science Education in the light of Global Sustainable Development – Trends and possibilitie*s" clearly signals the reference to contemporary issues of vital importance globally. This theme was addressed in the many papers and posters at the symposium, and in three keynotes: Senior Lecturer Lars Brian Krogh from VIA University College talked about "*Motivational perspectives on sustainability education – for the better*", Professor of Transformative Learning for Socio-Ecological Sustainability, Arjen E.J. Wals, from Wageningen University, Netherlands about "*Re-imagining Science Education on a Planet in Crisis*", and Professor in Science Education Niklas Gericke, Karlstad University, Sweden about "*Entering the Era of the Anthropocene - From Knowledge to Action*".

Following the graphic novel these proceedings start with some reflections from the arranging committee about the future of NFSUN based on the experiences from transformation to an online symposium. After this there are two invited papers discussing the specific Nordic research tradition in science education. Jens Dolin argues for the importance of strengthening the Nordic dimensions of science education research – before it is too late. Berit Bungum follows up on this discussion referring to the journal NorDiNa among other things referring back to the invited symposium chaired by the NorDiNa editors at NFSUN 2021.

Finally, the proceedings present a range of submitted single papers in English or in a Scandinavian language addressing a wide range of important research issues of value for further enhancing science education in the Nordic countries.

Please, enjoy the reading of this rich material from NFSUN 2021!

Becoming of NFSUN 2021



So the Danes started to make arrangements for the conference

They asked science education researchers to send proposals for contributions to the conference no later than January 2020

Photo: Susanne Kaae

BUT then in March 2020 a pandemic swept the globe

Photo: Martin Silassen

Photo: Vera Bager

The Danes were bewildered, they had planned to run the conference in June 2020

Photo: Jaana Herranen

Photo: Astra

Photo: Anna-Karin Westman

Photo: Arturs Kipsts

They had to postpone the conference to June 2021, they still hoped to see all their Nordic and other friends and colleagues in Aarhus, so they remade all their arrangements in accordance with this hope.

BUT the pandemic kept on and on

Photos:
Kirsten Bak Andersen

Photo:
Vera Bager

The Danes once again were be-wildered, they could not invite their friends and colleagues to visit Aarhus

They had to rethink the conference and make it into an online conference instead.

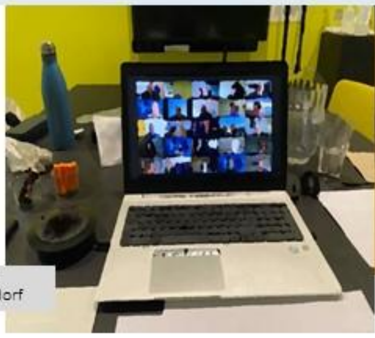
All the social activities were cancelled – distance had to be kept.

BUT how many would bother to participate in an online conference

Actually 131 from e.g. Germany, the Nordic and Baltic countries, joined the online keynotes, sessions and presentations.

Photo:
Simon Rebsdorf

The Danes moderated the sessions from their PCs



Photos:
Simon Rebsdorf

All of a sudden it was time for the closing session

Photos:
Birgitte Lund

... and as tradition prescribes the relay had been prepared for its further journey

Photo:
Martin Silassen

... finally the relay was passed on to Iceland for 2024.

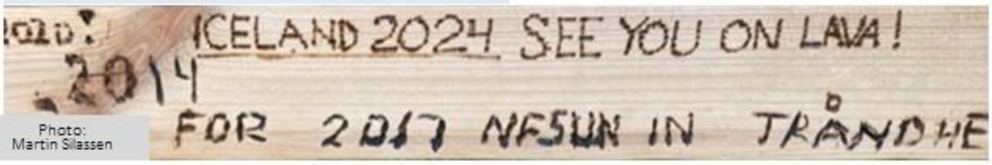


Photo:
Martin Silassen

What is the CO_2 footprint when having an on-line symposium compared to a face-to-face symposium? – considerations for future NFSUN-symposias

For the first time, NFSUN was conducted online in 2021 due to the Covid-19 situation. The symposium should actually have been held in 2020, where all participants from all over the Nordic region and neighboring countries should have met at VIA University College in Aarhus.
The theme of the conference was "Science Education in the light of Global Sustainable Development – Trends and possibilities". When the organizing committee from VIA University College was evaluating the conference retrospectively someone raised the question. "*I wonder how much CO_2 we have saved the atmosphere by doing NFSUN online?*" Then the idea to estimate the size of non-emitted CO_2 from all the non-travelling of the participants was conceived. Thus, this article is an attempt to make such an estimate, as well as pose some considerations regarding future formats of NFSUN. Inspiration for this calculation came from Ong, Moors, and Sivaraman (2012).

Prerequisites when estimating the CO2 emission

Estimating the CO_2 emission is by no way an easy task. An accurate calculation of a CO_2 emission includes knowledge of exact travel length, form of travel (bicycle, car, bus, ferry, train, plane), fuel consumption (diesel/gasoline) and several other factors. Since the purpose of the article is to get an estimate of the difference in CO_2 emissions at a face-to-face vs a virtual symposium, a number of assumptions has been made. As the participants' private addresses are not known, it is assumed that the starting point of the trip is from the place of employment. Thus, a uniform CO_2 emission has been calculated for participants who have the same place of employment.

Below is listed some parameters that are important for the estimation of the CO_2 emission:
Prerequisites when traveling by car (Danmarks statistik):
https://www.dst.dk/Site/Dst/Udgivelser/nyt/GetPdf.aspx?cid=31966)
We do not know the participant's car types. A car using gasoline have an emission of 111,6 CO_2 g/km, whereas a car using diesel have an emission of 113,9 CO_2 g/km. Though, some participants might have a hybrid or full electric car. In this paper there is used an average car emission of 112,75 CO_2 g/km.

Prerequisites when traveling by airplane

(https://flightemissionmap.org/#Aarhus/56.16,10.21/135/20000)

First, the used CO_2 calculator does not include so-called non-CO_2 effects which e.g. consists of NOx particles and water vapor that also have an effect on the climate. Second, each participant must travel from their own home to the airport, and Aarhus Airport is placed 40 km from Aarhus City. Thus, when travelling by airplane there is added 4 x 25 km. (100 km.) by car.

Prerequisites when traveling by train (https://dataportal.orr.gov.uk/media/1843/rail-emissions-2019-20.pdf)

When travelling by train, numbers from 2019-20 estimate an emission of 35.1 CO_2 g / km, which is the emission for electric trains. This number is also used in this paper. One source of error is the fact that the Danish railway network in Jutland is not electrified. Thus, when travelling by train from Aalborg to Aarhus and back, the CO_2 emission will be significantly higher.

Prerequisites when living in Aarhus

Six participants from VIA University College are living in Aarhus. Thus, it is assumed that these participants will cycle to the NFSUN venue, and therefore not contribute significantly to the CO_2 emissions.

CO_2 emissions if NFSUN 2021 had been a face-to-face symposium

In total we were 131 participants participating in NFSUN 2021. Of these 125 would be coming from other places than Aarhus. On the basis of the above given assumptions, in figure 1 we have calculated the CO_2 emissions from these 125 participants based on their institutional affiliations, a calculated guess on whether they would choose airplane, train, bus, bike or car as a means of transportation. We have used the participants list to estimate the number of persons travelling from different places. The calculated average carbon footprint of participants travelling from a destination outside of Aarhus is **254 kg CO_2** (se below table of calculations).

Figure 1. *CO_2 emissions calculated for different destinations which include various forms of travel.*

Distance	**CO_2 emission by airplane** (kg CO_2)	**CO_2 emission by car** (When travelling by airplane then is also counted 4 x 25 km by car = 11 kg CO_2)	**CO_2 emission by train** (35,1 CO_2 g/km)	**Total kg CO_2 emission when travelling** (kg CO_2)	**Number of persons from a destination**	**Total CO_2 emission** (kg CO_2)
Aarhus – Stockholm (incl. Mätardalen Univ, Vesterås)	2 x 158 kg = 316 kg	11 kg		327 kg	5	1635
Aarhus - Bergen	2 x 149 kg = 298 kg	11 kg		309 kg	5	1545
Aarhus – Reykjavik	2 x 529 kg = 1058 kg	11 kg		1069 kg	2	2138
Aarhus – Helsinki (incl. Oulu og Turku Univ.)	2 x 262 kg = 524 kg	11 kg		535 kg	4	2140
Aarhus – Riga	2 x 231 kg = 462 kg	11 kg		473 kg	2	946
Aarhus – Umeå	2 x 275 kg = 550 kg	11 kg		561 kg	8	4488
Aarhus – Tromsø (Arctic Univ. Norge)	2 x 421 kg = 842 kg	11 kg		853 kg	3	2559
Aarhus – Berlin	2 x 123 kg = 246 kg	11 kg		257 kg	2	514
Aarhus – Göteborg	2 x 55 kg = 110 kg	11 kg		121 kg	2	242
Aarhus - Amsterdam	2 x 147 kg = 294 kg	11 kg		305 kg	1	305
(Mittuniversitet) Sundsvall – Stockholm - Aarhus	Stockholm – Aarhus = 316 kg	6 kg	Sundsvall – Stockholm = 2 x 350 km x 35,1 g/km = 25 kg	347 kg	2	694
Linköping – Stockholm – Aarhus	Stockholm – Aarhus = 316 kg	6 kg	Linköping – Stockholm = 2 x 198 x 35,1 g/km = 14 kg	336 kg	2	672

Örebro – Stockholm - Aarhus	Stockholm – Aarhus = 316 kg	6 kg	Örebro– Stockholm = 2 x 199 x 35,1 g/km = 14 kg	336 kg	5	1680
Aarhus - Karlstad over Göteborg -		2 x 525 km x 112,75 g/km = 118,4 kg		118 kg	2	236
Aarhus - Malmø (incl. Lund)		6 kg	2 x 352 km x 35,1 g/km = 24,7 kg	31 kg	6	186
Kristianstad - Aarhus			2 x 445 km x 35,1 g/km = 31,2 kg	31 kg	5	155
Aarhus - København			2 x 310 km x 35,1 g/km = 22 kg	22 kg	16	352
Aarhus - Odense			2 x 145 km x 35,1 g/km = 10 kg	10 kg	2	20
Aarhus - Aalborg			2 x 119 km x 35,1 g/km = 8 kg	8 kg	4	32
Aarhus – Oslo (inkl. SE Univ. Notoden og Inland Univ. Hamar)	2 x 113 kg = 226 kg	11 kg		237 kg	32	7584
Aarhus – NTNU (Trondheim Norge)	2 x 809 km x 223 g/km = 361 kg	11 kg		372 kg	8	2976
Aarhus – Univ. Nord (Bodø Norge)	2 x 1256 km x 223 g/km = 560 kg	11 kg		571 kg	1	571
Aarhus – UC Syd (Haderslev)		2 x 110 km x 112,75 g/km = 25 kg			1	25
VIA UC (6 persons living in Aarhus are not included)		2 x 50 km x 112,75 g/km = 11 kg			5	55
Total CO2 emission by travelling to NFSUN conference in Aarhus 2021					**125 persons**	**31748 kg CO2**

Average CO2 emission by all 125 travelling participants		(**31748** kg CO2 / 125 persons)	**254 kg CO2 pr. person outside Aarhus**

CO_2 emission related to on-line meetings

However, conducting NFSUN 2021 online is not entirely CO_2 neutral. Many factors influence the CO_2 emission when using the computer (Ong, Moors, and Sivaraman, 2012). Among these factors are what kind and how old is the computer and how is the computer adjusted. How sharp is e.g. the light and is the video camera turned on? If the video is turned off and only the audio function is used, it is possible to save as much as 96 percent CO_2 emission. It is estimated that a person's computer is responsible for the emission of between 150 g. - 1000 g. CO_2/hour in on-line conferences (Dr/Dk). In this calculation, it is assumed that all participants have relatively new hardware and both their video and audio functions turned on, and therefore are responsible for a CO_2 emission of 600 g./hour. In average it is assumed that each participant was on-line for 7 hours each day.

As a result, an estimated total CO_2 emission directly related to the use of computer at NFSUN 2021 is therefore (600 g. CO_2/hour x 2 days x 7 hours x 131 participants) 1100 kg. CO_2. In average each person has emitted (1100 kg. CO_2 / 131 participants) **8.4 kg CO_2**.

Face-to-face meetings vs virtual meetings

The Skype platform, which was one of the earliest on-line meeting platforms, was started in 2000 by Niklas Zennström and Janus Friis from Sweden and Denmark, and in 2003 the Beta version was launched. Since then, several other on-line meeting platforms have been launched, including the Zoom, Google-Meet and Microsoft Teams platform. In particular, during the Covid-19 pandemic lockdown, the use of the various meeting platforms has exploded. At NFSUN 2021 Zoom was used, as it was a proven and safe technology that many participants felt familiar with.

NFSUN 2021 focuses on sustainability, and therefore this article focuses on the question: How could an on-line symposium mitigate a reduction of the total CO_2 footprint of the symposium. It is well-known that on-line meetings reduce the CO_2 footprint. Thus it was already found in 2012 that videoconferencing takes at most 6.7% of the energy/carbon of a face-to-face meeting (Ong, Moors, and Sivaraman, 2012). Teleconsultations with patients has also been used in the healthcare system.

It turns out that Teleconsultations led to reductions in distances and emissions of 95% (Oliveira et al., 2013). When replacing a traditional in-person pediatric cardiology conference with an on-line conference, a reduction of 98% in climate change impact was found. Under the given assumptions, the reduction of CO_2 emissions related to the NFSUN 2021 symposium is

estimated to (100 - (1100 kg CO_2 / 31748 kg CO_2) x 100%) = **96,5%** which is in line with the studies mentioned above. Though, as one of the authors in Duane et al (2021) states: *"A virtual conference may never completely replace the traditional in-person conference."*

Post reflections on the future format of the Nordic Symposium for Science Education research

Based on this analysis, the local organizing committee in VIA University discussed whether it is possible to combine the NFSUN 2021 online experience with traditional face-to-face symposia in the future.

Seen from the vantage point of the VIA organizing committee, the online format is a very efficient way of communicating. Participants were disciplined and engaged. Presenters were good at keeping time and the following Q&A sessions were lively and with good exchange of viewpoints. Even the postersession had good interactions between presenters and the audience.

Notwithstanding, following the long Covid-19 lockdown, many participants probably longed for face-to-face meetings and socialization with colleagues as the quote by Duane et al. also frames in the previous section.

In other fora it has been debated whether the three-year cycle is too long a period between NFSUN-symposia'? If the period was two years instead, it might be more in sync with the ESERA-conference every other year, which many researchers also attend.

In the VIA organizing committee we also came up with the idea to organize a one-day webinar more frequently, allowing for a more continuous platform for sharing research in the Nordic community.

We encourage the NFSUN-committee to use the online NFSUN 2021 experience to re-think the future of the Nordic Symposia in order to balance the need to meet face-to-face with other more virtual formats. At the same time, this might be the NFSUN-community's contribution to restore a sustainable climate.

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Links:

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https://flightemissionmap.org/#Aarhus/56.16,10.21/135/20000 (25.09.2021)

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https://www.dr.dk/nyheder/viden/klima/hjaelp-klimaet-og-sluk-kameraet-uden-video-udleder-dine-onlinemoeder-96-procent (25.09.2021)

The special Nordic science education and science education research tradition – and the importance of nursing it

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Abstract

The proceeding will shortly describe the specificity of the Nordic societies and the Nordic educational systems, and within this frame, point at some common aspects of science education across the Nordic countries – and some differences. With this background the results from a 2020 survey among NFSUN2021 participants about their Nordic values will be presented, analysed, and compared with an equivalent 2011 survey. A majority of the respondents acknowledged a special Nordic approach to science education and to science education research, both in relation to content themes and in relation to the values it is based on. Connecting to Nature and Sustainability was mentioned as core content; cross curricular teaching, experiments and inquiry orientation as central didactical approaches. Most emphasis was given to the values, though. The most central values were respect for the students, a democratic and non-authoritarian approach, and bildung as a central goal. The importance of strengthening these aspects of the Nordic science education research wherever possible is emphasised and some ways to do it is pointed out.

Keywords: Nordic dimensions, values in science education research

The question of whether there exist a special Nordic science education and science education research tradition – and if so, how it is characterized – must be a central question to a Nordic conference in science education research.

The Nordic countries have been linked closely together through centuries and have developed many common features within politics, economy, culture etc. – despite individual national identities. The educational sector has been a fundament for this development and science education researchers participating in the triannual Nordic science education research conferences (Nordisk Forskersymposium om Undervisning i Naturvitenskap - NFSUN) have had a role in the process. The first symposium took place as early as 1984 (11 years before our European counterpart, ESERA, was founded!) and I have participated in them since the 4th symposium in 1993 – which gives a personal background for this proceeding. I was a un-experienced researcher at that time, and I had just before presented at a European conference – and the difference was striking. From a linguistically faltering English presentation at a session with not much response – to be allowed to speak in my own Mother tongue for what I immediately felt as colleagues. That proved for me the immense value of a Nordic forum for science education research. And every NFSUN conference since then have confirmed this.

Since the first Nordic conferences things have changed a lot, though. EU has become a major funding agency and many of us have followed the money – meaning that our attention as science education researchers have been turned towards formulating and participating in EU-projects. We now do research with colleagues from Italy, Greece, Poland, Spain etc., researchers with very different methods and values and historical backgrounds than researchers from the Nordic countries. We often participated in these EU-projects together with other Nordic researchers – and doing so we often felt being in a community together with our Nordic colleagues within the larger group. However, in a way it also diluted the Nordic approach.

The tendencies became clear some ten years ago and it has become manifest in the language used at NFSUN. The language has traditionally been seen as an important unifying factor from the beginning of NFSUN. In the 1993-report 44 articles were in a Scandinavian language and 1 in English (and it was ok, Doris □). In the 2005-report 43 articles were in a Scandinavian language and 5 in English. The shift happened with the report from the 2008 conference in Iceland. 17 articles were in a Scandinavian language and 61 in English. The report from this 2021 conference is not published yet, but the proportion between Scandinavian and English language seems to be the same as the 2008 conference, with 23 of the presentations in a Scandinavian language and 60 in English.

From most participants presenting in their Mother tongue some ten-fifteen years ago to now, where the big majority of participants are presenting in English, can be seen as reflecting an internationalization. For better and for worse. See Berit Bungum (2021) in this volume. On the one side it is a professionalization and widening of perspectives, but it might also imply a streamlining of the research approaches and the research themes and the values that might threaten the special Nordic approach – if it still exists. In his NFSUN2021-presentation (in English!) Svein Sjøberg (2021) addresses this issue, pointing at "the confusing and often conflicting influences and pressures from international actors with different agendas."

This long introduction is an argumentation for the relevance of the research question for this proceeding: Is it meaningful to talk about a special Nordic science education and science education research tradition, and if yes, what is it? After a short description of the communalities of the Nordic societies and the Nordic educational systems, I will point at some common aspects of science education across the Nordic countries – and some differences. This gives a background for the two surveys among participants in the NFSUN 2011 and 2021 that gives the empirical data for answering the research question. At the end, I argue for the importance of strengthening the Nordic dimensions of science education research – before it is too late.

1. Common characteristics of the Nordic societies and the Nordic educational systems

All Nordic countries are constantly in top of the happiness index (Helliwell et al., 2021), measured as the respondents' evaluation of their current life situation within the areas economy, citizen engagement, social issues, education, well-being, environment, government and politics, safety, health, religion & ethics, transportation, and work.

These results reflect that the Nordic countries all have a welfare model based on a massive and strong state and centralized, national unions and employers' associations. They also have less social-economic inequality than other European countries and their citizens are having a profound belief and trust in democracy.

These particularities are the result of a long historical process. They were formalized and strengthened by the Nordic governments establishing the Nordic Council in 1952 and since 1954, we have had a common Nordic labor market and passport union. The Nordic Council of Ministers was set up in 1971 as the official body for inter-governmental co-operation in the Nordic Region and it has had a strong emphasis on culture and education.

So, you could argue that the individual lives unfold within a strong framing. Parallel with personal engagement in a diversity of local associations in private and professional life, we have centralized structures securing these activities. Meaning that most of us from the Nordic countries probably have this feeling: "*With a bit of personal effort, we could enter our adult lives well-educated, debt-free and confident that the system was working and would help us if something went wrong*." (Andersen & Björkman 2017, p. 8)

1.1. The Nordic educational systems

Of course, these societal similarities have trickled down to the educational systems. The Nordic model of education was developed in the Nordic countries in the decades after WorldWar II, where education was a central part of the social democratic welfare state project (Telhaug et al 2006). The school was seen as building the foundation of the society.

The state was considered to be the legitimate authority, having responsibility for education as a common good. Structurally, the Nordic model consisted of a public, comprehensive school for all children with no streaming from the age of seven to sixteen years. The overarching values were social justice, equal opportunities, inclusion, nation building, and democratic participation for all students, regardless of social and cultural background and abilities.

While very strong tendencies in the UK and the USA have emphasized a scientific curriculum and focus on national aims and measurable outcomes, Nordic legislation has focused on a comprehensive school and an education for democratic Bildung, participation, and equality (Blossing, Imsen, & Moos, 2013)

1.2. Nordic science education based on PISA data

With the introduction of comparative studies like TIMSS and PISA researchers got access to an abundant amount of data about science education in the participating countries. The quality of these data has been criticized (ref), both for their validity and for their reliability, and it has been called useless to compare very different countries across the world. It has, however, been argued that especially the Nordic countries have so many common features that a comparison among them make sense.

I will pick two sets of results from the series of studies of PISA data from the Nordic countries, Northern Lights on PISA, to illustrate this.
Svein Lie and Margit Kjærnsli (2006) have asked: How similar are we? They established 11 meta-constructs based on aggregated data from the PISA2003 student and teacher questionnaires (variables about teacher support, subject motivation, social motivation, learning strategies, accountability etc.). A cluster analysis grouped the countries
according to similarities in their data for the meta-constructs, and the participating countries could be divided into 7 groups, see table 1.

Table 1. Correlations between the Nordic countries and each of the country groups.

	1 Less developed	2 "Nordic"	3 English speaking	4 East Europe	5 East Asia	6 German speaking	7 "French"
Denmark	-0.23	0.24	0.19	-0.42	-0.18	0.49	0.13
Finland	-0.70	0.91	0.23	0.44	-0.12	0.41	0.22
Iceland	-0.33	0.41	0.70	0.09	0.28	-0.13	0.38
Norway	-0.58	0.88	0.28	0.27	-0.29	0.31	0.64
Sweden	-0.55	0.88	0.08	0.49	-0.23	0.41	-0.03

The Nordic countries fit into the same group, but not equally well. Finland, Norway, and Sweden have a high correlation with the Nordic characteristics. Iceland is more similar to the (non-European) English-speaking group. Denmark correlates relatively weak with the ''Nordic'' group and stronger to its southern neighbors, the 'German' group. As Lie and Kjærsli formulates it: "It seems as though on broader educational issues each of these two Nordic countries have ''drifted'' somewhat away from their Nordic neighbours, Denmark taking on a more ''continental'' profile and Iceland showing some similarity with ''overseas'' countries. " (p. 98)

These similarities give a good explanation of the well-known graphs of the Nordic countries' total performance in science, Figure 1.

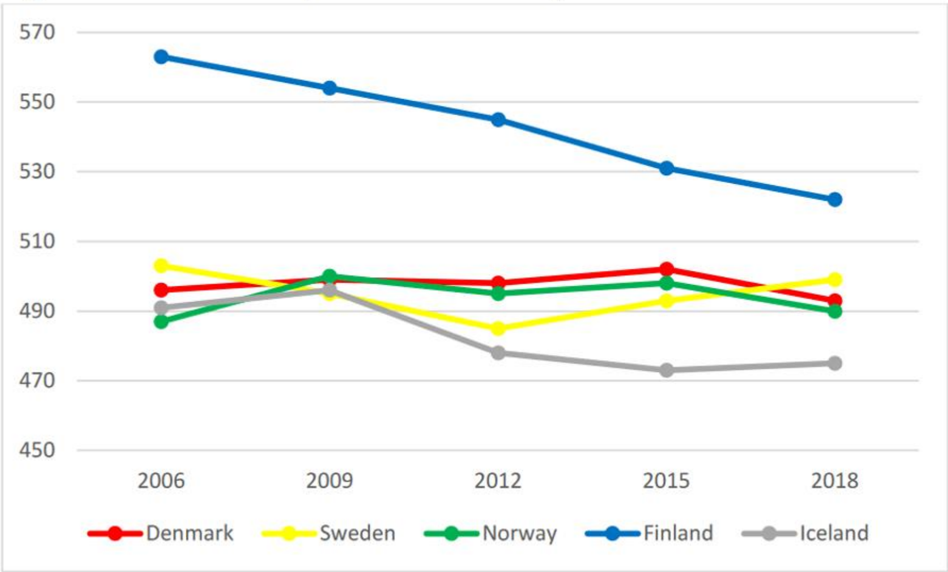

Figure 1. The development in PISA science results in the Nordic countries, 2006-2018 (Christensen 2019, p. 7)

As we see in figure 1, the Nordic countries are on the same level – except Finland. The case of Finland has been discussed in details and we will not deal with it here – but can ascertain, that Finland gets closer and closer to its Nordic siblings!

2. Method

Now to the question 'Is there a Nordic science education and science education research tradition?' This question is examined via two surveys, one among the NFSUN 2011 participants and one among the NFSUN2020 participants (those who later participated in the NFSUN2021). The 2020 survey is an enlargement of the 2011 survey, keeping all 2011 questions in exactly the same formulations, but expanded with some additional questions.

The NFSUN2011 survey was mail distributed to 120 participants and 30 responded. It is far from being representative, but the results pointed in the same directions. The NFSUN2020 survey was mailed via the conference team to the 99 participants signed up for NFSUN in Feb 2020. 47 responded and not all respondents answered all questions, which will appear from the figures. The response rate makes the 2020 survey closer to being representative for the NFSUN participants – but probably not for all science education researchers in the Nordic countries. It is not possible to judge about any bias of the respondents.

Therefore, I do not find the material suited for statistical analysis, like various correlations. I will simply present the sum results for the 2020 survey and refer to the similar 2011 data when it makes sense. Especially the open responses give many qualities to the statistical data.

3. Results

As a special 2020 survey question, the participants were asked which educational level, they researched, see fig. 2. Lower secondary is the most researched educational level, followed by an equal interest in upper secondary and higher education. It seems as if we ought to strengthen the research capacity on the first school levels and even more on vocational education.

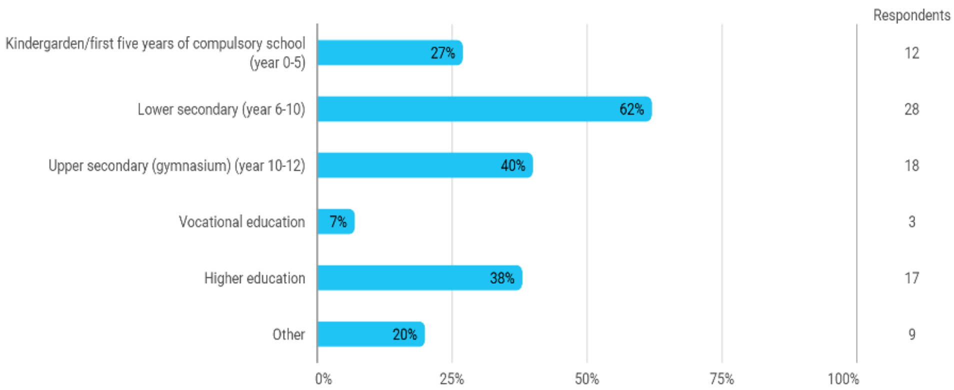

Figure 2. Which educational level are you researching?

I will concentrate on the two central questions common for the two surveys:

q1. I find that the Nordic countries have some common values that affects the school

If yes on q1 – Which expression or sentence can describe these values?

q2. My research is affected by Nordic values.

If yes on q2, in what aspects is your research 'Nordic'?

3.1 Common values

The big majority of the respondents agreed that the Nordic countries have some common values that affects the school – to some degree or to a high degree.

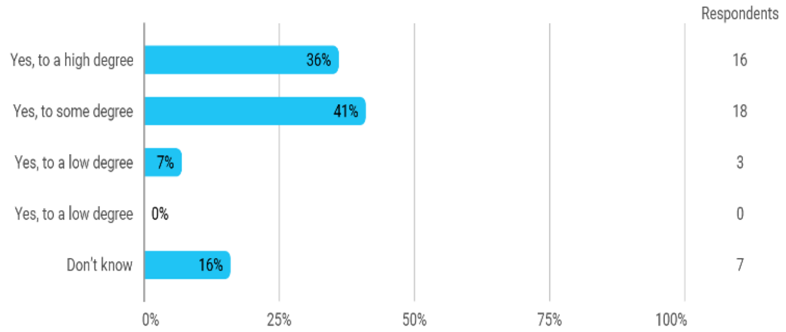

Figure 3. I find that the Nordic countries have some common values that affects the school

In the 2011 survey 24% answered to a high degree and 76% to some degree.

The open responses can be categorized into three groups.

18 respondents mentioned teachers' attitudes towards students and the relations between teachers and students, with these typical citations:

- *respekt for eleverne*
- *likeverd*
- *not so authoritarian*
- *medbestemmelse*
- *likeverd og trivsel*
- *Selvbestemmelse og medbestemmelse som afgørende i relationer mellem mennesker*
- *Focus on Equity (even if not succeed in creating Equal opportunities)*

13 respondents emphasized a democratic orientation and bildung as important goals:

- *a democratic orientation*
- *en blanding af såvel formal som material dannelse, samt et demokratisk dannelsesideal*

8 respondents mentioned aspects of science and didactics:

- *Quite a lot of focus on experiences in science education*
- *Emphasis of the outdoors and connecting to the nature*
- *verdsetting av naturen*
- *undersøgelsesbaseret undervisning*
- *tværfaglighed, anvendelse af naturfaglig viden i autentiske situationer*

The 2011 survey had pretty much the same answers.

3.2 Is the research affected by common values?

As for the science education research, it showed the same pattern as the science education, see fig. 4. 73% of the respondents found their research affected by Nordic values to some degree or to a high degree. This is actually an increase relative to the 2011 survey, which had these figures: High degree: 11%, some degree: 54%, low degree: 14%, no: 21%

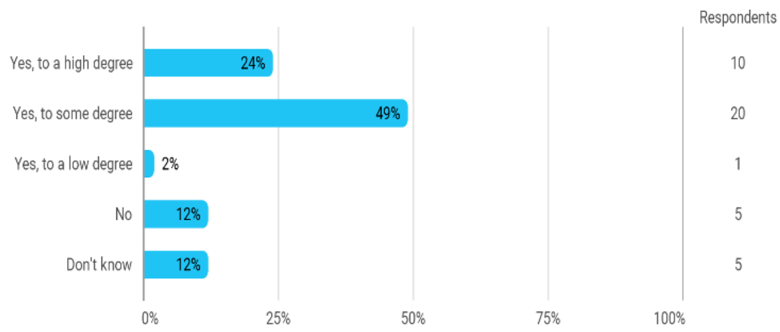

Figure 4. To which degree is the research of participants in the NFSUN2020 affected by Nordic values.

The open response answers to 'in which way?' could be put into four categories:

1) The research focuses on the individuals in the classroom and how to engage these in the activities, especially how to integrate teachers as active partners in the research:

- *fokus på lærere og elever*
- *fokus på og interesse for agency, hos den enkelte og relationelt - og på bottom-up processer*
- *teachers are partners in research*
- *Opptatt av hvordan stimulere flere elever, også de med svake forkunnskaper og svak motivasjon*

2) Research with emphasis on local aspects:

- *Legger vekt på det lokale og undersøker lokale forhold*
- *Lærernes frihed mht tolkning og omsætte fælles mål til praksis*

In relation to this category, it is interesting how some respondents point at the interrelatedness of the values of school as research object and the values of the research:

- *Fordi jeg forsker på hva som skjer i naturfagsklasserom i Norge blir min forskning påvirket av "nordisk klasseromskultur"*

3) The research explicitly has political aspects and goals:

- *kritisk over for myndigheder*
- *goal of research is to increase welfare and benefit for everybody*

4) The research has focus on nature and engagement in nature and sustainability:

- *Emphasis on childrens' participation in environmental education and sustainability education*
- *Elevenes nærhet til å være ute i naturen*
- *My focus is growingly on climate change issues*

As a follow up on the language aspects of the Nordic dimensions, the 2020 participants was asked whether they found it inhibitory to write research texts on another language than their Mother tongue.

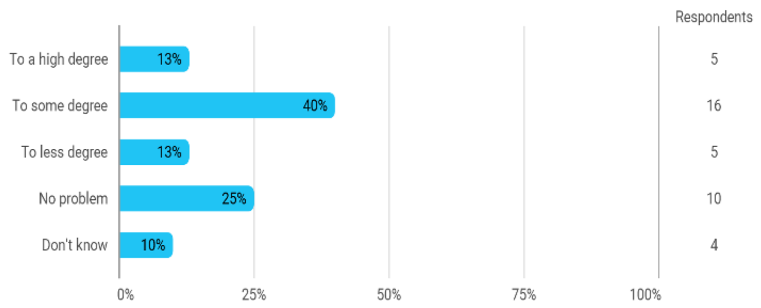

Figure 5. Degree of inhibitedness in writing research texts in another language than the Mother tongue

Despite internationalization and increased interaction in English with other researcher, half of us find it problematic to publish in English.

4. Conclusions and perspectives

We have seen how the Nordic countries have societal and educational common structures and values. Nordic education is by the NFSUN researchers characterized by a democratic orientation and bildung as important goals, respect for students and equity as an ideal – and with a strong focus on appreciating nature and fostering a sustainability attitude. The surveys confirm that these values can be retrieved in the Nordic science education research. The democratic ideals and equity aspect is here reflected in including teachers as partners in their research.

Nevertheless, the Nordic model of education and research has been in a vulnerable position since the millennium due to globalization (Imsen et al 2016). International assessments and comparisons, NPM, competition among researchers, international streamlining of research and publication on Anglo-Saxon premises are among the causes.

In a time with focus on climate change, sustainability, democracy, inequality, it therefore seems important and beneficial for Nordic science education researchers to develop and sharpen the Nordic dimensions of our research. The Nordic values and traditions simply resonate with the needs for engagement in dealing with these global challenges.

Preparing this proceeding, I went through the reports from the NFSUN conferences, and it was striking how many contributions dealt with values, democratic aspects, bildung, socio-scientific issues etc. We have a deep and broad knowledge base for engaging in these issues.

We can brand us as researchers and educators with strong values and special knowledge within these areas and demonstrate how they can be addressed in a meaningful way in our science educations and in our research.

To be able to do this, it is important to nurse and support and use institutions and initiatives that promote and give funding to the Nordic dimensions, whenever possible. We might be better at exploiting the possibilities in NordForsk. We can participate in general Nordic educational cooperation in NERA. We must affect our politicians to be aware of and to fund Nordic science education research.

The most obvious, however, is to prioritize NFSUN and NorDiNa as Nordic meeting points, as Berit Bungum (2021) argues for.

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Nordic research and meeting points: Reflections on the NorDiNa symposium at NFSUN 2021

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Abstract

This contribution reflects on the NorDiNa symposium that formed part of the NFSUN conference 2021, and the four papers presented there. The papers selected by national members of the editorial board show similarities in that they all present research on teachers, and also in how teachers are considered. It is suggested that this reflects a specific Nordic approach to science education research, where teachers are seen as important actors in the educational field, with beliefs, priorities and agencies for action. This stands in contrast to research found internationally that sometimes tend to view teachers rather as implementers of the ideas of others. It is argued that this reflects specific Nordic values in science education research, and that the journal NorDiNa and the NFSUN conference are important Nordic meeting points for research in our field in a time where internationalization is highlighted and cherished in our institutions for research and in curriculum development.

Keywords: NorDiNa, Nordic research, teachers.

1. Introduction: NorDiNa and NFSUN as Nordic meeting points

There is a strong push for internationalization in universities and other academic institutions. Funding for research projects requires an international profile, and we are expected to publish our work in international journal and conferences. This applies, of course, also to science education and educational research more generally. While internationalization is constructive in many ways, it also creates a tension between a desire to internationalize our work and relevance for schools and teachers, since educational issues are deeply rooted in culture, ideologies and also language. The

Nordic context is therefore so fruitful, since it offers more perspectives and a broader platform for collaboration than what is possible in each of our relatively small countries. Even if there are differences, the Nordic countries share specific cultural values that affect education and educational research. In his chapter in this proceedings, Jens Dolin discusses in more depth, and based on empirical data, what these values are, how they have contributed to shaping a specific Nordic research tradition in science education and why nursing this tradition is important.

The shared values are probably the reason why the NFSUN symposium sometimes feels like a family gathering compared to other conferences. Like in any family, we do not always agree, but we can better understand what the various viewpoints are grounded on and why. Also, like in any family, discussions may sometimes be more intense than what is the case out in the big international public. The NFSUN symposium is therefore an important meeting point for Nordic science education researchers. For similar reasons, the journal NorDiNa is an important arena for publications in our research field in written form. The journal was invented in 2005 by Anita Wallin (University of Gothenburg) and myself (Berit Bungum, at that time University of Oslo), with support from our more experienced senior colleagues Björn Andersson and Anders Isnes. We also established a Nordic editorial board in order to involve all Nordic countries in the process. Essential for successful start, and the further survival, of the journal was that The National centre for science education (Naturfagsenteret) in Norway allocated resources for layout work (excellently performed by Lise Faafeng in many years), a web site and infrastructure for distribution of the journal. In the beginning we defined a subscription fee, low enough so that people and institutions would subscribe. However, it turned out that the costs for administrating the subscription were higher than the income it resulted in. The centre therefore decided to distribute the journal for free. This way, NorDiNa was a forerunner with regards to open access publication!

To avoid a total burnout as editors (I promise it is a lot of work!), new editors took over, and so far, Christina Ottander, Sonja Mork, Are Turmo, Carl-Johan Rundgren and Clas Olander have acted as editors and this way contributed to the survival of NorDiNa.

Even if the journal is not related to NFSUN in any formal or organizational ways, it fulfils some of the same purposes and involves some of the same researchers in the roles of editors, reviewers, authors, and symposium organizers. It is therefore natural and welcome that NFSUN provides a space for a "NorDiNa symposium" as part of the conference.

2. Contributions to the NorDiNa symposium 2021

In the NorDiNa symposium at NFSUN 2021, one paper from 2018-2019 from Sweden, Denmark, Finland and Norway was selected by the national representatives in the editorial board (Iceland had no papers in those two years). The intention was to highlight significant papers that also shows a breath of research published in NorDiNa. (The papers do not cover 2020 issues since the symposium was first planned to take place in 2020 but postponed due to the Covid-19 pandemic). The papers do show a breath in research methods and perspectives, but it turned out that they have in common that teachers play an important role in the research. Further, they appear to have commonalities also in how teachers are looked upon, that might be signs of a specific Nordic profile in science education research. The character of this profile will be discussed below, after a brief presentation of the four selected papers that were contributions in the NorDiNa symposium at NFSUN 2021.

In the contribution from Denmark, the authors Peer S. Daugbjerg, Lars Brian Krogh, Charlotte Ormstrup present a study of teachers´ challenges with new interdisciplinary science in Denmark (Daugbjerg, Krogh, & Ormstrup, 2018). They refer to earlier Scandinavian research that shows that teachers are key actors in implementing reforms. It is therefore essential to identify and understand the challenges teachers face. Results of the study indicate that there are substantial challenges related to teachers' beliefs, subject matter knowledge, interdisciplinary self-efficacy and traditional teaching practices. They point to a range of organizational barriers such as too limited time to coordinate the new interdisciplinary teaching. Still, teachers are found to be mostly very positive to the curriculum reform, and express confidence in that they can handle the challenges. This may be seen as a discrepancy, and the authors present and discuss several possible interpretations of the finding.

In the Finnish contribution, also the vies and experiences of pre-service teachers are acknowledged. Anne Pellikka, Sonja Lutovac, Raimo Kaasila investigate the relation between pre-service teachers' views of an ideal teacher and their positive memories of biology and geography teachers (Pellikka, Lutovac, & Kaasila, 2018). In presenting their memories, the students emphasized teacher enthusiasm for the subject, freedom to do inquiries, acknowledgement of students' interests, creative use of illustrative metaphors and how news in e.g. newspapers relate to subject content. The researchers find that just one positive memory can have far-reaching significance for how the coming teachers view what it means to be a good teacher in biology and geography. The authors therefore suggest that teacher educators should address school time memories and acknowledge them as important factors in the development of a professional identity. In this research, the data collection in terms of descriptions of students' positive memories also formed part of the teacher education that the respondents attended. This way, the research itself may contribute to the teacher students' consciousness about their own identity as teachers and how it is formed.

Science teachers in vocational training are subjects of study in the Norwegian contribution. Mette Nordby, Berit Reitan and Guðrún Jónsdóttir investigate on what premises teachers make their choices in shaping science teaching for vocational students, and what room of action the curriculum provides for adaptation to these students' needs (Nordby, Reitan, & Jónsdóttir, 2019). Teaching in vocational education operates in a threefold tension between what is needed for the specific vocation and a desire to equip students with scientific literacy and a basis for further study. In a long-term action research study in collaboration with two teachers, the authors found that even if the teachers expressed a wish to offer the vocational students relevant education adapted to their needs, their teaching was dominated by deductive teaching methods, content knowledge rather than process skills, assessment methods based on written work. The teachers' ideological position seemed to be based on Robert's description of Vision I for science education (Roberts, 2007). A range of concrete recommendations are given to meet this dilemma on a curricular and organizational level.

In the Swedish contribution, Cristian Abrahamsson, Claes Malmberg, Ann-Marie Pendrill have undertaken a Delphi study of teachers' views on engagement in the science classroom (Abrahamsson, Malmberg, & Pendrill, 2019). A Delphi study is a systematic way to establish consensus understanding of a complex matter, based on input and feedback from experts in several iterations on individual level. In the study, Abrahamsson et al. investigated how teachers describe teaching that stimulates students' engagement, factors that influence the engagement and how it relates to specific science content. Results show that teachers describe teaching that provide for engagement involve variation, student activity and connections to students' experienced reality.

This seems to be independent of science content, and that teachers interpret students' emotional expressions and academic behaviour as engagement rather than their cognitive behaviour.

3. Views of teachers in the contributions

The fact that the national representatives of the editorial board independently selected contributions for the NorDiNa symposium with a focus on teachers, signifies that teachers are seen as important in science education and in research. Further, the papers have commonalities in *how* they view the teachers' role. Teachers are clearly viewed as actors with beliefs, informed priorities, and agencies for action rather than implementors of ideas developed by others. They are thus also the key actors for educational change. The papers all show respect for teachers' work and the challenges they face in creating good and motivating teaching for all students, and in realizing curricular intentions in complex classroom situations. Since teachers are key factors in all education, understanding their perspectives and challenges is essential for constructive development. This is in particular important in implementing reforms, as highlighted in the paper by Daugbjerg et al. (2018). The authors show respect for the teachers in how they suggest several possible interpretations of the result that show that teachers see major challenges in the reform, but also express confidence in that they will be able to cope with the challenges.

The papers at the NorDiNa symposium also show teachers in more active roles than objects of study in the research projects. Pellikka et al. (2018) highlight i their study how teacher students' good memories may contribute to shaping teachers' professional identity and agency. It is here acknowledged how a professional identity is shaped individually long before students start their teacher training and underscores the importance of good teachers in developing students' interests and engagement. By using a Delphi study in investigating teachers' views, the study published by Abrahamsson et al. (2019) places teachers in the role of *experts* in educational research. They are worth listening to, not only as respondents to investigate their views, but as important voices for establishing systematic knowledge about what good science teaching is and how it can stimulate students' engagement. In the study by Nordby et al. (2019), the empirical basis is discussions with teachers over time, which also contributes to develop the teachers' reflections over practice. One of the authors is also a teacher in the study and has contributed actively to data analysis and interpretations. As with the study of teacher students by Pellikka et al., the time respondents spend to help researchers also contributes deliberately to their own professional development. This is most often not the case in research studies that we find internationally.

Teacher participation in educational research is typically presented with research designs such as action research, design-based research or design experiments undertaken in classrooms in close collaboration with teachers. The “participation” is, however, questionable. Engeström (2011) has noted that *“in discourses on ‘design experiments’, it seems to be tacitly assumed that researchers make the grand design, teachers implement it (and contribute to its modification), and students learn better as a result”* (p. 600). Other Nordic researchers, Andrée, Danckwardt-Lillieström, and Wiblom (2020) describe how a lack of symmetry between teachers and researchers in research collaboration may be due to different values, and a ‘researchers as thinkers’- ‘teachers as doers’ dualism in how the roles in the collaboration are considered. While this may also to some degree be the case in Nordic research including the papers represented at the NFSUN NorDiNa symposium, the papers seen as a whole signal a deep awareness of the importance of considering teachers’ perspectives and their particular kind of knowledge in doing research in order to improve science education.

4. Conclusion

The awareness and respect for teachers’ work that the contributions to the NorDiNa symposium at NFSUN 2021 may be seen as representing a specific Nordic approach to research and educational thinking. This view is supported by results from a survey among Nordic science education researchers undertaken by Jens Dolin and presented at the NFSUN conference (Dolin, 2021) and in his chapter in this proceedings. He asks whether a special Nordic science education research tradition can be identified. Results of the survey, although with few respondents, indicate that Nordic researchers in science education to a large degree see Nordic countries as having some common values that affect schools and that their own research is affected by Nordic values. Among the researchers’ responses are that Nordic education is characterized by democratic values, respect for students, equity as an ideal, the agency of the individual and teachers as partners in research. This resonates well with the common views of teachers identified in the papers selected and presented at the NorDiNa symposium at NFSUN 2021. Dolin concludes that it is important to nurse and support the Nordic profile and use institutions and initiatives that promote and give funding to the Nordic dimensions. Further, he asserts that Nordic collaboration among science education researchers and educators should be strengthened, and the specific Nordic emphasis on sustainability, student motivation and a 'broad' understanding of science should be further developed. In all these respects, NFSUN and NorDiNa are very important as a Nordic meeting point for researchers and arena for publishing our research respectively, in particular in a time where internationalization is highlighted and cherished in our institutions for research and in curriculum development.

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Multidimensional Analysis of Knowledge-Linking within the Concept of Energy in Student Essays

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Abstract

In Germany there is a very conservative tradition to teach science in separated subjects during the secondary level of education. Considering the importance of knowledge-linking in all relevant learning theories of the 20th century, cross-curricular core concepts, like the concept of energy, found their way into German educational standards for biology, chemistry, and physics in 2005 (KMK, 2005a-c). The aim was to foster both more vertical (i.e. intra-subject) and more horizontal (i.e. inter-subject) linkage in subject-differentiated science education. Existing structural models or approaches for analysing and describing knowledge-linking focus exclusively either on the aspect of vertical or horizontal linkage. Based on existing models and approaches, we developed a theory-based model (MAVerBE) that allows a general analysis of the linkage performance in essays. In this study, we investigate to what extent we can identify vertical and horizontal linkage structures in student essays on the cross-curricular core concept of energy in grade 9. Our results presented here give an empirical insight into knowledge-linking of students in the sense of a normative survey. This survey should enable future comparative studies both on a national and international level to prove the popular assumption of the superiority of integrated-science teaching concerning knowledge-linking.

Keywords knowledge-linking, concept of energy

1. Introduction

1.1. Problem

As a reaction to Germany's disappointing performance in the past TIMS (Baumert et al., 1997) and PISA studies (Baumert et al., 2001; Prenzel et al., 2004), core concepts were anchored in the German educational standards for biology, chemistry, and physics (KMK, 2005a-c). The integration of cross-curricular core concepts, such as the concept of energy, was linked to the hope that in this way stronger vertical (i.e. intra-subject) as well as horizontal (i.e. inter-subject) linkage is possible (Demuth et al., 2005). To what extent these hopes are fulfilled, however, remains an empirically unanswered question.

1.2. Theoretical Framework

Theory-based considerations of constructivist learning theories (e.g. Jonassen, 1998) as well as the assumptions of cumulative learning (Gagné, 1965) support the importance of knowledge-linking. In the literature there are different models and approaches which describe either vertical or horizontal linkage within conceptual knowledge. In the following two chapters we provide a short overview about important works relevant to our research.

1.2.1. Models for the description of vertical linkage

The model of vertical linkage (Fischer, Glemnitz, Kauertz and Sumfleth, 2007) is pervasively used in German science education research. For instance, Wadouh (2009) utilized it for the analysis of students' linkage performance in videotaped biology lessons. The model in its final version is applied to the complexity dimension in ESNaS competence models (e.g. in Kauertz et al., 2010). The model of vertical linkage contains five linking levels in ESNaS competence models: *1 fact*, *2 facts*, *1 relation*, *2 relations* and *generic concept* (e.g. in Kauertz et al., 2010, pp. 142-143). In that way, the model of vertical linkage takes qualitative as well as quantitative aspects of linkage into account.

Bernholt and Parchmann (2011) adapted Commons' model of hierarchical complexity (1998) to chemistry lessons. In contrast to the model of vertical linkage mentioned above, the model of hierarchical complexity only considers qualitative aspects of linkage. This model differentiates between the linking levels *everyday experiences*, *facts*, *processes*, *linear causality,* and *multivariate* *interdependencies* (Bernholt & Parchmann, 2011). This model is also pervasively used for the analysis of videotaped lessons (e.g. in Podschuweit et al., 2016) and as a basis in different competence models (e.g. in Woitkowski et al., 2017).

Woitkowski, Riese and Reinhold (2011) identified many overlaps but also differences comparing the category definitions of the model of vertical linkage (Fischer et al., 2007) and the model of hierarchical complexity (Bernholt & Parchmann, 2011). Nehring, Päßler and Tiemann (2017) compared both models in practice. In this investigation they analysed teacher questions in chemistry lessons using the model of vertical linkage and the model of hierarchical complexity. The results of the analysis with both models were only comparable up to 70 % (Nehring et al., 2017). It is particularly notable that the authors could not even relate a single generic concept to a multivariate interdependency (Nehring et al., 2017). That is why in our opinion, it is necessary to combine and to optimize both models to achieve an accurate description of the analysis dimension *vertical linkage level*.

1.2.2. An approach to the investigation of horizontal linkage

Lewing and Schneider (2019) proposed co-occurrence analysis as an approach to the investigation of horizontal linkage. Using a computer-based procedure they looked for co-occurrences of terms in science textbooks. For the authors, two terms are defined as co-occurrent if they appear in two consecutive sentences (Lewing & Schneider, 2019, p. 724). To assign single terms to a specific subject (biology, chemistry or physics) or a combination of subjects, they checked the indices of subject-specific science textbooks.

Because all models and approaches presented in chapters 1.2.1 and 1.2.2 focus on the description of either vertical or horizontal linkage, we will present a model developed by ourselves which allows a general investigation of linkage performance in chapter 2.

1.2.3. Research question

Within the German standards for science education, the concept of energy is the only core concept that is relevant in all three separate subjects: biology, chemistry, and physics (KMK, 2005a-c). An analysis of students' knowledge linking in this concept seems to be the most functional approach to investigate the following research question:

In what way and to what extent do student statements concerning the concept of energy show both vertical and horizontal linkage structures?

2. Methods

To answer our research question, we designed an analysis procedure in which students write an essay about the concept of energy. We chose the essay method because it has many advantages regarding our main research focus (see chapter 4). The students do not need any training which is why it is feasible to survey a reasonable number of students (in our case all 9th grade students from one school).

For the analysis of students' cognitive structures, van Kirk (1979) assigned his students sentence generation tasks. A list of terms on topics like ecology stimulated the students' writing process. Following van Kirk's idea, we provide our students with a list of 26 terms dealing with the concept of energy. The procedure to select these 26 terms is described in Dietz et al. (2021).

For the analysis of the essays, we utilize Mayring's qualitative content analysis (2015). We developed our own model, which is based on the literature in chapter 1.2, and allows a general analysis of the linking performance in essays. The Model for the Analysis of the linkage of terms in essays (MAVerBE, in German: Modell zur Analyse der Vernetzung von Begriffselementen in Essays) consists of a three-dimensional category system (Fig. 1).

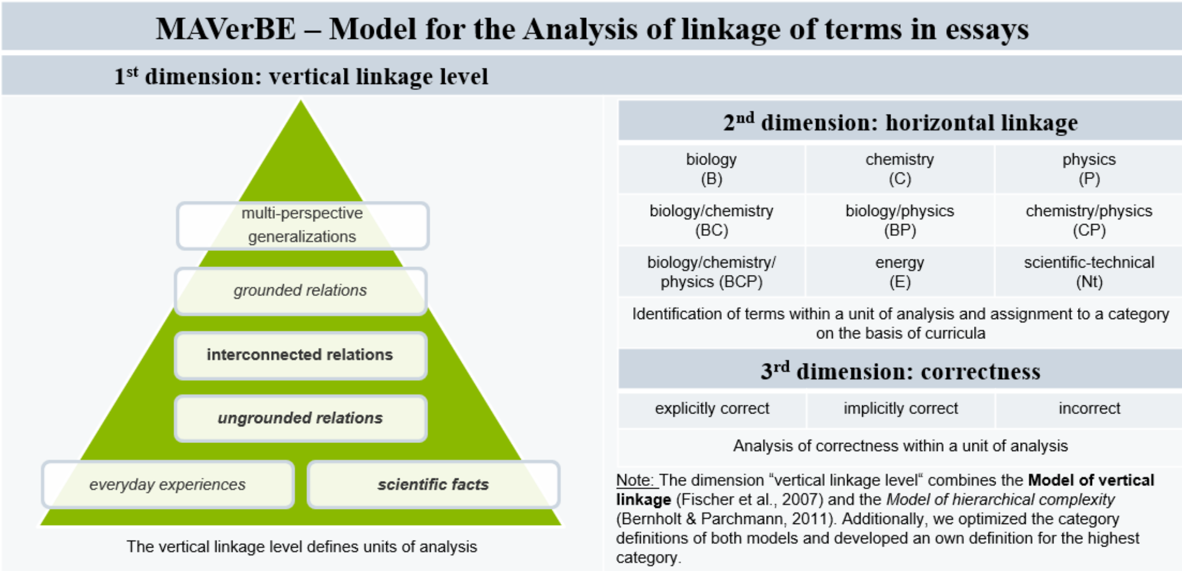

Figure 1. Structure of our theory-based model for the general analysis of knowledge-linking in essays

For the first analysis dimension, the *vertical linkage level*, we combine the model of vertical linkage (MvV) of Fischer, Glemnitz, Kauertz and Sumfleth (2007) with the model of hierarchical complexity adapted for chemistry lessons (MHC-C) of Bernholt and Parchmann (2011, see chapter 1.2.1).

At a low vertical linkage level, the students use isolated relations between terms in the form of *everyday experiences* or *scientific facts*. In contrast to the MHC-C, we allocated both categories to the same complexity level because in both cases terms are linked in a less complex manner using simple verbs like "have" or "be". The only difference between both categories is the origin of knowledge.

At the next vertical linkage level, the students formulate more complex relations. In this category we include student statements with at least two terms in the form of causalities, dependencies and conditions which are part of the category *relations* in the MvV. We also consider descriptions of processes which belong to the category *processes* in the MHC-C. Considering students' linguistic competences, in our opinion it is not functional to differentiate between these categories. For example, students could either state that heat is produced during or because of a chemical reaction. The first statement belongs to the category processes in the MHC-C, the second one belongs to the category *relations* in the MvV because it is a causality. In both cases students link the terms "chemical reaction” and “heat” in a more complex way than on the *scientific fact* or *everyday experience* level. Following the suggestion of Woitkowski & Riese (2017, p. 41) we name this category *ungrounded relations*.

Furthermore, in contrast to the MvV we do not take into consideration the number of linked elements. In the MvV it is possible to gain a higher complexity level only by listing facts (category *several facts*) or relations (category *several unconnected relations*). Here we follow Commons’ argumentation (1998, p. 240) that a higher complexity order cannot be accomplished by an arbitrary organization of lower order actions. In our opinion, stating several facts, like naming different energy forms, whether as a list or disseminated throughout an essay, should not be regarded as higher complexity.

Commons (1998, p. 252) noticed that an increasing number of linking operations lead to a higher complexity level. Following Common’s idea (1998) a higher complexity level can be achieved through the interconnection of relations. An example for such an interconnection is that students describe processes, which are coupled with each other. We refer to the category for these statements as *interconnected relations*. This category was also part of the MvV in its original version (Fischer et al., 2007).

A second, more complex, linking operation is the justification of a relation. The importance of justifying a relation is visible in the MHC-C. The category *linear causality* is the second highest category in this model (Bernholt & Parchmann., 2011). In this case, we also follow the idea of Woitkowski & Riese (2017, p. 41) and therefore we call this category *grounded relations*.

Due to the problems reported by Nehring et al. (2017) we developed our own category for the highest level. In this category students combine at least two central aspects of the concept of energy and explain this combination using at least one example. Central aspects of the concept of energy are *energy forms and sources*, *energy transformation*, *energy transfer*, *energy degradation*, *energy conservation*, and *entropy* (Duit 2014; Neumann et al., 2013; Poggi et al., 2017). According to Aebli’s perspective theory (1981, p. 206), to us it is a special linkage performance to interconnect at least two different perspectives of the concept of energy because the student has to take a multiperspective look at his semantic network. We call this category *multiperspective generalizations*.

To examine the second analysis dimension *horizontal linkage*, we conduct a co-occurrence analysis. In a first step, we code the vertical linkage level within the essays using the MAXQDA software (VERBI software, 2019). Thereby we obtain units of analysis, for example *scientific facts*. In a second step, we identify relevant terms within these units of analysis. To assign a single term to a subject (biology, chemistry, or physics) or a combination of subjects (biology/chemistry, etc.), we check the science curricula of the federal states Berlin and Brandenburg (SenBJF, 2017a-c) for these terms. In a last step, we generate networks to illustrate the results of our co-occurrence analysis with the UCINET software (Borgatti et al., 2013).

The third analysis dimension *correctness* ascertains the extent to which the students' statements are correct. Because students rarely write statements which could either be printed in scientific textbooks or are completely incorrect, we distinguish between the categories *explicitly correct*, *implicitly correct* and *incorrect*.

3. Results

3.1. Sample

At the beginning of the 2019/20 school year, we surveyed 134 9th grade students from a secondary school during a German lesson. Following the analysis procedure, a total of 1,894 units of analysis (and thus an average of 14.3 units per essay) were identified in 132 essays (two essays were rejected). On average the students were 13.9 ± 0.4 years old and wrote 126 ± 75 words per essay.

3.2. Vertical knowledge-linking

Fig. 2a shows the distribution of the units of analysis across the six categories of the first analysis dimension of our MAVerBE. 56.3 % of the student statements are on a low vertical linkage level. At this level, students name scientific facts like different characteristics of energy. For instance, they describe energy as existing in different forms. In many cases they also name these forms. Just 12.4 % of the student statements are on a high vertical linkage level. Within the category *interconnected relations* (11.2 %) the students describe energy transformation processes which are coupled with each other, like the energy transformation processes in a coal-burning power-plant.

3.3. Horizontal knowledge-linking

To show exemplary results from our analysis procedure (see chapter 2), we focus on explicitly correct ungrounded relations. Within these statements we could identify 509 co-occurrences between terms. In the generated network we recognize two dominant connections (Fig. 2, red and orange lines). First, the connection between the term energy and biology terms (11.1 %, red line in Fig. 2b). In these cases, students explain procedures to gain energy using the terms photosynthesis or nutrition. The second dominant line represents ungrounded relations between physics terms and terms which are present in both the chemistry as well as the physics curricula (10.2 %, orange line in Fig. 2b). In these cases, students often describe energy transformation processes between electrical energy (P) and light or heat (both CP).

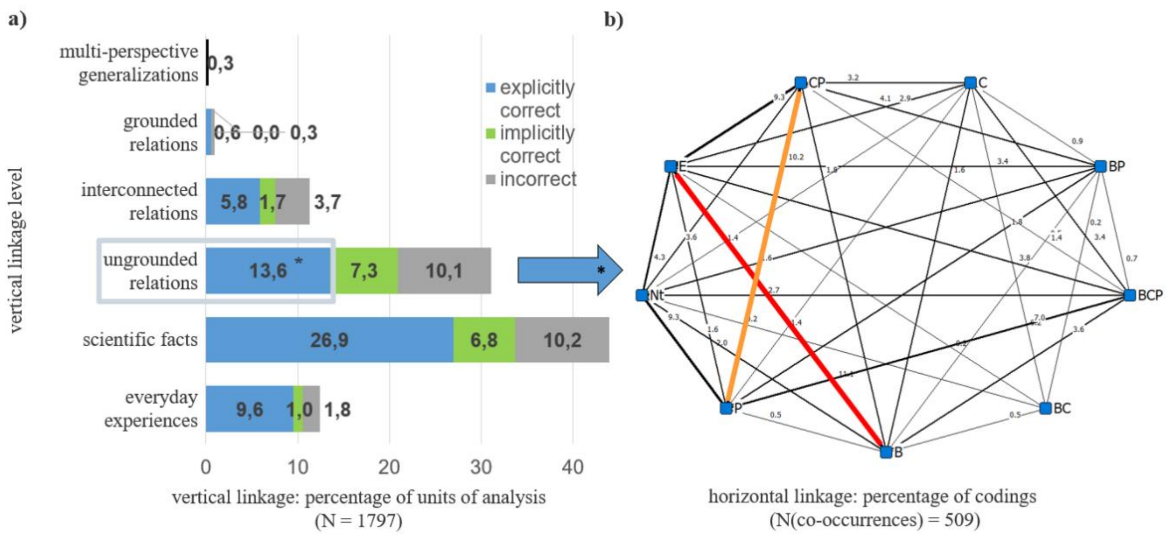

Figure 2. Selected results from the analysis with MAVerBE. a) concerning the analysis dimensions *vertical linkage level* and *correctness*, b) concerning the analysis dimension *horizontal linkage* within the explicitly correct ungrounded relations

4. Discussion and outlook

The innovative analysis procedure presented here turned out to be qualified for analysing the linkage of terms associated with the concept of energy. We should discuss critically the focus on the appearance of terms in the respective subject-specific curricula for the assessment of the *horizontal linkage* dimension. However, since curricula can be seen as a socially negotiated consensus based on the expertise of selected experts, the decision we made represents an objective and functional approach.

Concerning the next steps of our research, we are particularly interested in investigating the extent to which a science-integrated teaching approach yields qualitatively better knowledge-linking for students compared to the commonly used German practice of subject-differentiated science teaching. To investigate this, we collected essays from 9th grade students of the same secondary school at the beginning of the 2020/21 school year. These students had been taught science in a subject-integrated course in grades 7 and 8. The data is currently being evaluated and the findings will be compared to the results we have presented here.

5. Acknowledgement

We would like to thank the organization committee for the interesting, well-organized NFSUN-conference 2021 and for the opportunity of participation.

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The Role of Mathematics in STEM-activities – in the Light of Sustainability

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Abstract

In recent years STEM approaches in education have received increasing focus also in underpinning sustainable development. However, mathematics plays an understated role in these approaches. The 'LabSTEM' project focuses on developing STEM activities where mathematics plays a pivotal role. As a part of the 'LabSTEM' project a large review of 4812 articles were conducted and 37 articles, which describe STEM activities were selected, analysed and synthesized to search for the different roles mathematics can play in integrated STEM activities. Here two main categories were found: either mathematics can be applied as a tool in the STEM activity or mathematics is a specific goal. From the analysing process a construct which grasp the different ways mathematics can interplay in STEM activities were developed and subsequently verified by reviewing the 37 articles using the construct. We propose to use the construct as a clarifying and discussion tool when analysing and developing STEM activities with focus on mathematics in the future.

Keywords: STEM education, STEM integration, mathematics education, educator development, STEM teaching

1. Introduction

Currently integrated STEM approaches receive great attention in educational research and development, and STEM can be a part of the solution to future challenges such as ensuring a qualified workforce and to develop responsible citizens (Bybee, 2018). The challenges concerning global sustainable development could potentially benefit from integrated STEM approaches since these challenges cannot be seen as isolated ones - the solutions regarding the global sustainability development needs to have a wider perspective with integration in several topics, e.g., Science, Technology, Engineering and Mathematics (Bybee, 2013). The aim of STEM education is hence dual since STEM both should promote knowledge and practices in the individual disciplines and at the same time use integrated approaches to address real world problems (Maass et al. 2019). This raises questions on how the individual disciplines are and should be represented in STEM activities and many authors worries that mathematics is often overshadowed and play a too little role in integrated STEM approaches (English 2016; Fitzallen 2015; Maass et al. 2019; Shaugnessy 2013; Stohlmann 2018). Further it seems like mathematics benefits less from STEM-approaches as compared to the other disciplines (English, 2016). It is in the light of this issue the literature review presented in this proceeding was conducted.

There are different perspectives on how mathematics can interplay with the other STEM disciplines in integrated approaches. Fitzallen (2015) for example emphasizes the reciprocal relationship between mathematics and the other STEM disciplines: STEM can be seen as a context for learning mathematics, but mathematics is on the other hand also important for understanding the ideas and concepts of the other STEM disciplines. The author further argues that it is not enough to acknowledge mathematics underpinning role but suggest focussing on the instrumental nature of mathematics as a way to make mathematics more explicit in STEM activities. On the other hand, Shaugnessy (2013) suggests focussing on problem-based activities and suggest that STEM activities just need to involve a problem to solve and that mathematics then must contribute significantly when solving the problem.

Engineering design process are often used in STEM activities as a way to address real world problems (Honey et al. 2014). In this process the students could create, apply, and adapt mathematical concepts (English 2016b) but in the research literature Honey et al. (2014) found indications that engineering design process are oriented towards science at the expense of mathematics. Hence a focus on how to achieve a more balanced way to include mathematics in engineering design processes are needed (Honey et al. 2014). In general
it is important to make mathematics transparent and explicit in designing STEM-activities otherwise the role of mathematics will remain hidden (Shaugnessy, 2013) and an inadequate focus on the connections of mathematics to the other disciplines will weaken mathematics learning within STEM activities English (2016).

The ‘*LabSTEM’* project (https://www.sdu.dk/da/forskning/labstem) is a newly started ‘living lab’ for integrated STEM teaching and learning in Denmark. LabSTEM has an explicit focus on how to make mathematics central in STEM approaches and the aim of *LabSTEM* is to act in solving two key issues in the field of education: (i) the unclear importance and application of STEM and (ii) the isolation of the mathematics subject. To solve these challenges LabSTEM has established so-called laboratories consisting of pedagogues, teachers and researchers and they will in collaboration develop integrated STEM activities, which are tested and made available for practice.

Due to LabSTEM’s explicit focus on mathematics as a central part in STEM activities, we found it important to conduct a literature review to search for the different possible roles mathematics can play in STEM activities and we hence ask the following research question:

What roles does mathematics play in STEM activities as described in research literature?
In the review we focused on described STEM activities and the role of mathematics in these. The analysis of the papers included in this review resulted in a construct which seeks to capture the way mathematics interplay in STEM activity. The construct is meant as a heuristic that can help clarify and contribute to an understanding of the different roles mathematics can play in STEM activities and the construct are presented in the result section below.

2. Method

To answer our research question a systematic search, selection and reading of articles was conducted guided by the review procedures as described in Petticrew & Roberts (2006). The search string used focused on STEM in title or abstract and with an additionally explicit search for articles containing mathematics resulting in 4812 articles. Guided by exclusion criteria and with explicit focus on clear descriptions of STEM activities 37 articles were selected. The articles were read, analysed and summarized in a table with the four categories activity content, goals of activity, assessment of activity and mathematics. These four categories were further synthesized by the authors for every article answering the question: What role does mathematics play in the described activity? The analytical process followed, working out how to make sense of the notion of 'role of mathematics’'. Based on the literature studies, how can we create some kind of heuristic which grasps the different ways in which mathematics can interplay in STEM. This process took place as a facilitated, collective sense-making exercise centered around two whiteboards and resulted in two analytical constructs: one which seeks to describe whether mathematics is in the foreground or background in the STEM activity, and a second one which seeks to further qualify the role mathematics plays. The constructs were subsequently verified by reviewing the 37 articles using the analytical construct.

In this proceeding we present the second constructs.

3. Results

The construct (fig 1) contains two roles for the way mathematics relates to the other disciplines. Mathematics can be applied as a tool in the STEM activity or mathematics can be regarded as a specific goal. When mathematics is a tool in STEM activities mathematics can be used in a problem-based course. In the literature review examples of how mathematics is used in problem posing, understanding the problem, and solving the problem were found. In the review, it is also seen that mathematics is used in an engineering design process to enhance the process and the product. Finally, mathematics is found as a tool to develop a deeper understanding of science or technology for the students.

Mathematics can also be as a specific goal. Here we distinguish between two types of mathematical goals namely competencies (like mathematical modelling, or reasoning competence) on the one hand and mathematical content and skills on the other (understanding concepts like numbers, statistic or geometry). Niss & Højgaard (2011) distinguish between mathematical competence and mathematics skills and describe a mathematical competency as "*a well informed readiness to act appropriately in situations involving a certain type of mathematical challenge*." (Niss & Højgaard 2011, p. 49). In both cases, the other disciplines act as context for the learning of mathematics.

In our review it is a clear tendency that mathematics as a tool is the predominantly role of mathematics in STEM activities, and in only 6 cases mathematical goal was the primary purpose of the activity.

In regard to mathematics as a tool we found most often mathematics used as a tool in engineering design process, but also often as a tool to aquire scientific knowledge and understanding. Matematics used in problem-based activities is the least apperant role.

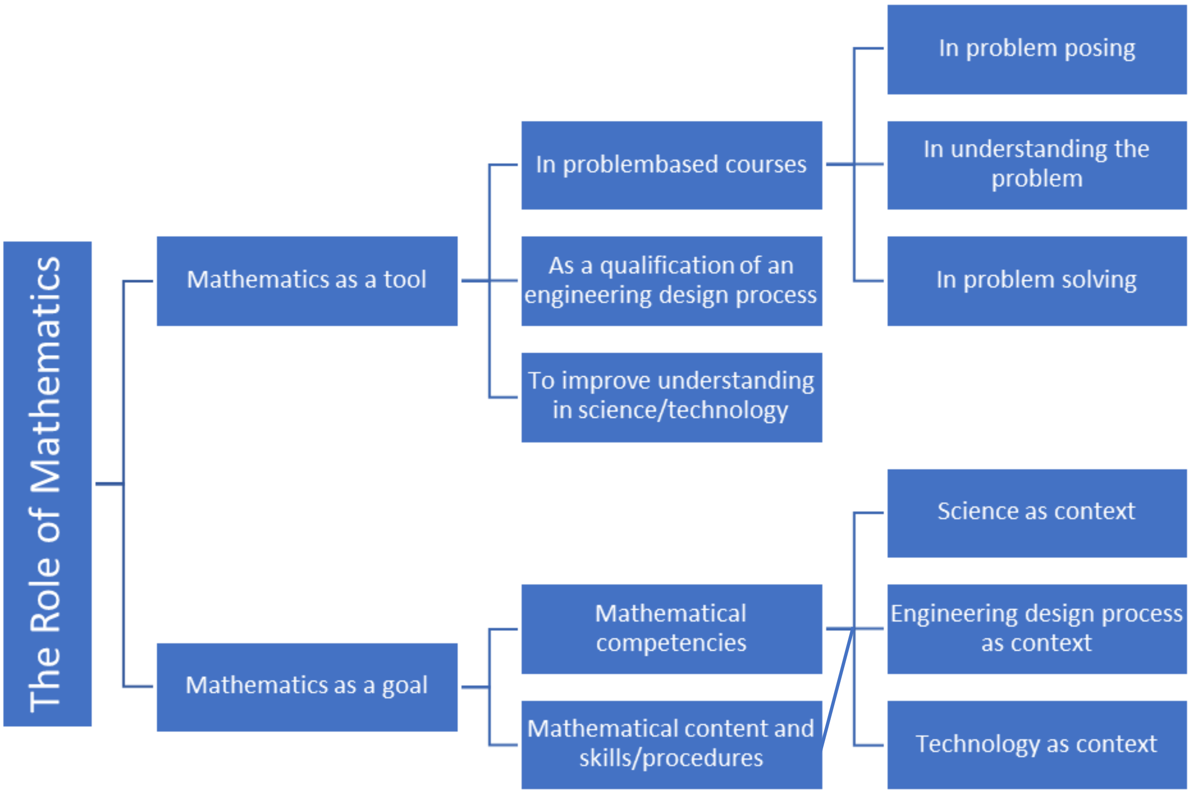

Fig. 1: Construct of the role of mathematics in STEM-activities

4. Discussion and conclusion

In the review we found different ways mathematics can interplay in STEM activities and we recognize both positions in the reciprocal relation between mathematics and the other disciplines. The different roles are captured in the construct, which we propose to use when analysing and discussing existing STEM activities but, just as important, when planning new STEM activities. Our review showed that mathematics most often is used as a tool, but we found 6 examples where mathematics was the primary goal of the activity. In these 6 activities it may however be difficult to determine whether mathematic is the primary goal or is an important tool in understanding e.g. science. We recognize that often the categorization of a STEM activity in either mathematics as a tool or mathematics as a goal will be up for discussion and specific STEM activities may fit well in more than one category. The construct is not a simple categorization device but rather meant as a discussion and clarifying device.

Our review confirms the described concerns of the role of mathematics in STEM activities and that mathematics and mathematical goal receives to little attention. In LabSTEM the main goal is to develop integrated STEM activities and to strengthen the role of mathematics in these activities. We argue that the construct will help making mathematics less understated in STEM activities, because by using this construct in LabSTEM as a discussion tool, teachers will become aware that mathematics can be integrated in several ways and get a new approach to develop STEM activities. The construct can further be used to make explicit and conscious choices of the way mathematics should interplay when STEM activities are developed. STEM often address real world problems were the disciplines isolated is not enough to encompass solutions, but integrated STEM activities should also be designed to support development of practices and knowledge form the individual disciplines as well (Honey et al. 2014). Honey et al. further argues that " *STEM curricula should also attend to discipline-specific learning progressions; if the learning goals of one discipline are primary, the knowledge and skills of other disciplines should be integrated into the curriculum with the learning progressions of that discipline in mind*" (Honey et al. 2014 p. 98).
We propose to use the construct presented here to address and seek the balance between interdisciplinary focus on real world problems and focus on disciplinary knowledge and practices by using both approaches where mathematics is the primary goal of the activity or were mathematics act as an important and necessary tool for acquiring deep knowledge in the other disciplines or in problem-based activities.

We also argue that by looking at global sustainable development as a hole - as with integrated STEM - responsible citizens will be able to meet some of the challenges to come.
Integrated STEM approaches can be a foundation in developing responsible citizens and supporting sustainable development. Mathematics must have a central role in this by offering competencies needed to address future challenges both in its own right and as underpinning the understanding of the other disciplines in STEM activities.

Whether the construct presented here is beneficial for teachers as a planning and discussion tool and the use of the construct improves the role of mathematics in the STEM activities developed in LabSTEM needs further research.

5. Acknowledgement

LabSTEM is handled by LSUL - Laboratory for Coherent Education and Learning at the University of Southern Denmark and is funded by the Novo Nordisk Foundation and the Region of Southern Denmark's education pool.

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Udvikling af et sprog for kommunale naturfagsindsatser

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Abstract

Astra supports each municipality in Denmark in their efforts to strengthen and develop the field of science education. We attend municipal processes of co-creation and aim for their own capacity building, so that they develop abilities to further pursue local and national goals, on a municipal level.

This article focuses specifically on the dialogue and conversations Astra's advisers have on a yearly basis with an appointed science coordinator from each municipality. We have developed a tool for the conversations called the compass of science education/science culture. We have investigated how the compass as a framework for the dialogue and its embedded concepts of a municipal science culture and the language development related to the conversations sustain the development processes in the municipalities.

We present results of a multiple case study, mainly based on interviews, observations and theory development. The study generally supports the hypothesis that Astra's dialogue with municipalities impacts the development of the science culture and the science education. We also invite researchers to attend this specific field further, as we see an increase in political interest and have found very little research so far.

Keywords: Municipality, science culture, science coordinator, policy, case study, science education

1. Introduction

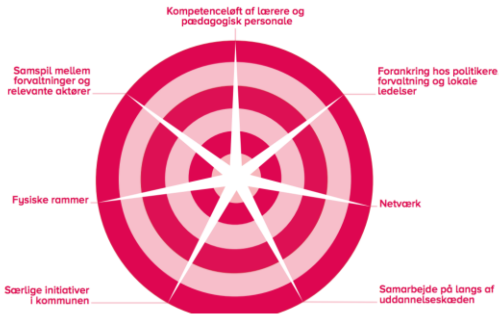
EVERY MAN is in certain respects
a. like all other men,
b. like some other men,
c. like no other man.
(Kluckhohn & Murray, 1953).

Kommuner er som alle andre, som nogle andre og som ingen andre.
(Ole & Elzebeth, 2021)

Siden 2017 har konsulenter fra Astra gennemført mere end 150 samtaler med kommunale naturfagskoordinatorer med naturfagskompasset som ramme (herefter kompassamtaler). En naturfagskoordinator forstås som en udpeget person, der har en koordinerende funktion i kommunen inden for naturfagsområdet, se evt. astra.dk/forankring/hvad-er-en-naturfagskoordinator. Formålet er at understøtte kommunale udviklingsprocesser inden for naturfagene i feltet mellem undervisningen og organiseringen på skolerne, forvaltningernes arbejde med lovmæssige krav samt lokal- og nationalpolitiske visioner. Altså udviklingen i den kommunale naturfaglige kultur. I vores samarbejde med kommunerne har vi udviklet tre grundlæggende antagelser (Kronvald, Buch-Illing 2018), som vores samlede indsats er funderet på, og som også har inspireret det indledende citat om kommunernes samtidige ensartethed og forskellighed:

a) Alle kommuner har en eller anden form for naturfagsindsats.
b) Alle kommuner er forskellige og bygger indsatser op om lokale styrkeforhold.
c) Kommuners naturfagsindsatser kobles oftest op på andre kommunale indsatser og strategier.

Naturfagskompasset er et dialogværktøj, der består af 7 indsatsområder, som udgør væsentlige elementer i en kommunal naturfagsindsats. Værktøjet illustreres gennem et edderkoppediagram, hvor indsatserne placeres på 7 akser ud fra midten af spindet. Naturfagskompasset er beskrevet i (Wøhlk, Kronvald, Buch-Illing 2018).



Astra tilbyder kommunerne én årlig kompassamtale foruden løbende sparring og videndeling efter behov, og der tages udgangspunkt i kommunens egne initiativer og problemstillinger. Antagelsen er, at kompassamtalen bidrager med flere elementer, nemlig en optik for den kommunale naturfagsindsats og et professionelt sprog for naturfagskulturudvikling. Vi tror på, at det er med til at kvalificere arbejdet med naturfaglig kultur i hele kommunen.

Figur 1: Naturfagskompasset er et samtaleværktøj med syv akser: Kompetenceløft af lærere og pædagogisk personale; Forankring hos politikere, forvaltning og lokale ledelser; Netværk; Samarbejde på langs af uddannelseskæden; Særlige initiativer i kommunen; Fysiske rammer; Samspil mellem forvaltninger og relevante aktører.

I den løbende evaluering og videreudvikling af Astras indsats overfor kommunerne er vi her optaget af, hvilket udbytte vi kan se af kompassamtalerne. Nærværende undersøgelse har derfor følgende undersøgelsesspørgsmål:

På hvilke måder bidrager den årlige kompassamtale til naturfagskoordinatorens arbejde med den fortsatte udvikling af den kommunale naturfaglige kultur?

For at operationalisere undersøgelsen har vi formuleret følgende tre hypoteser, der har været retningsgivende for vores behandling af de store mængder data, der fremkom i casestudiet:

1. Kompassamtalerne understøtter udviklingen af et fælles sprog for naturfaglig kultur på forvaltningsniveau.
2. Kompassamtalerne giver anledning til refleksion over og igangsættelse af konkrete handlinger.
3. Kompassamtalerne og naturfagskompasset understøtter naturfagskoordinatorens position i forvaltningen, således at naturfagskoordinatoren får mulighed for at bidrage til ledelsen af

naturfagsudviklingen både i forhold til naturfagslærere, forvaltningsniveau og kommunalpolitikere.

Undersøgelsen fandt sted i skoleåret 2020/21. Resultaterne af undersøgelsen er fremlagt på NFSUN 2021 og forventes at bidrage til både den fortsatte udvikling af kommunernes naturfagsindsatser og kulturudvikling, til en fortsat kvalificering af Astras kommunale indsats og ikke mindst til invitation til yderligere forskning og undersøgelse af feltet.

2. Teoretisk fundament

Der er indtil nu forsket meget lidt i, hvilken betydning det har for udvikling af den naturfaglige kultur i en kommune, at en naturfagskoordinator varetager en koordinerende opgave. Grundlæggende arbejder vi i Astra ud fra forståelsen af, at naturfaglig kulturudvikling (Sølberg, 2007) ses som et netværk af sociale praksisser, dvs. som et komplekst samspil mellem naturfagslærere og andre aktører, mellem lokale procedurer for udvikling og forhandling af værdier og forståelser, fx i centrale kommunale og nationale styredokumenter som fx strategier og handleplaner (Silassen, 2014). Centralt i det netværk står en naturfagskoordinator i en kommune, som arbejder for at forene og forhandle naturfagsudviklingen.

(Sillasen og Valero, 2013) peger på, at en naturfagskoordinator spiller en stærk rolle som “mægler” eller “brobygger” mellem naturfagslærere, skoleledere og skoleforvaltning i en kommune. Samtidig er styrken af mæglingen/brobygningen afhængig af, hvordan naturfagsindsatsen som helhed og naturfagskoordinatorens handlemuligheder i særdeleshed varetages i den enkelte kommune. Det handler om naturfagskoordinatorens muligheder for at skabe stabile relationer til skolernes naturfagsmiljøer, fx naturfagsvejledere, om kommunens ressourcetildeling til fx netværks- og udviklingsaktiviteter samt naturfagskoordinatorens adgang til at bidrage i de strategiske processer i skoleforvaltningen. (A.v.d. Fehr, 2016) peger i sin forskning på, at naturfagsudviklingen i projektet Science Kommuner skete i komplekse netværk, hvor naturfagskoordinatorer var én blandt flere centrale aktører. Disse aktører sås bl.a. som gatekeepere for vigtig information i netværkene, men også som forbindelsesskabende mellem forskellige dele af den kommunale naturfagskultur, fx på de enkelte institutioner, eksterne læringsmiljøer og i skoleforvaltningen.

Selve kompassamtalen baserer sig på narrativ konsulentpraksis, der har til formål at undersøge og udvide naturfagskoordinatorens fortælling om egne oplevelser, ønsker og udfordringer med naturfagsområdet (Westmark et al, 2012). Astra har udarbejdet en semistruktureret spørgeguide, som danner ramme for samtalen.

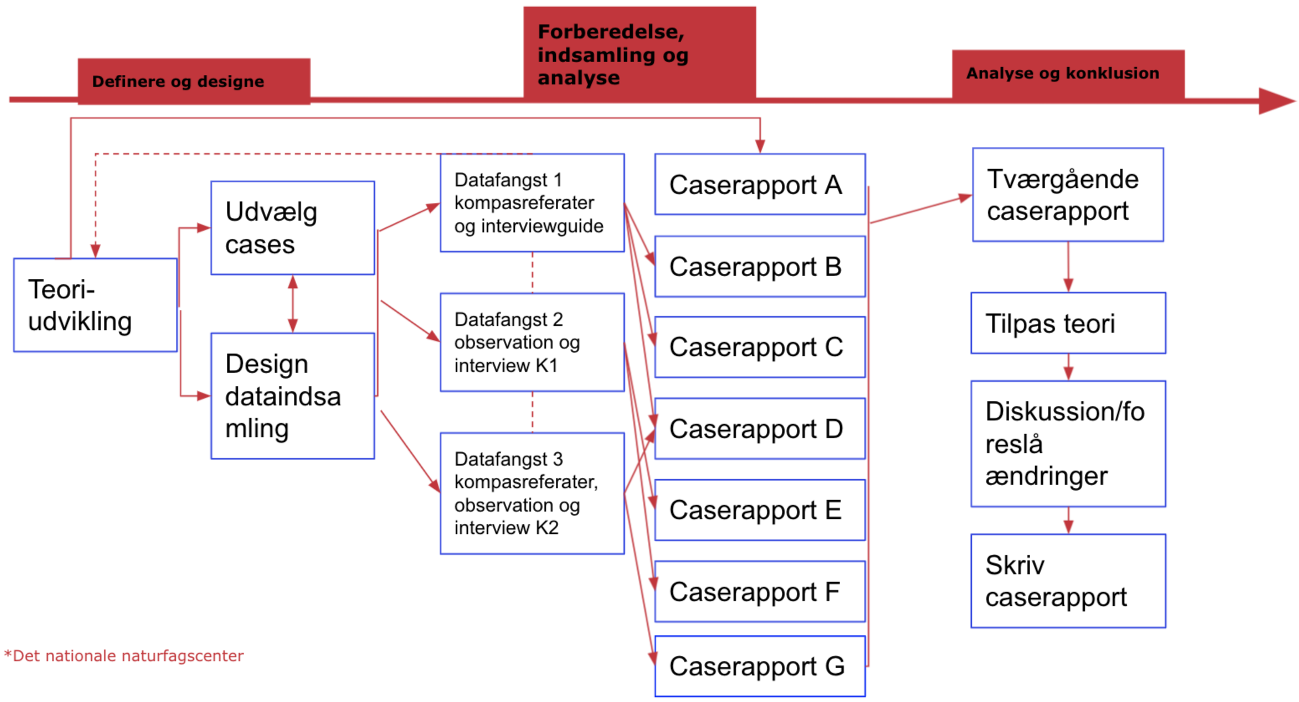
3. Metode

Vores problemstilling beskæftiger sig med et fænomen (kompassamtalen) i dets umiddelbare kontekst (samspillet mellem naturfagskoordinator og forankringskonsulent i feltet omkring kommunens naturfaglige kultur), hvorfor konkret, praktisk og kontekstafhængig viden er værdifuld. Derfor har vi valgt et "almindeligt casestudie" i et multiple case design. Casemetoden forudsætter faglig ekspertise af os som Astrakonsulenter og tillader os endvidere at arbejde løbende med information og design, herunder at justere og formulere tematikker til undersøgelsen. Den almindelige (common) case muliggør generalisering og udvikling af generelle teser og teorier, hvilket er produktivt for vores videre udvikling af det kommunale indsatsområde i Astras Forankringsafdeling, mens det multiple case design giver mulighed for at anvende flere synsvinkler på undersøgelsens genstandsfelt (kompassamtalen), hvorved risiko for bias og automatisk verifikation mindskes. Det indlejrede casedesign betyder, at hver case undersøges som et selvstændigt input, men i lyset af samme problemstilling og vel vidende, at alle kommuners naturfagsindsats i nogen grad er underlagt ens nationale politiske og økonomiske rammer (Yin, 2014).

Vi har hentet information ved fire datakilder i tre kommuner. Kommunerne er udvalgt på baggrund af de ovenstående grundlæggende antagelser, og indledningsvist var der tale om kommune A og B udvalgt efter bl.a. et størrelseskriterie, et øst/vest-kriterie og et "etableret/mindre etableret"-kriterie. Pga. situationen med covid-19 måtte kommune A imidlertid udgå, hvorfor vi erstattede kommunen med kommune C, som vi vurderede havde en relevant profil. De fire datakilder er:

- referater fra tidligere afholdte kompassamtaler (kommune A, B og C)
- interviews med kommunale naturfagskoordinatorer (kommune B og C)
- observationer af kompasamtaler (kommune B og C)
- spørgeguide til kompassamtaler (generelt dokument)

Herunder ses et diagram over vores undersøgelsesforløb:



Figur 2: Diagram over undersøgelsens forløb

Vi har foretaget vores valg af informanter jf. ovenstående grundlæggende antagelser, og vi har anvendt en semiåben kodning af data tematiseret både med baggrund i problemstillingen og de afledte hypoteser og i vores erfaring med at afholde kompassamtaler med kommuner.

De enkelte caserapporter i figur 2 uddybes under "Fund".

3. Fund

I dette redegøres for vores fund i de enkelte caserapporter. For hver datakilde og for hvert tema har vi i undersøgelsesprocessen skrevet en caserapport, mens vi i den endelige caserapport har anvendt de tre hypoteser som optik for diskussionen. Endelig svarer vi på problemformuleringen i artiklens konklusion. Herunder ses en oversigt over de del-caserapporter, vi har udarbejdet:

Caserapport A

Genstandsfeltet for caserapport A er en teoretisk kategorisering og tematisering af begreber på baggrund af problemstillingen. Følgende begreber er udvalgt til den efterfølgende kodning:

- Kompasbegreber (hvordan anvendes begreberne fra naturfagskompasset?)
- Naturfagskoordinatorens narrativ (hvad fortæller naturfagskoordinatoren, når det kommer til tid, historik, anciennitet, værdi, handlinger, positionering, ønsker/drømme/ forhåbninger?)

- Typer af spørgsmål og typer af information i referaterne (i hvor høj grad og hvornår er der tale om informerende indhold, strategisk indhold og stilladserende indhold?)
- Interviewers egen professionelle position (hvad er Astrakonsulentens intention, diskurs og hvordan operationaliseres de grundlæggende antagelser?) (*OBS: Dette perspektiv inddrages kun perifert i de følgende analyser, da det i højere grad handler om Astra-interne udviklingsprocesser end naturfagskoordinatorerne og kommunerne*).

Caserapport B

Caserapporten er det analyseværktøj, vi har anvendt til at analysere interviewguiden og kompasreferaterne. Temaerne fremgår af caserapport A.

Caserapport C

I caserapport C har vi analyseret de spørgsmålskategorier og indholdet i de spørgsmål, der stilles til naturfagskompassets syv akser.

Analysen viser blandt andet:

- Spørgeguidens vægtning af hhv. informationssøgende, stilladserende og strategiske spørgsmål og Astrakonsulentens rolle som samtalepartner ændrer sig undervejs i kompassamtalen og afhænger af den enkelte kompasakse.
- Spørgmålene omkring politisk forankring af naturfagsindsatser er særligt intentionelle, dvs. der registreres et ønske om at høre om eller animere til en opmærksomhed på aksen.
- I spørgsmål relateret til naturfagskoordinatorens samspil med andre aktører søges det at tilvejebringe information og refleksioner over nye og eksisterende samarbejdsmuligheder.
- I spørgeguiden tillægges kompetenceløft stor betydning ift. udvikling af naturfaglig kultur, fx i forbindelse med udvikling af naturfagteams og kommunal koordinering.
- Spørgsmål vedr. sammenhæng på langs af uddannelseskæden har udviklet sig mest siden spørgeguiden blev udarbejdet. I begyndelsen spurgtes der mest informationssøgende, men efter indholdsområdet og kompasaksen er blevet en større del af Astras kerneopgaver, spørges der mere stilladserende og strategisk.

Caserapport D

Caserapporten omhandler analysen af kompasreferaterne, som er delt i 1) kompasbegreber og 2) naturfagskoordinatorens narrativ om egen position i den naturfaglige kultur. På tværs af de mange referater, der er analyseret, viser rapporten:

1) Kompasbegreber:

- Aktører: der fortælles om både generelle aktører på skole- og dagtilbudsområdet, forvaltningsophænget (den direkte styringskæde) og de naturfagsspecifikke aktører.
- Niveauer: naturfagskoordinatorerne forholder sig til et "lodret" kommunalt perspektiv, nemlig det, der iagttages i uddannelses- og styringskæden, og der fortælles om styrkepositioner og relationelle net.
- Placering: naturfagskoordinatoren forholder sig også til et "vandret" organisatorisk perspektiv med aktører placeret både i og udenfor den formelle ramme, som skolesystemet udgør. Her italesætter naturfagskoordinatoren også sin egen position og bevægelser.
- Aktiviteter: der fortælles først og fremmest om en stor mangfoldighed i aktiviteterne og deres strategiske funktion, men der registreres også et ønske om at vise handlekraft og anerkendelse inden for naturfagsområdet. Aktiviteterne sættes både ind i en sammenhæng, når det kommer til progression og til kapacitetsopbygning.
- Styringsbegreber: naturfagskoordinatorerne anvender "kommunesprog", som fx strategi, indsats, sammenhæng, ressourcepersoner, ledelsesinvolvering mv.

2) Naturfagskoordinatorens narrativ om sin egen position i den naturfaglige kultur

- Tid, historik, anciennitet: begreberne anvendes som målestok for årsager og virkninger i udviklingen af den naturfaglige kultur, og naturfagskoordinatoren spejler sig i egen praksis og de muligheder, der enten var engang eller som kan anskues fremadrettet.
- Værdi: naturfagskoordinatoren fortæller om etablerede værdier i kommunen, som der er et ønske om enten at nærme sig eller fjerne sig fra. Desuden ses et ønske om løbende at skabe værdi og at få øje på nye værdier ved den indsats, der er i gang.
- Handlinger mellem aktører: som ovenfor registreres både et "lodret" perspektiv (fx når forvaltningen sætter en samlet indsats i gang eller skolelederne bliver bedt om at give input til en indsats) og et vandret perspektiv (fx når skoleforvaltningen indgår samarbejde med åben-skole-aktører uden for det formelle skolesystem eller når et lokalt museum henvender sig med et projekt for skoler).
- Afgrænsninger organisatorisk, placering, positionering: naturfagskoordinatoren er naturligt hovedperson i fortællingen om naturfagsindsatsen, og de fortæller om på den ene side at stå i

en “parat” position, klar til at gribe muligheder og tilbud og på jagt efter nye alliancepartnere, og på den anden side at være “i kamp” mod andre dagsordener eller indsatser i kommunen, der kan risikere at tage rampelys og/eller ressourcer fra naturfagene.

- Ønsker, drømme og forhåbninger: i samtalerne registreres der ved naturfagskoordinatorerne et stort ejerskab og en loyalitet, men også en ydmyghed, i forhold til naturfagsområdet. Desuden er der en tydelig retning mod organisatorisk kapacitetsopbygning.

Caserapport E

I caserapport E beskrives udviklingen af observations- og interviewguiden til brug ved kompassamtalerne. Observationsguiden indeholder tre kolonner: tidskodning, objektive observationstemaer og mulighed for at notere Astrakonsulentens egne refleksioner.

Interviewene, der finder sted umiddelbart efter samtalerne, indeholder tre temaer inspireret af undersøgelsens tre hypoteser:

- kompassamtalen - før, under, efter
- betydningen af det, vi taler om
- betydningen af måden, vi taler på

Caserapport F

Caserapport F indeholder en analyse af observationen og interviewet i kommune B.
I kompassamtalen (som observeres) fortæller naturfagskoordinatoren om sin position, aktiviteter og målgrupper jf. kategorierne i caserapport A og E. Naturfagskoordinatoren fortæller om det på en måde, der tydeliggør blikket på egen position, forventninger til funktionen og arbejdsopgaverne. Beskrivelserne sættes ind i en strategisk indsats. Kompassamtalen understøtter tilblivelsen af fortællingen ved bl.a. at undersøge relationer mellem deltagere i forskellige aktiviteter, men også gennem samtalens artefakter (naturfagskompasset, Marias rejse) og de tre spørgsmålstyper (informerende, stilladserende og strategiske). I det efterfølgende interview afprøves undersøgelsens tre hypoteser, og naturfagskoordinatoren bekræfter, at “kompassproget” og -begreberne forstås og anvendes samt oversættes i organisationen efter behov. Naturfagskoordinatoren fortæller, at den årligt tilbagevendende kompassamtale er med til at understøtte udvikling af både sprog og relationer samt at refleksioner fra kompassamtaler bringes med videre til drøftelser med fx egen leder.

Caserapport G

Caserapport G indeholder en analyse af observationen og interviewet i kommune C. I kompassamtalen er der fokus på naturfagskoordinatorens strukturering af opgaven med naturfagsindsatsen, ressourcer til denne opgave samt naturfagskoordinatorens position og dermed mulighed for at lykkes med opgaven. Naturfagskoordinatoren fortæller om det på en måde, der understøtter et stærkt blik på den systematik, naturfagsindsatsen indgår i, og den strategiske skoleudvikling, som indsatsen er en del af. Samtalen understøttes som i kommune B også af de artefakter, der anvendes i samtalen (naturfagskompasset, skabelon til lokale naturfagshandleplaner, Marias rejse) samt ved spørgsmål relateret til naturfagskoordinatorens selvforståelse og relationer. I interviewet gives der udtryk for, at den årligt tilbagevendende kompassamtale er med til at understøtte udvikling af kompassproget samt at fastholde opmærksomhed på naturfagsområdet. Kompasbegreberne anvendes aktivt til at analysere egne indsatser i kommunen. Naturfagskoordinatoren bruger kompassamtalen til at kvalitetssikre eksisterende og nye initiativer, og naturfagskompasset som artefakt støtter ifølge naturfagskoordinatoren dennes position i forvaltningen og danner udgangspunkt for egne strategidokumenter.

De enkelte fund knytter sig naturligvis til de konkrete kommuners arbejde med naturfagsindsatserne, og da fundene er fremkommet i de konkrete samtalesituationer, kan de muligvis fremstå som mangfoldige, eventuelt som 'små' fund og måske også spredte. Fundene giver imidlertid et blik på både en række tematikker, der knytter sig til fænomenet "kompassamtaler", og samtidig skal fundene ses som gyldige eksempler på indhold under tematikkerne, som naturfagskoordinatorer arbejder med i den daglige naturfagskoordinatorpraksis.

I det følgende diskussionsafsnit relaterer vi de enkelte fund til de tre hypoteser.

4. Discussion and conclusions

I dette afsnit diskuterer vi indholdet af de syv caserapporter i lyset af de tre hypoteser, vi har formuleret for undersøgelsen. Afslutningsvist sammenholder vi diskussionens delelementer med undersøgelsens problemstilling for at formulere en konklusion.

Hypotese 1: Samtalerne understøtter udviklingen af et fælles sprog for naturfaglig kultur på forvaltningen

Fra observationer og interviews i kommune B og C kan vi overordnet se, at der fortælles om at anvende metalingo, dvs. at naturfagskoordinatoren forstår og skifter mellem sproglige koder, hhv. lærer- og elevrettet sprog (forklarende) og forvaltnings- og politikerrettet sprog (som minder om skriftsprog og som indeholder "kompasbegreber"). Det peger på en naturfagskoordinator med en mediatorfunktion, idet både sprog og handlinger tilpasses den givne situation "lodret" og "vandret". Der er en bevidsthed om, at sproget under kompassamtalen har en strategisk og refleksiv placering i organisationen (skoleområdet i kommunen), men at samtalen relaterer sig til undervisningsområdet og dermed -sproget. Naturfagskoordinatorerne kobler dermed mellem det strategiske og det operationelle plan. Begreberne (akserne og de tilhørende begreber, som identificeres i spørgeguide og referater) i naturfagskompasset anvendes til at analysere kommunens naturfagsindsats og aktivt til at analysere praksis fra skolerne.

Naturfagskoordinatorerne bifalder den tilbagevendende og ensartede måde, kompassamtalerne gennemføres på, fordi det giver en tryghed i relationen og genkendelige forventninger til samtalen. Det, at der er tilbagevendende samtaler, er en del af en vigtig modus omkring at fastholde opmærksomheden på naturfagsområdet i kommunen.

Hypotese 2: Samtalerne giver anledning til refleksion over og igangsættelse af konkrete handlinger

I analyserne af kompasreferaterne, observationerne samt interviewene i kommune B og C findes der rigtig mange fortællinger om naturfagsaktiviteter, både nuværende, tidligere og ønskede, og der reflekteres også over dem og deres betydning. Det fremgår, at konkrete handlinger igangsættes med baggrund i kommunens strategier eller opståede muligheder, men reflekteres i kompassamtalen. Dvs. kompassamtalen anvendes som en form for kvalitetssikring eller sparringsrum, men ikke et egentligt arnested for udvikling af eller inspiration til igangsættelse af nye aktiviteter. Det er i højere grad mål på naturfagsområdet og naturfagskoordinatorens relationer, der får betydning for, hvilke og hvordan handlinger sættes i gang.

I både interviews og observationer oplever vi, at naturfagskoordinatorerne i alle tre cases optræder meget loyalt og ydmygt overfor den ramme, de hver især arbejder inden for. Det handler bl.a. om, at de anerkender naturfagsområdet som en del af et større fagligt område i forvaltningerne, og derfor lægger de sig op ad gældende strategier og aktuelle kommunale styrkeområder. På den måde er de med til at skabe det rigtige tidspunkt for at sætte konkrete initiativer i gang. Kontakter til relevante kommune-interne aktører samt timing bliver således vigtige parametre for naturfagsudviklingen i kommunen. Dette uddybes i næste afsnit.

Hypotese 3: Samtalerne og naturfagskompasset understøtter naturfagskoordinatorens position i forvaltningen, således at naturfagskoordinatoren får mulighed for at bidrage til ledelsen af naturfagsudviklingen både i forhold til naturfagslærere, forvaltningsniveau og kommunalpolitikere.

Når det kommer til naturfagskoordinatorens **position i forvaltningen**, så viser analysen af kompasreferater, observationer samt interviews, kommune B og C, at naturfagskoordinatorerne er opmærksomme på egen position. Dette står da også som et centralt emne på tværs af kompasakserne og genfindes bl.a. i naturfagskompassets spørgeguide. Naturfagskoordinatorerne bevæger sig i feltet mellem styrings- og uddannelseskæden og ind og ud af relationer med aktører (niveauer), mens de forsøger at placere sig strategisk ift. hvor beslutninger træffes, hhv. centralt, decentralt eller helt udenfor det formelle system. Naturfagskoordinatorerne overvejer også deres organisatoriske placering ift. andre konsulenter, ledelse og kommunalpolitikere (placering). Vi kan se et stort fokus på værdiskabelse i en politisk styret organisation og et fokus på top-down bevægelser, som kan styrke naturfagsområdet. Naturfagskoordinatorerne er stærke i at argumentere for deres handlinger og indsatser, og de søger alliancepartnere, som kan bidrage. De har øje for kommunale visioner for naturfagsindsatsen, og de viser loyalitet og ydmyghed overfor samarbejdspartnere og den kommunale ramme (styringsbegreber).

Når det kommer til **handlinger**, så viser analyser af kompasreferater, observationer samt interviews i kommune B og C, at naturfagskoordinatorerne forstår sig selv som igangsættere, særligt ift. praktikere/undervisere, men også i forhold til at skabe mere forståelse for naturfagsområdet ved bl.a den øverste ledelse. Kompassamtalen tilbyder et refleksionsrum for naturfagskoordinatorer, og det iagttages, at scoring i kompasset skaber dialog og muligheder for refleksion. Kompassamtalen bidrager med argumenter til naturfagskoordinatoren, når der skal argumenteres ind i organisationen, for kompassamtalen handler også om aktiviteternes strategiske position i naturfagsindsatsen. Naturfagskompasset og kompassamtalens struktur og metodik bliver en konkret artefakt, der kan imiteres eller udvikles til kommunal eller lokal kontekst, hvilket bevirker, at naturfagsindsatsen ses ind i både kommunale, regionale og nationale strategier.

På baggrund af undersøgelsen af de tre hypoteser har vi formuleret følgende konklusion på problemstillingen:

På hvilke måder bidrager kompassamtalen så til naturfagskoordinatorens arbejde med den fortsatte udvikling af den kommunale naturfaglige kultur?
Naturfagskoordinatoren kan med sit systematiske blik og sprog koble an til generelle strukturer i skolekulturen og dermed skabe rum for udvikling af naturfagskulturen. Naturfagskoordinatorens position (om man er fysisk placeret i en forvaltning eller ej) ser ikke ud til at være afgørende for, om udvikling af naturfagskulturen kan lykkes, men kompassamtalen bidrager til, at naturfagskoordinatoren får øje på sin egen position og muligheder og dermed styrkes i sine muligheder for at udvikle derudfra. Naturfagsaktiviteterne iagttages i samspil med de strukturer, der er omkring dem, fx kommunale styrkepositioner, indsatsområder mv. snarere end "udefra kommende", og kompassamtalen bidrager til at etablere et fagligt sprog for naturfagsudvikling i kommunerne. Endvidere bidrager kompassamtalen til at give naturfagskoordinatorerne et fællesskab om deres funktion. "En del af noget større".

I forlængelse af dette casestudie ligger der fortsat flere perspektiver, der kan belyse området yderligere. I vores analyser af kompasreferater, ved interviews og observationer får vi data på, at kompassamtalernes forløb er forskelligartede. Det kan muligvis pege på en variation, afhængig af, hvem af Astra-konsulenterne der deltager i de enkelte kompassamtaler, fx mht. samtaleteknikker og egne vurderinger af den enkelte kommunes styrkepositioner. Dette perspektiv har vi i høj grad fokus på i Astras interne udviklingsprocesser, men et spændende studie kunne være at undersøge, hvilke effekter det har for naturfagsudviklingen i de enkelte kommuner.

Et mere teoretisk perspektiv til yderligere undersøgelse kunne være at sætte vores antagelser om at kunne identificere og udvikle en kommunal naturfaglig kultur under luppen. Giver det mening, enten fra et naturfagligt perspektiv at skalere faglige udviklingsprocesser op til at tale om et kommunalt systems naturfaglige kultur, eller fra et generelt skoleudviklingsperspektiv at opdele hele kommunens styring og udvikling af skoleforvaltningen i fagområder? Hvilke fordele og ulemper, muligheder og barrierer giver det at lægge så brede rammer for, i sidste ende, det enkelte barns læring i naturfagene i grundskolen? Vi tror på, at der er basis for at interessere sig yderligere for fænomenet "den kommunale naturfaglige kultur", og vi deltager gerne i udviklings- og forskningsprojekter herom.

5. Tak

Tak til de tre deltagende kommuner og i særdeleshed de tre naturfagskoordinatorer samt disses kolleger, der deltog i nogle af samtalerne. De er lovet anonymitet, men ved, hvem de selv er. Også tak til vores kolleger i Astras Forankringsteam for værdifuld sparring og udviklingslyst.

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De tre nævnte artefakter: Naturfagskompasset, Marias rejse og Den lokale naturfaglige handleplan kan downloades fra astra.dk.

NORWEGIAN 10TH GRADERS ANNO 2020: MORE CONCERNED ABOUT THE ENVIRONMENT, AND MORE COMMITTED TO CHANGE

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Abstract

In 2002, the large international questionary-based study ROSE (the Relevance of Science Education) showed among many results that Norwegian 10th grade students were moderately concerned about environmental issues, and not very interested in learning about it. Recently, an international questionary-based follow up-study ROSES (ROSE Second) was launched, and in the current study we present some of the Norwegian findings from ROSES, mainly concerning what students think about the environment and sustainability in 2020. The new results are in some extent compared to the findings of the 2002 ROSE study.

Regarding sustainability in the present study, Norwegian 10th grade students of today are more interested in environmental issues, more willing to act – especially among the girls, and at the same time more concerned about the future when it comes to environmental problems compared to students in 2002. In addition, more than half of the students in the ROSES study would like to take part in a climate strike or another action for the environment and show signs of genuine commitment.

Keywords Concerned, environment, commitment, action, change, sustainability

1. Introduction

Knowledge about students' interests and attitudes is important in order to develop science as a meaningful subject for all. From 2002 to 2006 an international project, ROSE (the Relevance of Science Education), was conducted as a survey among students in approximately 40 countries. The project investigated 15-year-old learners' attitudes towards and motivation to learn science and technology (Schreiner & Sjøberg, 2019; Sjøberg & Schreiner, 2019). The survey also included questions related to the students' interest in and concern for environmental issues. ROSE showed that Norwegian 10th grade students in 2002 were moderately concerned about environmental issues, and not very interested in learning about the environment (Schreiner & Sjøberg, 2005).

In 2019 an international follow-up study of ROSE, ROSES (ROSE Second) was launched (Jidesjö et al., 2020). More than 50 countries have expressed their interest to participate, but only a few have completed data collection so far. This gives a unique opportunity to shed light on how young people's engagement with environmental issues has developed.

In this study we present some of the findings from the Norwegian ROSES survey. Our backdrop is a growing global concern about environmental issues like increasing deforestations, chemical and plastic pollutions, climate changes, a global loss of biodiversity and a human consumption that seems to keep increasing. At the same time youths seem eager to contribute to a better future by for example striking for a better climate, collecting waste and recycling (Corner et al., 2015; Karsgaard & Davidson, 2021; McDougle et al., 2011; Sinnes, 2020).

The present study aims to gain a better insight into Norwegian students' opinions about environmental and sustainability issues in 2020, compared to results from the 2002 ROSE project.

The research questions are:

- In what ways has Norwegian 10th grade students' interest in, concern for and willingness to act for environmental and sustainability issues changed between 2002 and 2020?
- Do we see signs of commitment to solving environmental problems among the students?
- Are there differences between girls and boys with regards to students' interest in, concern for and willingness to act for environmental issues and sustainability?

2. Method

The study incudes Norwegian ROSE data from 1204 students (50,0% of each gender), with permission and support from the project manager Svein Sjøberg, and ROSES data from 810 students (52,1% girls, 47,9% boys).

In order to compare results over time, most of the survey questions in ROSES are identical to questions from ROSE, (Schreiner & Sjøberg, 2019; Sjøberg & Schreiner, 2019). Regarding sustainability, the international ROSE/ROSES questions mostly focus on environmental problems. Therefore, the Norwegian survey also includes questions on sustainability drawn from PISA 2015, as well as the Sustainability Consciousness Questionnaire (SCQ) and a questionnaire on action competence (SPACS-Q) (Gericke et al., 2019; Olsson et al., 2020). Finally, we added some questions related to climate strikes and environmental actions.

ROSES data were collected between November 2019 and April 2020 from 41 schools, distributed geographically representative for Norway. Even though all schools closed down March 12th, 2020, there were no major differences in students' responses collected before or during the Covid-19 outbreak in Norway. This means that the timing in relation to shutdown does not seem to affect the results.

Most of the ROSE and PISA questions are on a four-point Likert scale, expressing students' interest or agreement. In contrast, the SCQ and SPACS-Q questions use a five-point Likert scale. It should be noted that the midpoints therefore are different for the scales (2,5 and 3, respectively).

The data are analysed by means of descriptive analyses and T-tests for investigation of whether differences in means are statistically significant.

3. Results

3.1. Comparisons between Norwegian ROSE 2002 and ROSES 2020

Results show an increase in several questions that reflect students' concern for, interest in and willingness to act to environmental and sustainability issues (Figure 1). Most students believe that it is possible to solve our environmental problems, but our data also indicate a more pessimistic outlook than in 2002.

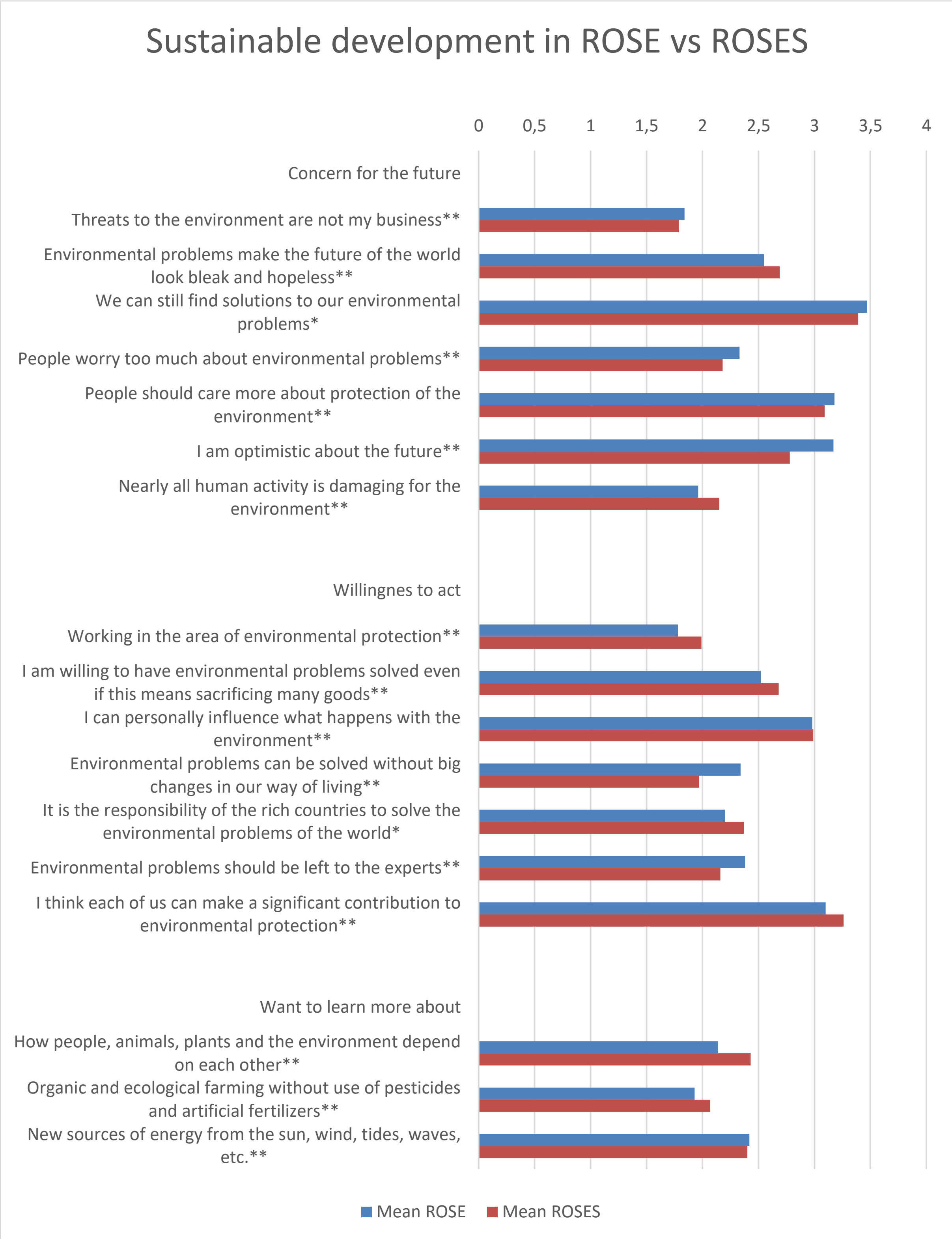

Figure 1. Students' responses in 2020 (ROSES) compared to students' responses in 2002 (ROSE) to questions related to environmental problems and sustainable development. Coding: Concern for the future: 1 = disagree, 4 = agree. Willingness to act,

1st question: 1 = not important, 4 very important. The rest: 1 = disagree, 4 = agree. Want to learn more about: 1 = not interested, 4 = very interested.

*   p=0,010-0,049

** p<0,010

If we split the responses in Figure 1 into gender (Figure 2), we can see that the ROSES girls (red) are more concerned and show a higher degree of willingness to act for environmental and sustainability issues than ROSE girls (pink). For the boys, the picture is more complex. For some questions, marked by orange circles in Figure 2, the ROSES boys (dark blue) are less concerned or willing to act than the ROSE boys (light blue), resulting in an increased gender difference in ROSES. For other questions, marked by green circles in Figure 2, both girls and boys are more concerned or willing to act in ROSES, compared to ROSE.

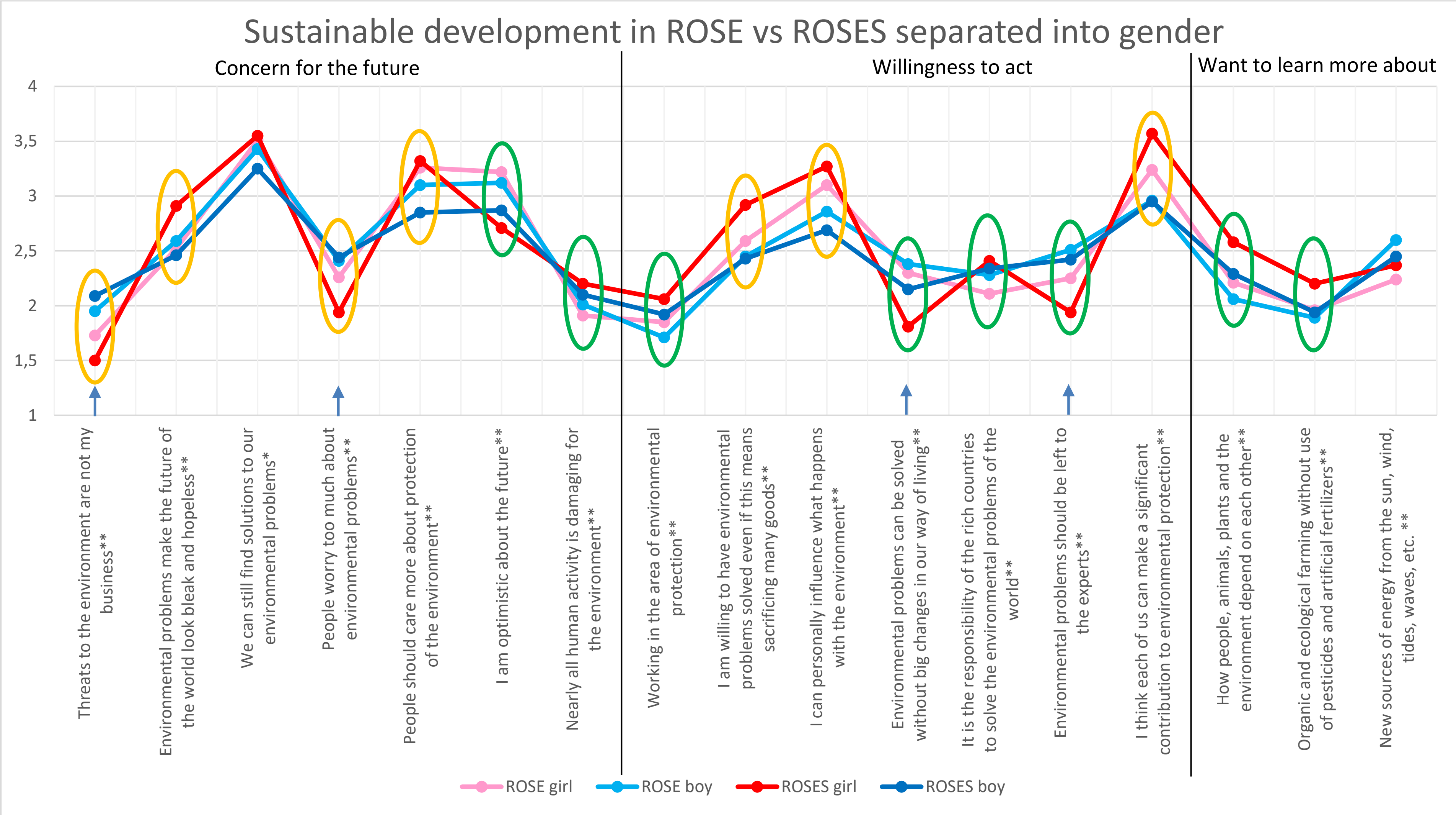

Figure 2. The responses to questions about sustainable development separated into gender. Orange circles indicates an increase between the ROSES girls and boys compared to the ROSEs girls and boys. Green circles indicate a rising concern in both ROSES genders compared to the ROSE students. Blue arrows indicate negative questions, hence a negative response to these questions

is a positive response. Coding: Concern for the future: 1 = disagree, 4 = agree. Willingness to act, 1st question: 1 = not important, 4 very important. The rest: 1 = disagree, 4 = agree. Want to learn more about: 1 = not interested, 4 = very interested.

3.2. Results exclusively from ROSES 2020

In the ROSES study only, students were asked about participating in some sort of action for the environment. 50,1% of the students had participated in a climate strike or other action for the environment over the last three years. Furthermore, 56,3% would like to participate in future climate strikes or actions for the environment and will be denoted as "Potential Campaigners" in the following. The students that did not want to participate are denoted as "Potential Non-campaigners".

The Potential Campaigners that wanted to participate, were asked to describe their reasons briefly. Nearly 80% gave an answer, the main reasons given being to

- contribute
- emphasize that young people care
- tell decision makers that they must act
- emphasize that this is about our common future
- make a difference
- be heard

Still others state that a safe and secure future is the most important thing for them. Surprisingly few wanted to participate to get time off from school.

The Potential Non-Campaigners' reasons for not wanting to participate are quite diverse. Common answers are

- I am uninterested or lazy, or do not care
- strikes are boring
- wants to do something else for the environment

Some fear sanctions from school, others believe that going to school is more productive than striking, some prefer other types of actions. Only a few respondents are openly sceptical or climate "deniers".

Regarding concern for the future (Figure 3), the Potential Campaigners are less optimistic and more strongly concerned about environmental problems compared to Potential Non-campaigners. However, it should be noted that both groups are not very far from the scale midpoint of 2.5.

Similarly, the Potential campaigners believe more strongly than the Potential Non-campaigners that their actions can have a positive impact on the future, see Figure 4 (note: midpoint is 3.0). Potential campaigners also have a markedly stronger motivation both for action for the environment, and for learning about sustainable development in school.

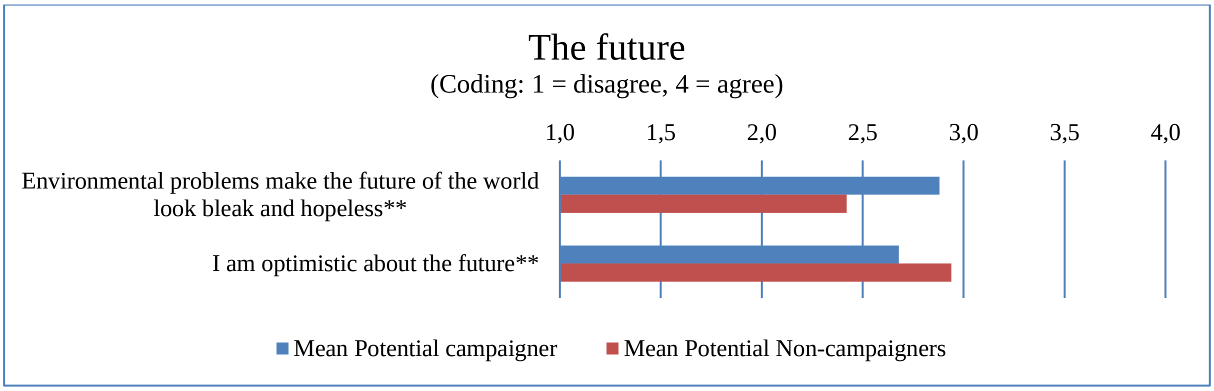

Figure 3. The Potential campaigner and Non-campaigner students in ROSES' response to what they think the future will bring.

* p=0,010-0,049

** p<0,010

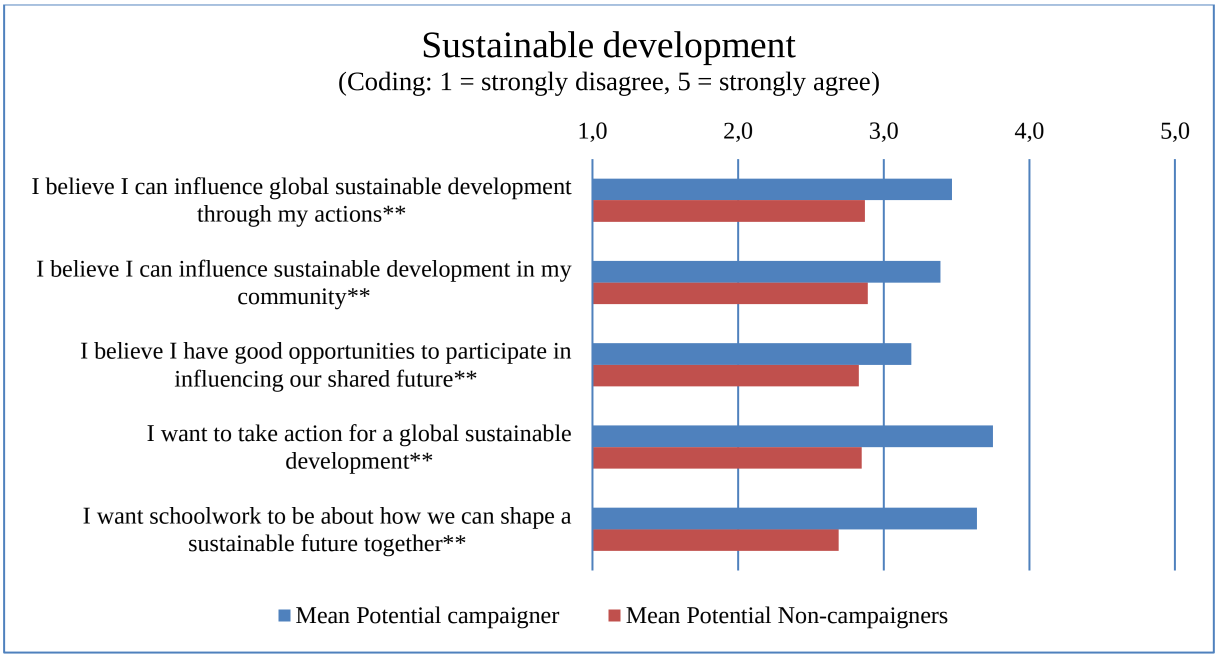

Figure 4. The Potential campaigner and Non-campaigner students in ROSES' response to some sustainable development questions.

* p=0,010-0,049

** p<0,010

When separating into genders, 40 % of the girls and 20,4% of the boys have participated in climate strikes over the past three years (

Table 1). Furthermore, 45,4 % of the girls and 29,6% of the boys participated in other actions for climate and the environment (eg. picking up plastic along roads or seashores).

Table 1. The students' responses to questions about climate strikes and other actions for the environment

	Girls			Boys		
	Yes	No	Missing	Yes	No	Missing
Have you participated in climate strikes for the last three years?	40	56	4	20,4	73,6	6
Have you participated in any other type of action for the environment in the last three years?	45,4	50,2	4,4	29,6	64,1	6,3

Regarding the students' wish to participate in future climate strikes or actions for the environment, approximately 2/3 of the girls were identified as Potential Campaigners, compared to only 1/3 of the boys (Figure 5).

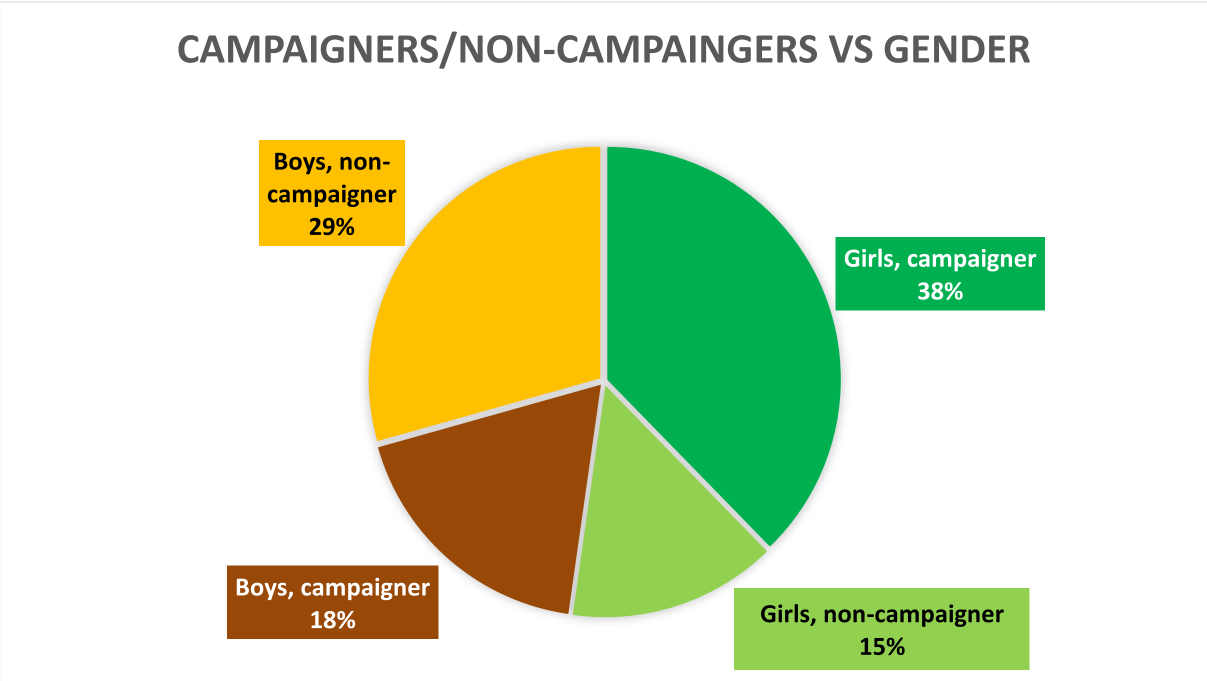

Figure 5. The students' responses to questions about climate strikes and other actions for the environment

When we divide the answers in Figure 2 into gender and Potential Campaigners/Potential Non-Campaigners we can see in Figure 6 that the Potential Campaigning girls are more concerned and more willing to act than all the other respondent groups. The Potential Non-

Campaigning girls and the Potential Campaigning boys are relatively equal in many questions. The Potential Non-Campaigning boys, however, are the least concerned and the least willing to contribute to any sustainable action. This is also confirmed in the Commitment section in Figure 6.

As an example of how the responses to different questions among the four respondent groups support each other, the red circle in Concern for the future section in Figure 6 is the response to “People should care more about protection of the environment”: The red arrows represent responses that supports the results in the red circle, and it is also confirmed in the Commitment section, marked by a blue circle, in Figure 6.

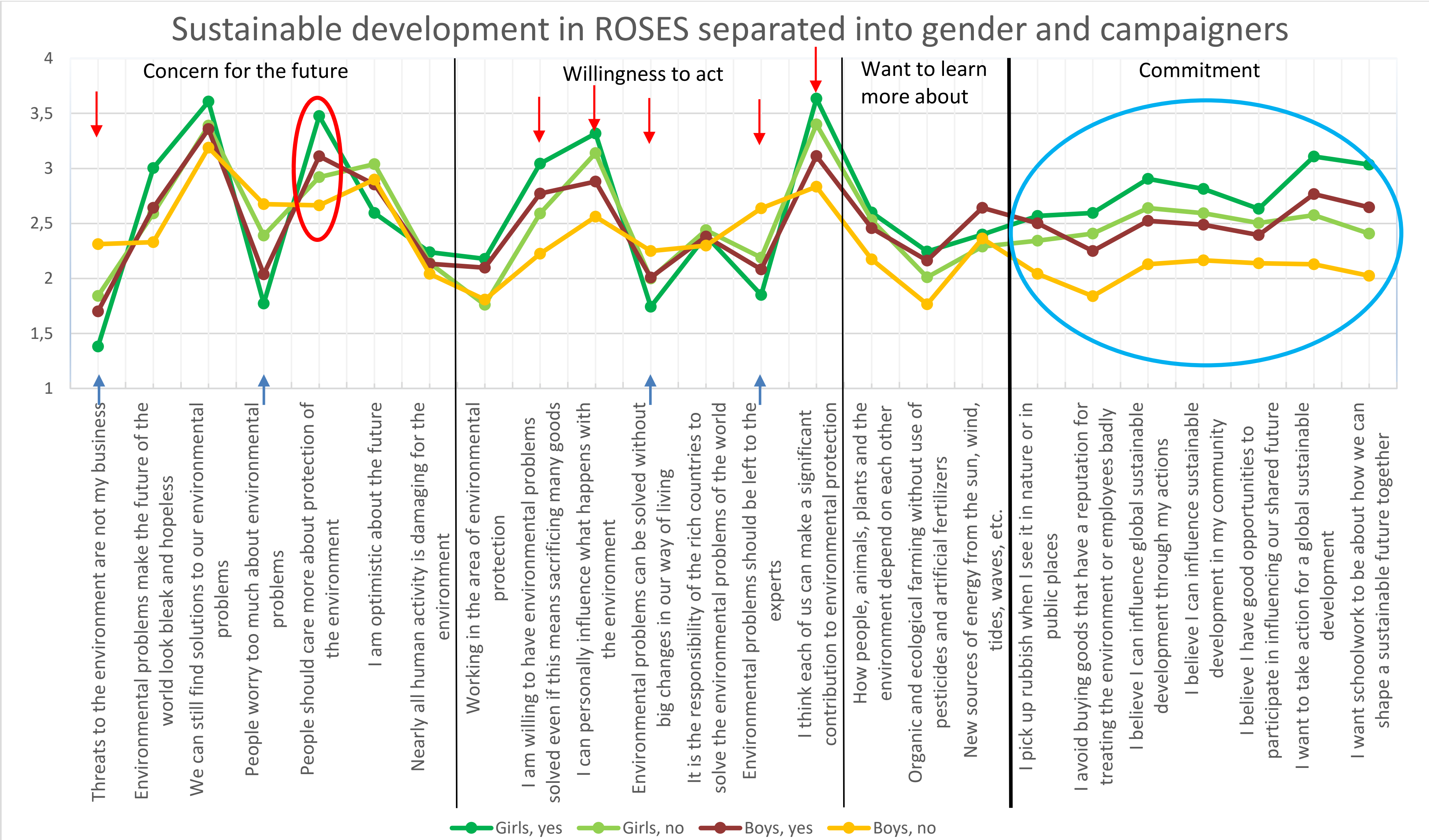

Figure 6. To the left of the bold, vertical line: The ROSES student's responses to questions about sustainable development separated into gender and Potential Campaigner/Potential Non-Campaigner. Blue arrows indicate negative questions, hence a negative response to these questions is a positive response. Coding: Concern for the future: 1 = disagree, 4 = agree. Willingness

to act, 1st question: 1 = not important, 4 very important. The rest: 1 = disagree, 4 = agree. Want to learn more about: 1 = not interested, 4 = very interested. To the right of the bold, vertical line: The ROSES student's responses to questions about commitment to sustainable actions. Coding: 1 = strongly disagree, 4 = strongly agree.

4. Discussion and conclusions

In this study we found that Norwegian 10th grade students of today are more interested in, concerned for and willing to act for environmental issues and sustainability, compared to students in 2002. In most regards, however, the students are still only moderately interested, concerned or willing to act for environmental issues and sustainability in 2020 - just like in 2002 (Schreiner & Sjøberg, 2005). Nevertheless, when looking at the 2020 data, more than half of the students in our study say that they would like to participate in a climate strike or other form of action for the environment, and approximately half have already participated in such actions. This general increase among adolescents' willingness to participate in action for the environment is also found by Corner et al. (2015) and Karsgaard og Davidson (2021). It is important to mention that much of the research on willingness to act or empowering youth for action etc is focusing on either environmental problem in general or the more specific challenge of climate change. It is reasonable to assume that the same motivations that leads to a commitment for action for climate change will also contribute to commitments to a broader range of topics regarding environmental protection and sustainable development.

The reasons students give for taking part in future climate strikes or actions for the environment suggest that their commitment is genuine. This is further supported by the overall increased interest, concern and willingness, as well as the significantly higher belief in their own influence among the Potential campaigners compared to Non-campaigner students (Karsgaard & Davidson, 2021; Lee et al., 2020).

When looking at gender differences, we see that most of observed increase in interest in, concern for and commitment to environmental and sustainability issues between 2002 and 2020 is due to a general and substantial increase among the girls. The development among boys is much less uniform, and for many questions the boys are less interested, concerned or committed in 2020 than in 2002. The finding that girls tend to have a different attitude towards environmental issues than boys and that they in general are more willing to act compared to boys is also supported in other findings (Kollmuss & Agyeman, 2002; Ojala, 2015; Torbjörnsson et al., 2011). Kollmuss and Agyeman and Corner et al. (2015) argue that it is social and cultural factors such as inner motivation, values, and attitudes that cause the commitment rather than precise scientific and environmental knowledge. The fact that boys tend to be less committed to act could be explained by that they have more trust in science and technology to solve the problems (Jenkins, 2006; Kollmuss & Agyeman, 2002). In contrast, girls tend to believe in personal actions and personal sacrifice to solve environmental problems (Jenkins, 2006; Kollmuss & Agyeman, 2002; Lee et al., 2020), an argument that fits with our observations.

In conclusion, Norwegian 10th grade students' interest in, concern for and willingness to act for environmental issues and sustainability have increased since 2002, and the commitment seems genuine. Most of the increase, however, is due to a general increase among girls, while the changes among boys are more mixed. This may suggest that when planning education for sustainable development, teachers should strive to engage the boys to a greater extent.

5. Acknowledgement

ROSES is based on the ROSE study, with permission and support from project manager Professor Svein Sjøberg. Details of the background, development and results from ROSE can be found in the final reports (Schreiner & Sjøberg, 2019; Sjøberg & Schreiner, 2019)

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Nature of science in the Norwegian curriculum and implications for sustainability education

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Abstract

In this study, the new Norwegian science curriculum is analysed with a focus on the aspects of nature of science that are addressed in this curriculum. Knowledge of nature of science is important for handling complexity in socio-scientific issues related to sustainable development. Previous research from other countries has shown that social and institutional aspects of nature of science are underemphasized in these curriculums. In this study, the curriculum is analysed via keyword analyses and a qualitative search for the aspects of the nature of science that are explicitly addressed. The family resemblance approach to the nature of science is used as the theoretical framework. The findings show that there is a strong focus on scientific methods and practices in the curriculum and that the focus is on *performing* inquiry and not that much on knowing about nature of science. In line with findings from other countries, this is particularly true when it comes to social and institutional aspects of the nature of science, such as the importance of peer review, collaboration and funding issues. However, the presented analysis makes a contribution in pointing out how knowledge about nature of science can be included in education for sustainable development.

Keywords: Nature of science, Curriculum analysis, Social-institutional aspects, Education for sustainable development.

Introduction

Knowledge about nature of science is important for handling the complexity of socio-scientific issues related to sustainable development (Knain, 2019; Kolstø, 2000). Preparing students to handle this complexity should be an important part of education for sustainable development. Knowledge of science as a social process and the characteristics of frontier science have been highlighted as important tools for dealing with the science dimension of complex socio-scientific issues (Kolstø, 2001). In frontier science, social processes, such as competition and collaboration, critique and argumentation, are important. Further, these social processes are institutionalized through peer review, attending conferences and funding issues. Although these social aspects of nature of science have been highlighted as important by many science educators (Knain, 2001; Kolstø, 2001), they are often neglected (Erduran & Mugaloglu, 2013; Kaya & Erduran, 2016).

Education for sustainable development is a major theme in the new Norwegian curriculum (Ministry of Education in Norway, 2019). Also, 'scientific practices and reasoning' is highlighted as a core area that can influence the work with the science subject as a whole. An important aim when engaging students in scientific practices is that they learn about nature of science (Crawford, 2014; Osborne, 2014; Sjøberg, 2021). However, research suggests that both teachers and students lack an advanced understanding of nature of science and that students cannot understand nature of science by merely doing science (Lederman & Lederman, 2014). In line with this, Osborne (2014) points to the important distinction between doing science and knowing (about) science and argues that some of the challenges involved in teaching science as inquiry is that it leads to confusion between doing science and knowing science. Given the important focus on scientific practices in the new curriculum, it is important to analytically examine the implications of the new curriculum concerning what the students should learn about the nature of science. This is important for the identification of implicit aspects in which the importance of knowledge about science could be made more explicit. Teaching traditions are often quite resistant to change, and teachers tend to use their existing teaching traditions in their interpretation of new reform documents or curriculum materials (Gyllenpalm et al., 2010). Furthermore, research shows that inquiry is often associated with hands-on experiences (Gyllenpalm et al., 2010) and that knowledge about science is not considered as important as knowledge in science by teachers. In order to contribute to the implementation of the new science curriculum and the intentions of teaching science through scientific practices, the following research question will be answered in this study:

- What aspects of the nature of science are addressed in the revision of the curriculum in Norway?

Theory

One of the leading approaches to research about nature of science is the consensus approach (Erduran & Dagher, 2014; Lederman & Lederman, 2014). The consensus approach consists of principles or statements about the nature of scientific knowledge on which philosophers of science largely agree and which are considered important for scientific literacy. One of the most important principles is that there is no *one* scientific method. Other principles state that scientific knowledge is tentative, theory-laden, relies on creativity and is socially and culturally embedded (Lederman & Lederman, 2014). The consensus approach has been criticised for making an artificial distinction between the nature of scientific knowledge and scientific inquiry (Duschl & Grandy, 2013; Irzik & Nola, 2011). According to Duschl and Grandy (2013), explicitly teaching nature of science means engaging students in authentic scientific practices—having them learn about nature of science *through* experience and not just by learning a list of statements. Erduran and Dagher (2014) suggest that we need to reconceptualise the nature of science in science education. Based on the work of Irzik and Nola (2011, 2014), they developed a new theoretical framework for nature of science referred to as the family resemblance approach. This framework consists of open-ended categories that can broadly be categorized into two main areas: cognitive-epistemic aspects of the nature of science, such as methods, scientific practices and scientific knowledge, and social-institutional aspects, such as social values, professional activities and financial systems. These social and institutional aspects of science are important for highlighting the fact that the activities of scientists are not disconnected from social and institutional interests and processes. Therefore, they comprise particularly important knowledge for dealing with socio-scientific issues that include not only a scientific dimension, but also, for instance, social, ethical and economic dimensions.

Literature Review

Studies have investigated nature of science in curriculums from different theoretical and methodological perspectives. McComas and Olson (1998) examined statements in eight documents from different countries, qualitatively searching for statements that appeared to represent knowledge about nature of science. This research has contributed to the consensus approach referred to above. For instance, they found statements regarding the tentative nature of scientific knowledge.

In Sweden, Johansson and Wickman (2012) analysed the development of the Swedish curriculum over a period of 50 years in order to investigate trends in what students are supposed to know about scientific inquiry and nature of science. They found an increased focus on a conceptual understanding of nature of science rather than a sole emphasis on students simply being able to carry out investigations. This is in line with the established knowledge that an understanding of nature of science will not develop from simply doing science, without an explicit reflection on these aspects (Lederman & Lederman, 2014).

Recently, Kaya and Erduran (2016) used the family resemblance approach to analyse the development of the curriculum in Turkey and compare curriculums in Turkey, the U.S. and Ireland. Their findings showed that science as a social-institutional system is underemphasized in these curriculums.

In Norway, not many studies focus on analysing the nature of science in the curriculum. Holt and Øyehaug (2010) analysed the previous curriculum in Norway and found that the aim of teaching about the nature of science was not followed up in the competence aims. In a discourse analysis of science textbooks, Knain (2001) found that an image of science was presented, focusing on the work of individual scientists and their discovery of truth through experiments. This indicates that textbooks also underemphasize science as a social process. Furthermore, he found that the primary focus was on scientific inquiry and not so much on the importance of debate and argumentation within scientific communities. This review points to the tendency for little attention to be explicitly paid to nature of science and particularly to the social aspects of the nature of science in curriculums as well as in textbooks.

Methods

In this study, the new Norwegian curriculum (The Ministry of Education in Norway, 2020) was analysed with a focus on the aspects of nature of science that are addressed in the curriculum. Two methodological approaches have been applied in order to investigate explicit aspects of nature of science as well as areas in which aspects of nature of science could be addressed. First, in line with Kaya and Erduran´s (2016) study, a keyword analysis based on the family resemblance approach was performed. This method is appropriate for obtaining an overview of gaps in the curriculum when it comes to nature of science and for identifying potential implicit aspects in the curriculum that could be made more explicit. The keywords were translated from English to Norwegian and assessed for relevance in a Norwegian context. For instance, in the category of scientific practices, the following keywords were used (Norwegian keywords in parentheses): observation (observasjon), experimentation (eksperimentering), data (data), explanation (forklaring), model (modell), argumentation (argumentasjon), classification (klassifisering) and prediction (prediksjon). Then, examples from the curriculum were investigated further for alignment with the meaning of the category described in the family resemblance approach (Erduran & Dagher, 2014). In addition, the whole curriculum was inspected qualitatively for explicit statements about science in line with the approach applied by McComas and Olson (1998). A comparison of the results of these two different methodological approaches will provide an impression of the relationship between implicit and explicit aspects of the nature of science in the curriculum. The validity of the results is also strengthened by this methodological triangulation (Cresswell & Miller, 2000).

Findings and Discussion

The analysis shows that there is a strong focus on scientific methods and scientific practices in the curriculum. Particularly, the students are supposed to engage in inquiry at all levels of science education. Although there is a heavy focus on students *performing* inquiry, there are also aspects of nature of science and scientific inquiry that the students are supposed to know *about*. For instance, in the case of modelling, students are supposed to develop and use models but also know *about* the importance of modelling in scientists' knowledge production. This knowledge about the importance of modelling can be characterized as explicit knowledge about the nature of science. However, given the teaching traditions when it comes to inquiry and the nature of science (Gyllenpalm, 2010; Osborne, 2014; Lederman & Lederman, 2014), it is really important that these explicit aspects are developed and given attention in curriculum materials and that professional development courses are offered. Otherwise, this important knowledge may not be a part of the experienced curriculum. In line with previous studies from other countries (Kaya & Erduran, 2016; Johansson & Wickman, 2012), social aspects of nature of science are not given much explicit attention in the curriculum at all. This is problematic, as such knowledge is particularly important for dealing with the socio-scientific dimension related to sustainable development (Knain, 2019; Kolstø, 2001). However, there are some general statements in the curriculum about the development of new knowledge in frontier science and the importance of collaboration and critique in such processes. Although peer review, funding issues and financial aspects of the nature of science are not mentioned explicitly, these aspects could, and arguably should, be included in the work with such competence aims. Further studies should focus on investigating how knowledge about nature of science is addressed in science textbooks and curriculum materials in general but, in particular, how it is addressed in education for sustainable development. Further research could also focus on teachers' interpretations of the curriculum through classroom research, surveys or interviews. It would also be interesting to investigate the development of the Norwegian curriculum concerning the nature of science and to compare the curriculum in different Nordic countries.

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The School Meal as a Pedagogical Tool in Education for Sustainable Development

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Abstract

This paper discusses how school meals can be integrated into children's education for sustainable development (ESD) based on experiences from an action research project in a Swedish primary school. The project comprised a three-year intervention with the establishment of a research circle among a group of teachers. The circle aimed to develop and test teaching activities in relation to school meals with a focus on ESD. Possibilities to use the school meal as a basis for ESD were identified, as well as outcomes from, and necessary conditions for, this work. The teachers in the research cycle developed teaching activities that were tested in real classroom situations and the outcomes were analyzed and reflected on. Interviews and observations formed the basis for the ongoing evaluation performed. The teachers expressed concerns that they felt that they did not have up-to-date and sufficient knowledge to feel comfortable while working with the school meal and environmental issues in education. They also called for more opportunities to work thematically and to reflect on learning activities. Opportunities for cooperation between teaching staff and school catering staff were found to be crucial. A common year wheel that appointed themes related to the school meal was developed by the teachers as a structure for the work to be carried on in the vent of staff changes.

Keywords Primary school, research circle, action competence, food council, curriculum

1. Introduction

Learning for sustainable development (ESD) does not only concern learning content. Pedagogy and learning environments that facilitate interactive and student-centered working methods where the purpose is action competence to be able to co-create ones' world and future is at its core (UNESCO, 2019). ESD needs to be holistic, transformative, and action-oriented. As everyone has a relation to food and it relates to all aspects of human life, food holds the potential to be a good entry point for such learning. Food and school meals may be used to achieve learning goals in virtually all subjects as well as to train key competencies for sustainable development identified by for example UNESCO (2017) and Wieck et al (2011).

This is highly relevant in the Swedish context, where the school meal is an integrated part of the school day. Sweden is furthermore one of the few countries in the world with a statutory free school lunch for all pupils in compulsory school who must also meet national nutritional standards (Swedish Education Act, 2010:800). It lends the opportunity to use the school lunch in education in the classroom as well as in the school canteen and in pupil councils at the school and also provides training in for example democratic working methods. The Swedish National Agency for Education emphasizes that ESD needs to be characterized by democratic working methods, critical approaches, interdisciplinary collaborations, a diversity of pedagogical methods, and participation and influence from pupils (Sandahl et al., n.d.). School meals may help with this.

Among motives to use food as an entrance to ESD is also that the present food system contributes significantly to climate change and to the global environmental challenges that we are presently confronting (Steffen et al. 2015). Changing the food system is crucial to reach the Agenda 2030 goals and it concerns both what we eat and how this food is produced (FAO, 2019). Children's education that makes use of school meals as an entry point offers "opportunities not only to take responsibility for the environment in areas where they [the pupils] themselves can exercise direct influence, but also to form a personal position with respect to overarching and global environmental issues" (Swedish National Agency for Education 2018, pp.8). The school meal may be used as an introduction to "sustainable literacy", "the knowledge, skills, and mindsets that allow individuals to become deeply committed to building a sustainable future and assisting in making informed and effective decisions to this end" (UN Sustainable Development Goals Plattform, 2020).

Despite the potential school meals may pose for ESD, studies that use school meals as a teaching aid to reach learning goals that impart knowledge and skills important in ESD are generally scarce (Schoubye Andersen et al. 2017). However, one of the few published studies concerns a project in a Danish primary school, where the organically produced school lunch was integrated into the curriculum and was the basis for lesson planning in different subjects with a focus on learning skills for ESD (Danielsen, 2009). Experiences from this work and others are highly needed. School meals have also been seen as a useful arena to educate children about food and to develop a healthy lifestyle, and research on school meals in education has so far mainly focused on this (e.g. Oostindjer et al. 2017).

This paper aims to explore ways that schools may work with the school meal as a pedagogical tool for ESD and identify difficulties as well as important means to facilitate this. The hypothesis is that children learn from eating school meals whether it is used in their scheduled education or not, but that these meals can be much better used than today for EDS in relation to all its parts; ecological, social as well as cultural, and democratic.

2. Theoretical framework

In this project, we consider ESD as a pluralistic education where environmental issues are viewed in a context of conflicting values, interests, and priorities as described by Rudsberg and Öhman (2015). Our interpretation of ESD also aligns with Sund et al. (2018) stating the aims of learning is to orientate and critically evaluate different alternatives and to develop skills to act based on this.

The research is furthermore theoretically based on John Dewey's view of learning and education, which in several ways is in line with the National Agency for Education's description of learning for sustainable development, with a focus on democracy and the transformative potential of education (Skolverket, 2020; Dewey, 2004). An important part of such teaching consists of the pupils discussing, reflecting, and using their own experiences, for example of food and the meal, in various problem-solving and practical activities. In this way, opportunities are created for transformative learning, where teaching contributes to developing pupil action, competence, and a willingness to continue learning about sustainable development through a changed view of the world, society, and themselves. Dewey emphasizes the importance of democratic working methods, teaching based on the pupil's life and thoughts as well as pupils as co-creators of the education (Dewey, 2004).

3. Research methods

This paper draws from experiences and preliminary results from a three-year action research project in a primary school (pre-school to grade 6) to test a model for using school meals as a teaching tool. The project started in 2018 with a “cookshop”, a cooking activity in the school canteen for teachers followed by a workshop aimed at setting common goals for the work. A central part of the project was a research circle within the teachers' group over four terms, aimed at developing and testing teaching activities concerning the school meal. Seven teachers participated and the circle has had on average 5 meetings per term, with an environmental science researcher from Örebro University as coordinator (author of the paper). The research cycle included in-service training in the field of sustainable development and food. Other important aspects of the project included children from grades 4-6 gaining practical experience in the school canteen for a day and the restart of the school meal council to make it an educational event where the pupils could learn democracy by doing democracy and where what they were learning could guide their actions. The schools comprised about 120 children and were located in southern Sweden. The study has been ethically reviewed, by the Ethical Review Authority in Sweden.

The project was evaluated by interviewing school personnel (teachers and school caterers as well as the school's headmaster and personnel from students' health) before and at the end of the project (19 respondents) which was carried out by two researchers in the field of pedagogy. Observations were also made during the project by all three researchers. Group interviews with children in grades 2 and 4 were carried out at the beginning of the project, but due to the Covid19 pandemic and the restrictions imposed during 2020 and 2021, the interviews planned for the end could not be carried out. This paper is mainly based on the overall experiences from the work at the school and a first preliminary examination of the interviews.

4. Results

4.1 Experiences and outcomes of the teachers' research cycle

The research cycle was used as a part of the teachers' in-service training. Each circle occasion started with a learning event organized as a discussion based on texts on different aspects of sustainable development selected by the researcher coordinating the circle. This was followed by the teachers developing relevant teaching activities based on food and the meals that were served in the canteen. The outcomes of these activities were further analyzed and discussed in the circle. Among the teaching activities developed was a competition called "Top of the vegetables", where the children in grades 1–3 made a list of vegetables they had tested from the school's salad buffet every day. The most popular vegetable was scored each week. This was used in math lessons to teach the pupils basic math and how to make diagrams. The teacher noticed that this increased the children's interest in eating vegetables during the time of the competition and raised biological questions about how vegetables were grown and how that could be used in their education. Children in preschool and grade 1 also made their own food plates out of clay. They used this exercise to discuss what a meal may contain for it to be healthy. Thematic days with food from different countries were also used to learn about these countries in subjects such as geography, social science, and music. Measurements of food waste were initiated by the catering staff and teachers sought to integrate the results from these measurements to different subjects such as math.

4.2 Students doing practice in the school canteen

Each child in grades 4–6 participated by working in the school canteen during a day each year. The exercise was to prepare the vegetarian dish that was served as one of the two dishes on the menu and serve a teaser of that dish to their classmates. The teachers in the research circle organized the event and decided on the exercise. What was learned from this was that if the children could taste a vegetarian dish before it was served, they ate more of it. An increase in the consumption of vegetarian food during the project was noticed by the school catering staff. The fact that their classmates proudly presented the dish eventually also increased approval. The organization of the children's work day in the canteen entailed a useful collaboration between the teaching staff and the catering staff that produced synergy effects, for example in the atmosphere in the canteen and the development of further activities such as the measurement of food waste which was later included in the children's assignments when it was their day to work in the canteen.

4.3 Food council in education

Food councils (or food as a theme in the pupil's council) are organised by headmasters at Swedish schools as a means to provide the children with some influence over the education as stated by Swedish school law (Swedish Education Act, 2010:800). In the project the existing food council was reorganized to form an integrated part of the education, to learn democracy by "doing democracy". This included information and discussion about the mandate for the council, active involvement from the teachers, pre-work and following-up work in the classroom as well as reforming the routines for the selection of representatives from the classes and the structure of the council so that decisions taken were effectuated.

One of the things decided and organized by the food council during the project was the development of a weekly menu by all classes separately. The objective was to deepen the understanding of the food that was served and to enhance the children's understanding of food and the food system. This has been done as an iterative work between the classes that prepared the menus, the catering staff, and the food council. The work included the children learning about the requirement for meals to be served at a school: economic, (what is the budget?) and environmental (which meals are the most environmentally friendly?) as well as social and cultural (what is healthy and tasty, how to combine dishes, and what works practically in a school kitchen?). This work provided an opportunity to work with central goals in practically all subjects. In the end, when a class menu was approved by the food council and served as the menu over a period of one week in schools throughout the whole department, this was a visible result to be proud of.

5. Discussion and conclusion

Experiences from the project indicate that children become easily engaged in the food they eat. Early in the project, the teachers decided to plan for the children to take part in practical work in the school canteen. This was found to be important to facilitate the work with school meals as a teaching tool. It led to questions and discussions that could be followed up in the classroom. Furthermore, it increased cooperation between teachers and school catering staff, established as crucial for successfully employing educational opportunities from school meals, but which has been more or less lacking before. Another important observation was that the children became more positive about eating vegetarian dishes.

The teacher in the research circle said that they felt that they did not have enough competence in the area of sustainability science to feel comfortable working with this in education. They also called for more opportunities to work thematically and to reflect on learning activities together to increase competence in working with ESD. Also called for was in-service training in the area of ESD, as well as on environmental and social aspects of sustainability and the Agenda 2030 in relation to the lifeworld of the children.

The food council may be a perfect means for gaining action competence, one of the main aims for EDS (Almers 2009) because food relates to everyone, and the school meal is something that the school could have a mandate to decide on. Food, furthermore, relates to all dimensions of sustainability. The restart of the food council at the school was planned in the teachers' research circle. The objective was to explore the possibilities and challenges to use it as a learning activity. Things that were found to be important to focus on included the need for the children to understand the institutional settings for the council, in example what issues they may have a stake in. But also, to find ways to include all children and to see to that all suggestions were dealt with and decisions effectuated. This called for teachers to pay attention to and reflect on things that happened in the council and to plan how to use them in the curricula. One challenge was to find a structure for spreading the information to all involved about the work in the council and to spread and store the meeting notes so that they were available and could be used.

An established structure for the work to proceed, as well as for thematic cooperation was found to be crucial to handle the regularly high staff turnover among teachers. Written material exemplifying possible teaching activities based on school meals related to central content in the curriculum was also called for. The teachers neither were used to develop these kinds of activities themselves nor perceived that they had time for this. One tool to achieve a structure that was initiated by the teachers during the project was a common year wheel, appointing themes related to the school meal, to which each teacher could plan their own individual teaching activities coupled to central goals in the curriculum for different subjects.

In conclusion, early results from this project indicate that developing EDS with food and school meals as a focal point contains important ingredients for developing a commitment to contribute to sustainable development. Meals have a strong relationship to sustainable development in that the food system is central to all the sustainability challenges we face (FAO, 2016). All students have their own emotional relationship to food and through the school food council, knowledge and emotions can be combined with practical action. Combining knowledge, emotions and practical aspects is, according to Öhman and Sund (2021), crucial for commitment "necessary for playing an active role in providing a sustainable transformation of society".

6. Acknowledgement

The author gratefully acknowledges the collegium at Finnerödja school, Laxå department for their participation without which this project would not have been possible and scholars Sara Frödén and Charlotta Petterson at Örebro University for collaboration.

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Hva stimulerer utforskende undervisning i naturfag?

Et studium av rollen for læreboken og andre undervisningsressurser i noen norske ungdomsskoler.

What stimulates Inquiry-Based Teaching in Science?

A study of the role of textbooks and other educational resources in some secondary schools in Norway.

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Abstract

The textbook has a strong position in the Norwegian school system. Teaching based on the textbook often is seen as oppositional to inquiry-based teaching. On a national level, research about the use of textbooks and its implications for science teaching is sought. A survey has been conducted among science teachers at 68 lower secondary schools in three (recently merged into two) counties in Norway. The survey data is used to measure the role of the textbook for science teachers, and the extent to which the textbook contributes to inquiry in science teaching. Quantitative analyzes show that the textbook has a central role for science teachers. The textbook is partly perceived as a support for facilitating inquiry activities, especially for textbook-oriented teachers. At the same time, the study shows that those teachers frequently facilitating for inquiry is not closely tied to the textbook. Inquiry-based education is highly emphasized in recent curricula. This study contributes important knowledge about the connections between science teachers' orientation towards the textbook and facilitation for inquiry-based teaching. It will be important to map this connection better, in working towards how to better facilitate for inquiry-based education.

Keywords: Inquiry-based teaching, textbook

1. Introduksjon

1.1. Lærebokens rolle i skolen

Læreboken har en sterk stilling i norsk skole, og har lenge vært det dominerende læremiddelet i naturfagundervisningen (Juuhl, Hontvedt, & Skjelbred, 2010; Skjelbred, Solstad, & Aamotsbakken, 2005). Den tildeles automatisk lærere og elever i den norske skolen, og er ifølge forskningen fremdeles et viktig verktøy i faget blant annet fordi mye av undervisningstiden blir brukt til individuelt arbeid med oppgaver fra læreboken (Bergem, Kaarstein, & Nilsen, 2016). Den brukes også som et strukturerende element hvor lærerne varierer med andre undervisningsressurser (Furberg, Dolonen, Engeness, & Jessen, 2014; Trygstad, Smith, Banilower, & Nelson, 2013). Dagens naturfaglærere har frihet til å velge hvilke læremidler de ønsker å bruke så lenge målene i læreplanen ivaretas. Likevel viser studier av Gilje m.fl. (2016) og Waagene & Gjerustad (2015) at læreboken er av de mest populære læremidlene i naturfagundervisningen.

Lærebokens betydning kan ha flere årsaker. Blant annet skal læreboken ivareta kompetansemålene i læreplanen og legger opp til en progresjon i faget gjennom flere år. Dette påpekes som positivt av lærere (Gilje m.fl., 2016). Forskningen har videre vist at mange lærere føler en trygghet ved å bruke læreboken (Waagene & Gjerustad, 2015). Ifølge Darling-Hammond (2006) vil lærerens valg av undervisningsmetoder og undervisningsmateriell være sterkt knyttet til lærerens faglige kunnskap og erfaring med undervisning. Flere undersøkelser har her vist at læreboken er spesielt viktig for nyutdannede lærere, vikarer og lærere uten naturfaglig bakgrunn (McDonald, 2016).

1.2. Utforskende arbeidsmåter

Tidligere naturfagundervisning, som også har vært sterkt preget av lærebøker, har ofte vært sett på som en tradisjonell undervisning hvor teoretisk kunnskap har hatt større fokus enn å beherske naturvitenskapelige praksiser, herunder også utforskende arbeidsmåter. Med utforskende arbeidsmåter menes læringsprosesser hvor elevene engasjerer seg i aktiviteter for å vurdere, diskutere og besvare naturfaglige problemstillinger jf. inquiry frameworks 5 faser (Pedaste m.fl., 2015). Vi har de siste årene sett en tendens mot at læreboken blir mindre dominerende i undervisningen, samtidig har nye læreplaner gradvis de siste tiårene lagt økt fokus på naturvitenskapelige praksiser og tenkemåter. Det norske skolesystemet er i perioden 2020-2022 i en overgangsfase mellom to læreplaner (fra LK06 til LK20). Utforskende arbeidsmåter er integrert i begge læreplaner gjennom hovedområdet Forskerspiren (LK06) og kjerneelementet Naturvitenskapelige praksiser og tenkemåter (LK20). Disse sentrale deler av læreplan i naturfag innebærer at elevene skal gjøre seg praktiske erfaringer med hvordan naturvitenskapelig kunnskap etableres gjennom utforsking av naturfaglige spørsmål. Slik vil de også opparbeide seg forståelse av naturfaglig kunnskap.

Utforskende arbeidsmåter har vist positiv sammenheng med elevenes prestasjoner i naturfag (Martin, Mullis, Foy, & Hooper, 2016) og dybdelæring (Ødegaard m.fl., 2021), som etter den nye læreplanen har fått stort fokus. Det er nå godt dokumentert innen skoleforskningen at utforskende arbeidsmåter kan være mer effektive enn andre mer instruerende undervisningsmetoder, så lenge elevene får tilstrekkelig støtte (Lazonder & Harmsen, 2016). Dette begrunnes med at elevengasjement er nøkkelen til vellykket læring (Freeman m.fl., 2014), og utgjør en viktig bakgrunn for vår studie.

1.3. Sammenhenger mellom lærebok og utforskende undervisning

TIMSS og PISA undersøkelsene peker på flere utfordringer i norsk naturfagundervisning; Blant annet presterer norske elever noe bedre på oppgaver som måler kunnskap om naturfaglige fakta, teorier og begreper og evnen til å forklare naturfaglige fenomen, kontra kunnskap om naturfaglige prosesser og evnen til å planlegge og evaluere eksperimenter (Kjærnsli & Jensen, 2016). Videre bruker norske lærere mye tid på tradisjonelle undervisningsmetoder og legger mindre vekt på utforskende arbeidsmåter og eksperimenter sett opp mot andre TIMSS-land (Bergem m.fl., 2016; Martin m.fl., 2016). TIMSS 2015 peker spesifikt på behovet for mer forskning på følgene av lærebokstyrt undervisning.

Ofte har det blitt gjort et skille i naturfagundervisning, hvor man på den ene siden har undervisning basert på læreboken, mens man på den andre siden har undervisning som er basert på utforskende arbeidsmåter (Kahveci, 2010). Ifølge Norris & Phillips (2003) fremstår disse tilnærmingene til undervisning ofte som motsetninger, særlig i klasserom hvor utforskende arbeidsmåter dominerer (referert i McDonald, 2016, s. 502). Med bakgrunn i den sentrale rollen læreboken har i naturfagundervisning, sammen med økt fokus på utforsking, er denne studiens formål å danne et bredere kunnskapsgrunnlag om lærebokens rolle i sammenheng med implementering av utforskende arbeidsmåter. Dette vil være et bidrag til kunnskap om hvordan kombinere bruk av lærebok og gjennomføre utforskende arbeidsmåter i undervisningen. Noen andre faktorer som lærerens naturfaglige utdanning og fartstid i yrket, er også tatt med i undersøkelsen for å kunne gi et bredere perspektiv.

I denne studien har vi formulert disse problemstillingene for nærmere belysning:

1. Hvor stor betydning har læreboken for naturfaglærere i norske ungdomsskoler?
2. I hvor stor grad mener ungdomsskolelærerne at naturfagsboken legger opp til *utforskende arbeidsmåter*?
3. I hvilken grad bidrar læreboken til at norske ungdomsskolelærere praktiserer *utforskende arbeidsmåter* i naturfag?

2. Metode

2.1. Utvalg og datainnsamling

Våren 2018 og 2020 ble det gjennomført en nettbasert spørreundersøkelse blant lærere som underviste i naturfag på ungdomstrinnet ved skoler i Finnmark, Troms og Oslo. Undersøkelsen er utformet og gjennomført i Nettskjema.no. Den ble pilotert før utsending. Undersøkelsen ble sendt ut til 250 lærere fordelt på 98 skoler. 20 lærere er trukket fra utvalget grunnet at respondenter fikk tekniske feil med innsending av spørreskjema, ugyldige mailadresser, samt blokkering av Nettskjema invitasjon fra e-post administratorer. Totalt gjennomførte 108 lærere fra til sammen 68 skoler undersøkelsen. Dette tilsvarer en svarprosent for lærerne på 47%.
På grunn av den lave svarprosenten, ble 2 lærere fra hvert fylke tilfeldig trukket ut for en frafallsanalyse. Den ble gjennomført ved telefonoppringning, og 5 av 6 nevnte tidspress i den aktuelle skolehverdagen som grunnen for manglende respons. Et sentralt spørsmål er om resultatene vil ha gyldighet ut over de aktuelle gruppene. Ut fra vår subjektive vurdering var mangelen på respons nokså tilfeldig siden undersøkelsen kom på et tidspunkt med høyt arbeidspress. Dette indikerer høy sannsynlighet for at vi har et normalutvalg som fanger opp sentraltendens og variasjon. I vår analyse regnes deltakerne N=108 derfor som representative, selv om det ikke kan hevdes at de er representative i strikt forstand grunnet lav svarprosent.

2.2. Måleinstrumenter og analysemetoder

Spørreskjemaet ble utviklet med lærebok og utforskende undervisning som utgangspunkt. Det omfattet også spørsmål om undervisningsklassen og lærernes bakgrunn.

En 6-punkts Likertskala ble brukt for de fleste spørsmålene med skåringsalternativ fra 1 (i svært liten grad) til 6 (i svært stor grad). For noen variabler var det naturlig med andre svaralternativer, og disse skalaene er da marker.
Det er utviklet samlevariabler for lærebokens betydning for læreren (*Lærebokorientering*, 8 items), lærebokens fokus på utforskende arbeidsmåter (*Lærebok utforskende*, 15 items) og på lærerens praktisering av utforskende undervisning (*Utforskende arbeid*, 15 items).
For å kunne sammenlikne resultater med nasjonale og internasjonale studier, ble det tatt utgangspunkt i noen spørsmål fra TIMSS og andre lærerundersøkelser (Bergem m.fl., 2016; Waagene & Gjerustad, 2015). Samlevariabler for tilrettelegging til utforskende undervisning og lærebokens oppfattede stimuli til utforskende arbeid er utviklet på bakgrunn av inquiry framework (Pedaste m.fl., 2015).

Påliteligheten til samlevariablene er testet ved hjelp av reliabilitetskoeffisienten Chronbachs alpha (CA) (Everitt, 2002). Videre er samlevariablenes normalfordeling testet ved Kolmogorov-Smirnov test. Styrken i samvariasjon mellom variabler måles ved Pearsons korrelasjonskoeffesient *r*, der 0-0,19 er Veldig svak, 0,2-0,39 er Svak, 0,4-0,69 er Moderat, 0,7-0,89 er Høy og 0,9-1 er Meget høy (Cohen & Holliday, 1982). Lineær regresjonsanalyse gjøres for å se i hvilken grad signifikante faktorer samlet kan forklare variabelen *Utforskende arbeid*. Alle data fra denne studien er analysert med hjelp fra SPSS Statistics 26 for Windows.

3. Resultater

Tabell 1 viser resultatene for de tre samlevariablene som inngår i studien. De viser alle akseptabel indre konsistens med CA mellom 0,7 og 0,9, og er tilnærmet normalfordelte (Figur 1, 2 og 3).

Tabell 1. De tre samlevariablene med gjennomsnitt, standardavvik (SD), Chronbachs alpha (CA) og Kolmogorov-Smirnov test (KS).

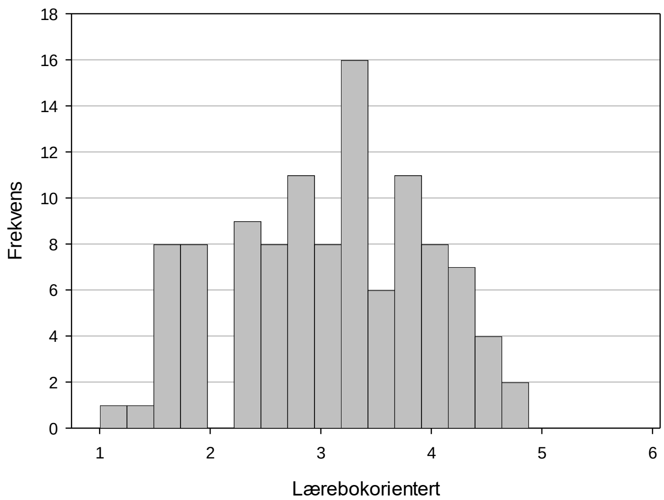
Variabel	Skala	Snitt (SD)	CA	KS
Lærebokorientering	1-6	3,09 (0,90)	,72	,109
Lærebok utforskende	1-6	2,86 (0,92)	,96	,200
Utforskende arbeid	1-5	3,12 (0,60)	,91	,110

Lærerne i denne undersøkelsen benytter seg av varierte læremidler, men flertallet mener læreboken er det mest sentrale læremiddelet i naturfagstimene deres (Tabell 2).

Tabell 2. Svarfordeling på spørsmål om læreboken (item i samlevariabel lærebokorientering)

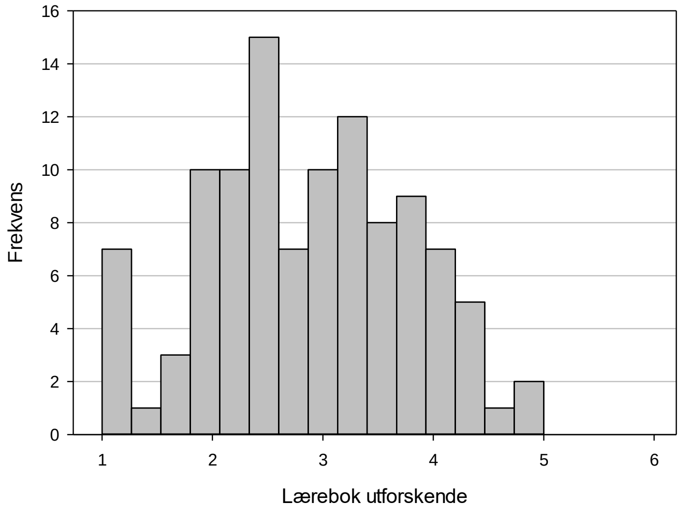
Læreboken er det mest sentrale læremiddelet i mine naturfagstimer		Antall	Prosent av total	Prosent av total
	1	14	13 %	
Uenig	2	20	19 %	46 %
	3	16	15 %	
Enig	4	24	22 %	
	5	24	22 %	54 %
	6	10	9 %	
Total		108	100 %	100 %

Undersøkelsen viser stor variasjon i naturfaglæreres orientering mot læreboken i planlegging og gjennomføring av undervisning (Figur 1). Lærerne i undersøkelsen scorer i gjennomsnitt noe under middels på lærebokorientering (gj.snitt= 3,09).



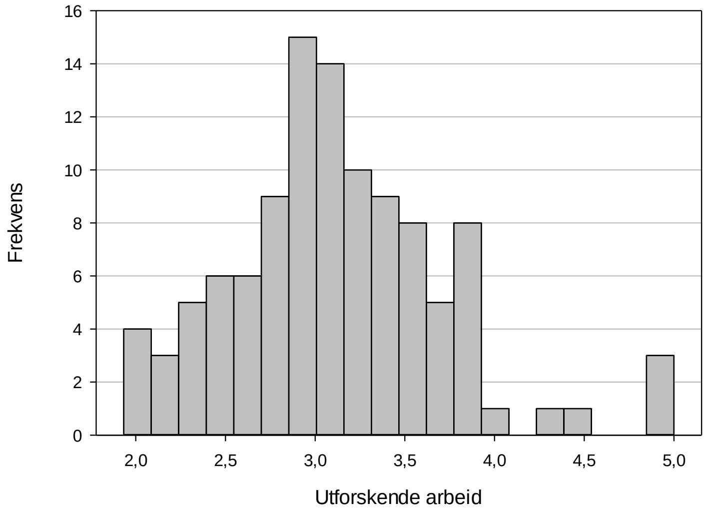
Figur 1. Histogram som viser respondentenes selvrapporterte score på samlevariabelen *lærebokorientering* (8 items) (1 – svært liten betydning/helt uenig, 6 – svært stor betydning/helt enig)

Ungdomsskolelærernes gjennomsnittlige opplevelse er at naturfagsboken i mindre grad legger opp til utforskende arbeidsmåter (gj.snitt = 2,86) (Figur 2).



Figur 2. Histogram som viser respondentenes selvrapporterte score på *samlevariabelen lærebok utforskende* /I hvilken grad læreboken stimulerer til utforskende undervisning (1 – i svært liten grad, 6 – i svært stor grad).

Gjennomsnittlig tilrettelegger lærerne i denne studien for utforskende arbeid i 25%-50% av naturfagstimene (gj.snitt = 3,12) (Figur 3).



Figur 3. Histogram som viser respondentenes selvrapporterte score på samlevariabelen *utforskende arbeid* / hvor mange av timene respondentene tilrettelegger for utforskende arbeidsmåter (1–aldri, 2–sjelden (mindre enn 25% av naturfagstimene), 3–noe (25-50%), 4–ofte (50-75%), 5 – vanligvis (mer enn 75%))

Korrelasjonsanalysen i Tabell 3 viser interessante sammenhenger mellom våre tre hoved-variable med negative eller svake korrelasjoner.

Tabell 3. Korrelasjoner mellom studiens samlevariabler

	Lærebokorientering	*Lærebok utforskende*	*Utforskende arbeid*
Lærebok utforskende	,391**	1	,173
Utforskende arbeid	-,207*	,173	1

Utforskende arbeidsmåter i undervisningen korrelerer svakt negativt med lærerens lærebokorientering (r = -,207*), og veldig svakt i positiv retning (r = ,173) med at læreboken er utforskende. Stimuli som fører til *Utforskende arbeid*, må dermed i stor grad stamme fra kilder utenfor disse to variablene. I vårt studium har vi med flere variabler som kan bidra til å kaste lys over dette. Resultatet av denne ekstra undersøkelsen er vist i Tabell 4.

Tabell 4. Korrelasjonstabell over variabler som viser signifikante korrelasjoner med *Utforskende arbeid*. Grå markering viser samlevariabler, hvite er enkeltvariabler. (* signifikant på 5% nivå, ** signifikant på 1% nivå, ns ikke signifikant)

Del av undersøkelsen	**Variabel**	**Utforskende arbeidsmåter**
Karakteristikk av klassen	Antall elever	ns
	Klassetrinn	ns
Naturfagundervisning, undervisningsressurser og planlegging	Tverrfaglig undervisning	,232*
	Lokalmiljø	,383**
	Eksterne aktører	,263**
	Planleggingstid	ns
Karakteristikk av læreren	Fagfordypning realfag	ns
	Naturfagdidaktikk	ns
	Naturfag (for lærerutdanning)	ns
	Undervisningserfaring	ns
	Alder	ns

Kjønn	ns
Type pedagogisk utdanning	ns
Pedagogikk	,251*

Tabell 4 viser positive korrelasjoner mellom tilrettelegging for utforskende arbeidsmåter og bruk av lokalmiljø (r = ,383**), eksterne aktører (r = ,263**) og tverrfaglig undervisning (r = ,232*). Det vises blant annet ingen korrelasjoner mellom utforskende arbeidsmåter og karakteristikker av klassen. For karakteristikk av læreren vises det ingen signifikant korrelasjon med naturfag, naturfagdidaktikk i utdanningen, men positiv korrelasjon med mengde pedagogikk i utdanningen (r = ,251*).

Ved hjelp av de 4 signifikante variablene i Tabell 4, samt variabelen *lærebokorientering* (Tabell 3), kan vi formulere en multippel regresjonsmodell for å predikere bruk av utforskende arbeidsmåter i naturfagstimer, se Tabell 5.

Tabell 5. Ustandardiserte lineære regresjonskoeffisienter for å predikere *Utforskende arbeid* i naturfag. (* signifikant på 5% nivå, ** signifikant på 1% nivå, ns ikke signifikant)

	Lærebokorientering	Tverrfaglig Undervisning	Lokalmiljø	Eksterne aktører	Pedagogikk
Utforskende arbeid =	-0,135*	0,099*	0,256**	0,235ns	0,216*

Faktorene i modellen i Tabell 5 har en samlet forklaringskraft på 0,27, som betyr at 27% av variasjonen i resultatvariabelen (*Utforskende arbeidsmåter*) kan forklares av de samlede variablene i modellen. Resten av variasjonen ligger utenfor modellen.

4. Diskusjon og konklusjon

Resultater fra denne studien viser at læreboken fortsatt er et viktig verktøy i norsk naturfagundervisning. Samtidig støtter denne studien senere forskning som viser en tendens til at læreboken blir mindre dominerende i naturfaget (Furberg m.fl., 2014). Sammenlignet med Waagene og Gjerustad (2015) lærerundersøkelse er læreboken mindre viktig som læremiddel for naturfaglærerne i denne studien.

4.1. Sammenheng læreboken – utforskende arbeidsmåter

Resultater fra denne studien støtter opp om det dualistiske synet mellom tradisjonell undervisning hvor lærebøker har en sentral rolle og en mer utforskende undervisning. Det vises en tendens til at lærebokorienterte lærere tilrettelegger mindre for utforskende undervisning, kontra lærere som er mindre lærebokorienterte. Sett i sammenheng, kan det videre virke noe paradoksalt at lærebokorientering korrelerer positivt med lærerens oppfatning av lærebokens stimuli til utforskende undervisning. Dette kan tyde på at lærebokorienterte lærere mener læreboken stimulerer godt til utforskende arbeid, men tilrettelegger likevel mindre til utforskende arbeid enn mindre lærebokorienterte lærere. Lærebokorienterte lærere ser dermed ikke ut til å fullt utnytte potensiale de ser i læreboken for å arbeide utforskende. Utforskende arbeidsmåter forankres i stedet i lokalmiljø, eksterne aktører og tverrfaglighet. Det kan også tenkes at lærere som bruker læreboken flittig, kjenner dens innhold bedre og dermed er bedre i stand til å vurdere dens stimuli til utforskende arbeid, kontra lærere som bruker den mindre.

4.2. Begrensninger og videre studier

En mulig svakhet i dette kvantitative studiet kan være skjevhet/underrapportering i svarene omkring lærebokorientering. I en svensk studie viste det seg eksempelvis at noen lærere ikke anså sin naturfagundervisning til å være basert på læreboken i stor grad, mens forskerne bak studien identifiserte samme korrelasjoner mellom hvordan læreboken presenterte fagstoff og lærernes presentasjon i klasserommet blant alle lærerne i studien (Bergqvist & Rundgren, 2017).

Forskning viser at norsk klasseromspraksis særlig fokuserer på datainnsamlingsfasen i utforskende arbeidsmåter, og at læreboken har en rolle her, og mindre på at elevene stiller egne spørsmål og kognitive prosesser (Ødegaard m.fl., 2021). Videre forskning rundt dette tema vil være å undersøke hvorvidt læreboken stimulerer til de ulike fasene i utforskende arbeid.

Denne studien viser at lærebokorientering, tverrfaglig undervisning, lokalmiljø, eksterne aktører og pedagogikk samlet forklarer 27% av variasjonen i lærerens tilrettelegging for utforskende arbeid. Kvalitative oppfølgingsstudier (Isaksen, Ødegaard & Utsi, upublisert) peker på ytterligere faktorer som kan forklare lærerens tilrettelegging for utforskende arbeidsmåter. Blant annet vurderes tid, kompetansemål og om det er kunnskapsmål eller arbeidsprosess som er formålet med undervisningen.

Undersøkelsen viser at naturfagsboken fremdeles har en sentral rolle for norske ungdomsskolelærere. Naturfaglærere opplever at den er en ressurs som til dels legger opp til utforskende arbeidsmåter. Dette gjelder spesielt lærebokorienterte lærere. Studien viser samtidig indikasjoner på at læreboken for den gjennomsnittlige lærer ikke er en avgjørende ressurs for å praktisere utforskende arbeidsmåter i naturfag. Denne studien bidrar med viktig kunnskap om sammenhenger mellom naturfaglæreres orientering mot læreboken og tilrettelegging for utforskende arbeidsmåter. Denne sammenhengen vil være viktig å kartlegge bedre for å forsøke å forene det dualistiske synet på bruk av lærebøker og utforskende arbeidsmåter. Kunnskapen denne studien bidrar med vil være av særlig interesse for lærebokforfattere samt lærerutdanningsinstitusjoner.

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Lower secondary school students’ use of geological gestures and conceptual understanding about plate tectonics

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Abstract

This qualitative video study examines how eight students (13 y) communicated their understanding of plate tectonic theory and to which extent the students developed conceptual understanding in the course of a curriculum unit. The link between word knowledge and conceptual understanding forms the focus for analysis of video recordings of a modelling activity as well as pre and post instruction interviews. Students’ multimodal communication was also a matter of interest, made apparent by geological gestures. Data shows that students expressed their understanding multimodal by talk and through gestures. The findings support the argument that student word knowledge alone is not sufficient to analyze student conceptual understanding. Hence, we propose new implications to instruction of plate tectonics regarding using geological gestures as representations of plate boundaries, alongside dialogue between students and students and teachers.

Keywords: plate tectonics, geological gestures, lower secondary school, conceptual understanding

1. Introduction

Plate tectonics is regarded as one of the great ideas of science (Harlen, 2010), but challenges our view of the physical world regarding its many interlinked processes acting over large distances and vast time frames. The theory is a relatively new theory in science, and explains why the earth is a dynamic planet with volcanoes, earthquakes, formation of mountains and landscapes, ocean basins, new crust and recycling of old crust. Although several studies report common student misconceptions within the theory (Marques & Thompson, 1997); (Francek, 2013); (Mills, Tomas, & Lewthwaite, 2016), research into instructional approaches to plate tectonics are scarce and requested (Mills et al., 2016). In order to meet this call to increase the scholarship on pedagogies related to the topic, we developed a 12 hours curriculum unit with two science teachers as focus for an exploratory case study. Twenty-five students (13 y) from lower secondary school participated in the project. Data consisted of video recordings of interviews and modelling activities. By exploring students' multimodal expressions of understanding, including visual, verbal and gestural forms, we wish to achieve better insight into how students develop conceptual understanding about plate tectonics.

The research questions are:

RQ 1: To what extent did students develop their conceptual understanding about central concepts of plate tectonics?

RQ 2: How did lower secondary school students include gestures when communicating their ideas about plate tectonics before, during and after instruction?

Conceptual understanding can be defined in terms of word knowledge (Haug & Ødegaard, 2014), in which *an active* conceptual understanding corresponds to increasing cognitive processes (Bravo, Cervetti, Hiebert, & Pearson, 2008). To exemplify, an active understanding is expressed when a person knows how to use the word in context and understands how the word fits in different sentences. On the other hand, a passive understanding is expressed when a person recognizes a word and knows its definition, but not its relation to other words. This framework for detecting conceptual understanding through word knowledge is presented in figure 1 below.

Conceptual knowledge

Level of word knowledge	*Cognitive process*	*Explanation*
Passive	Recognition →	Knowing how a word sounds or looks when it is written.
	Definition →	Being able to recite a word's definition, but having little understanding of the meaning of the word or its implications.
Active (increasing with	Relationship →	Knowing the word's relationship to other words and concepts.
	Context →	Knowing how to use the word in context. Understanding how the word fits in different sentences.

cognitive processes)	Application →	Knowing how to apply the word in context when engaging in inquiry about a phenomenon. Linking the word to the empirical data.
	Synthesis →	Knowing how to use the word when communicating the emerging knowledge about the phenomena under study. Solving problems in new situations by applying acquired knowledge.

Figure 1: Framework for examining students' word knowledge (based on Bravo et al., 2008).

The process in which people construct meaning and communicate in this world is not limited to verbal language or text alone, but involves the contexts of physical space and available technologies, including bodily gestures and face expressions (De Silva Joyce & Feez, 2018). Research indicates that students' learning is facilitated by the use of different meaning making resources, either actional, visual or linguistic in modes, thus implying that learning is multimodal (Jewitt, Kress, Ogborn, & Tsatsarelis, 2001). Gestures are seen as complex movements with the hands, linear to other language modalities, and can serve as means to convey abstract concepts and processes (Abels, 2016). During students' learning processes, gestures may convey new levels of understanding before the student is able to express that understanding with own words (Roth, 2007). Van Boening and Riggs (2020) argue the importance of seeing gestures as an important element of communication in geology, and present a framework for characterizing the use of geological gestures. The authors categorized five gesture types: point, domain, flat-hand, frame, and form gestures. Additionally, there are 11 gesture functions: tracing, highlighting, locational, directional, rotational, constraining, sizing, emphasis, sequential, illustrative, and constructive gestures. First order and second order gestures corresponds to the use of single or multiple types of gesture use to convey geological meaning.

2. Methods

Context. The new science curriculum in general education in Norway (Norwegian Directorate for Education and Training, 2020) focuses on scientific practices such as modelling in addition to main principles of plate tectonics.

The participants. This study focuses on eight 13 year olds in a class of 25 students, from lower secondary school (grade 8th) in Norway. The students' science teachers implemented the curriculum unit and cooperated with the authors in the design of the teaching materials.

Instructional approach. The curriculum unit consisted of five main learning activities, in which the first began with an introduction to plate tectonics and modelling plate boundaries in modelling clay.

This was followed by an introduction to rock observation and the three main groups of rocks, and students later sampled rocks from their local environment. Back in the classroom, students analyzed the rocks and inferred them to the historic type of plate boundary of the area. They further modelled the plate boundary in the software Minecraft Education.

The interviews. Students in groups of 2-4 students were interviewed before instruction and two months after instruction. Interviews with students typically lasted 15 minutes and were video-recorded and transcribed for analysis. Students were presented with photographs illustrating processes related to plate tectonics, to prompt students' consideration of particular concepts concerning plate tectonics.

Data collection. Head cameras (brand: Contour 2) captured video material from the implementation of the teaching unit and the interviews.

Data analysis. Interviews were transcribed and revised in order to sort the content to conceptual areas of plate tectonic theory. The video data from both interviews and science lessons was coded with the software Nvivo 12, with the aim to illuminate different cases and episodes where students expressed multimodal conceptual understanding. Topic areas for conceptual understanding regarding plate tectonics were the following three categories: volcanoes and their origin, tectonic plates and plate boundaries, igneous rocks and identification. Students' use of gestures were identified based on a the framework by Van Boening and Riggs (2020). Conceptual understanding expressed by student talk was analyzed according to the word knowledge framework by (Cervetti, Pearson, Bravo, & Barber, 2006), and student talk was coded as active or passive conceptual understanding. Nonexistent ideas and misconceptions was also coded, based on Francek (2013) and Mills et al. (2016).

3. Results

The following tables and excerpt provide information regarding both research questions.

Table 1 shows students' active and passive understanding, missing ideas or misconceptions of main topics prior to instruction. Students' use of geological gestures is also included in the table.

Table 1: conceptual understanding (a), passive conceptual understanding (p), misconception/alternative ideas (m) or nonexistent ideas (n), and geological gestures (g).

Group	Volcanoes and their origin	Igneous rock formation processes and identification	Tectonic plates and plate boundaries
1	(m) Melting occur due to high temperature. Volcanoes are mountains with magma inside. (n) Students did not relate volcanoes to plate boundaries.	(n) Students do not remember any names or rock types. (n) Do not mention pattern as identification strategy.	(p) Uses the term "earth plates" and relates them to movement and earthquakes. "The plates have started to move more". (n) Students do not mention any of the three types of plate boundaries. Use first order, flat hand directional gestures representing collision of plates (g)
2	(m) Student draws and explain that volcanoes are connected to the earth's core. (n) Students did not relate volcanoes to plate boundaries.	(n) Students do not remember any rock names or rock types. (n) Do not mention pattern as identification strategy.	(p) Students explain that the earth and countries consists of plates. (p) When plates move, earthquakes occur. (n) Students do not mention any of the three types of plate boundaries.
3	(n) Students could not explain how they think volcanoes form. (n) Students did not relate volcanoes to plate boundaries.	(n) Students do not remember any names or rock types. (n) Do not mention pattern as identification strategy.	(p) Students say that plates collide when earthquakes happen. (m) Plates are located under the earth. (n) Students do not mention any of the other types of plate boundaries. (g) Use first order, flat hand directional gestures representing collision of plates.

During instruction, when the students were modelling plate boundaries in modelling clay, the following excerpt illustrate how students combined talk and first order, directional geological gestures:

Linda: Mary, you shall make the trans… I never remember what it's called
Mary: How does it look like?
Linda: It's just like.. [using her arms as an analogy of the relative plate movement involved]

Here, Linda tried to recall the scientific word for transform plate boundary. Linda further tries to help Mary and communicates the word and process by gesturing - using her hands, corresponding to the "definition" level in the word knowledge framework, a passive understanding.
Figure 3 illustrates the first order, directional gesture used by the students during instruction and in the post-interviews.

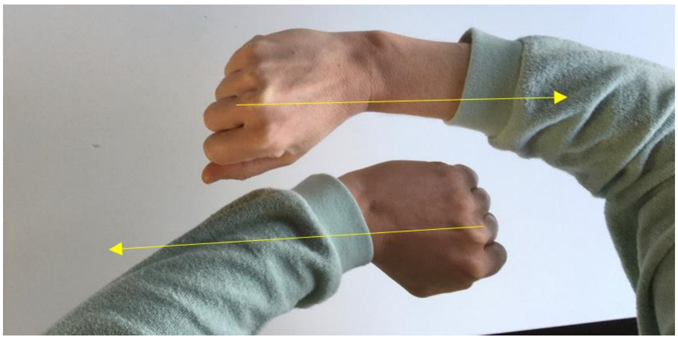

Figure 3: First order, flat hand directional gesture indicating a transform plate boundary.

Data collected during the post instruction interview is presented in table 2 below, indicating an increasing trend in students' conceptual understanding.

Table 2: Post interview conceptual understanding (a), passive conceptual understanding (p), misconception/alternative ideas (m) or nonexistent ideas (n), and geological gestures (g).

Group	Volcanoes and their origin	Igneous rock identification	Tectonic plates and plate boundaries
1	(p) Somehow related to plate movement. (n) Do not relate volcanism to plate boundaries.	(a) Identifying igneous rocks by connecting its dotted pattern and naming it dried lava.	(p) Recalls the different plate motions, but not the nomenclature. Little understanding of the processes. (g) Use first order, flat hand* directional gesture hesitantly to illustrate sideways movement.
2	(a) Connecting both constructive and destructive plate boundaries to the formation of volcanoes. Describing collision between oceanic plate and continental plate. (a) Relating the formation of igneous rocks to volcanoes and plate boundaries.	(a) Relating dots in the rocks to crystals formed by magma.	(a) Using correct nomenclature of all three types of plate boundaries. Knowing thickness of crust Relating earthquakes to plate movement and collision of plates. Earthquakes occur at all plate boundaries. (g) Use first order, flat hand directional gestures for divergent plate boundary.
3	(m) (n) Relating volcanism to hot spot volcanism, do not mention plate boundaries and movements as cause. (n) Do not relate volcanism to plate tectonics.	(a) The subsurface in the area consists of igneous rocks, having a dotted pattern.	(g) (p) Use first order directional, flat hand gestures to show that plates move apart and towards each other, as well as talk. (n) Little on plate characteristics.

3. Discussion and conclusion

3.1. Students understanding and use of geological gestures

Analyzed data shows that students in two out of three groups *prior to* instruction used first order, flat hand directional gestures to express themselves when asked about plate boundaries. These findings were unexpected, since the topic was new to the students. During the post instruction interviews, students in all groups included first order, flat hand directional geological gestures when talking about plate boundaries. Van Boening and Riggs (2020) characterization schemes of geologic gestures are based on how university-level students use gestures during geologic fieldwork. This study however, shows that geological gestures can provide affordance when teaching students in lower secondary school about plate tectonics, in the sense of being representations of plate boundaries.

In plate tectonic theory, both areal and temporal dimensions are factors controlling vital geological processes, representing essential elements of the theory for students to comprehend. Being able to visualize processes through time and space is perhaps the main scientific practice in geoscience. In the excerpt above, where the group is about to begin modelling plate boundaries, one group member uses her hands to gesture the relative plate movement of the boundary in question, but she cannot remember the name of the plate boundary, indicating an implicit and developing understanding of the properties of the plate boundary. This episode reflects Roths' (2007) perspectives on the novices' use of gestures when there is a lack of own words to express understanding of a new concept.

A teachers' focus on her students' use of gestures during learning activities is more likely to promote a developed understanding *if* the teacher pays attention to contextual and gestural clues given by the students. In these situations, where students are not able to verbally articulate their ideas, but manage to express implicit understanding through gestures, there is an increased potential that instruction and dialogue will increase students' understanding (Roth, 2007). Today, studies involving instructional approaches including the use of geological gestures are lacking in the educational literature. Instruction of geoscientific concepts rich on representational gestures, will promote students' own use of gestures (Kastens, Agrawal, & Liben, 2008). We now propose a set of gesture-characteristics of increasing complexity involved with the three types of plate boundaries (figure 4), relevant for instruction to the topic. Here, first order flat hand directional gestures corresponds to a passive understanding of plate boundaries. Second order geological gestures of plate boundaries consists of multiple types of geological gestures, illustrating the associated processes occurring at the distinct plate boundary. The multiple gestures involved when illustrating these processes would request that the student knows how concepts are related to one another, such as a dividing plate boundary and subsequent volcano formation and sea floor spreading.

Increasing Conceptual Understanding	Level of representational gesture complexity	Characteristics of gesture-use related to constructive, destructive and transform plate boundaries
	First order, flat hand directional gestures Divergent boundary Convergent boundary Transform boundary	Both hands dividing (←→) Both hands colliding, one hand going beneath the other (→←) Both hands sliding along each other (↓↑)
	Second order geological gestures Divergent boundary Convergent boundary Transform boundary	Both hands slowly dividing (←→), use one hand to illustrate magma rising in the area between the "two plates" (hands). Illustrate earthquakes by shaking the hands. Both hands slowly colliding, one hand going beneath the other (→←), use one hand to illustrate that the subsiding plate then melts and that magma rises to the surface of the overriding plate (the other hand). Illustrate earthquakes by shaking the hands. Volcano mountains could be gestured on the overriding plate. Both hands sliding very slowly along each other (↓↑), illustrate earthquakes by shaking the hands simultaneously as they move.

Figure 4: Framework for increased sophistication of gestures representing plate boundaries.

The gap between non-verbal expressions of understanding and verbal expressions of understanding is a place for the teacher to scaffold students' conceptual development. To exemplify, students' talk may express misconceptions, but attempting to relate the teacher-student dialogue to include gestures could help students in their four dimensional imaging of tectonic processes as well as developing word knowledge. Small group activities where the teacher can model geological gestures in line with the presented framework, and use scientific words to explain the physical processes happening at the plate boundaries, is likely to support the students' conceptual development. We now call for research exploring such scenarios.

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AFFECTIVE ASPECTS OF LEARNING HOW TO TEACH SCIENCE AND OF TEACHING SCIENCE CLASSES THE FIRST TIMES

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Abstract

In our study we focus on the questions: How do science teacher students perceive career-related challenges when they learn to teach and teach science the first times during a one-semester internship? And how do these students mentally process what they experience in the practical semester? Our theoretical framework is based on works concerning the perception of the motivational learning environment (MoLe) and supplemented by selected variables of the Self-Determination Theory (SDT), as well as the model of teachers' professional knowledge elaborated by Shulman (1987). Furthermore, it is built on studies by Schaarschmidt and Fischer about the reconstruction of individually shaped, work-related behavior and experience patterns (AVEM). 52 science teacher students have been involved in our study. Our results indicate that during the practical semester the motivational learning climate and the selected SDT characteristics were, on the whole, positively perceived and assessed by the students. However, almost half (46.2%) of all participants fell into the two AVEM risk patterns, which indicates that these students assess the practical semester as particularly stressful and almost every fourth student during the practical semester feels exposed to chronic exhaustion and resignation in the first weeks of the trainee program.

Keywords: Motivational Learning Environment, Vocational learning climate, Pre-service teacher education, Teachers' Continuous Professional Development, Work-related behavior and experience patterns, Vocational stress

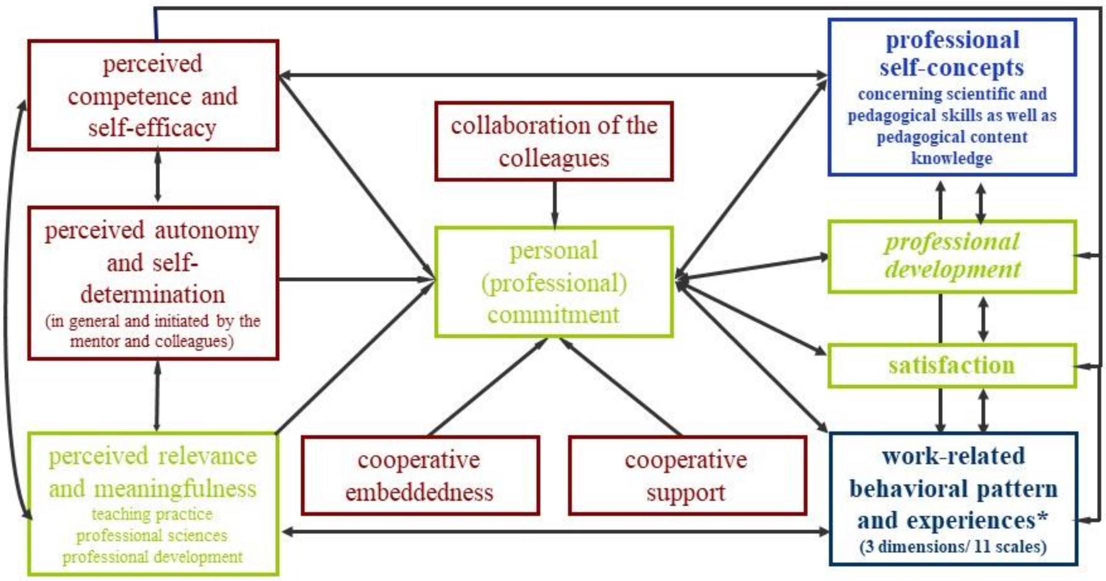
1. Introduction

As part of the reform of the teacher education program in Berlin, a one-semester internship for teacher students was established (SenBJW Berlin, 2012). In light of this reform, requirements of the study and examination regulations were changed (FUB, 2015a; b) as well as the key points of the internship ordinance were comprehensively revised (FUB, HUB, TUB, & UdK Berlin, 2016). Following these changes in the curriculum and the resulting modifications of the seminars that are linked to the semester internship, but also with a view toward the lesson activities expected from the trainees, we assumed that this could lead to serious challenges in the teacher students' perceptions regarding their requirements. Therefore, the following questions arise: How do teacher students with at least one natural science teaching subject perceive the career-related challenges associated with the one-semester internship? To what extent do the colleagues in the internship schools provide a buffer for the new requirements that the teacher students are faced with so that they may feel professionally supported and socially involved in the teaching staff? In addition, we ask: To what degree do the teacher students experience themselves as autonomous and effective individuals? Finally, we are interested in how the students mentally process what they experience in the one-semester internship.

2. Theoretical framework

To answer these questions, our investigation is mainly based on four theoretically sound fields of pedagogical psychology and didactics (see Fig. 1).

The first theory is based on works concerning the analysis of students' perception of the *motivational learning environment* (MoLe) (Bolte, 1996, 2004, here: concerning the perception of the vocational learning climate assessed by teacher students in the context of their subject-specific and instructional studies within the one-semester internship). This theoretical nucleus is supplemented by selected elements (variables) of *Self-Determination Theory (SDT)* elaborated by Deci and Ryan (1985; 2002). Furthermore, we also included the *model of teachers' professional knowledge* introduced by Shulman (1987) combined the elements of *academic self-concept theory* according to Dickhäuser and colleagues (2002) in our theoretically sound model (see Fig. 1).



Figur 1. The MoLE+ Model to investigate the perception of the vocational learning climate assessed by teacher students in the context of their subject-specific and instructional studies within the one-semester internship

Besides these theory-elements mainly reflecting the motivational aspects of teachers and teacher students' continuous professional development (CPD), our framework builds also on studies by Schaarschmidt and Fischer (2001, 2008) on the reconstruction of individually shaped, *work-related behavior and experience patterns* (in German: Arbeitsbezogene Verhaltens- und Erlebnis-Muster – *AVEM*; see Fig. 1 and Fig. 2).

2.1. Motivational Aspects during Science Teachers' and Science Teacher Students' Continuous Professional Development

Motivational aspects guide and influence the professionalization as well as the psycho-emotional (working) satisfaction of all involved in all educational contexts in general, as well as in schools or in the context of the support of teachers' and/or teacher students' continuous professional development (CPD) at all levels in particular – either at the university level or (e.g. in Germany) in the second and third period of systematically organized teacher education. Therefore, our theory-based framework reflects how (intrinsically) motivated teachers or teacher students work on their own personal CDP and how they cope with the professional challenges they are or they feel confronted with. Therefore, the MoLE+-model takes considerations into account as described in:

- the Pedagogical Interest Theory (Prenzel, Krapp, & Schiefele, 1986; Krapp, 2002),

- the Self-Determination-Theory (SDT) according to Deci und Ryan (1985; 2002), combined with
- the Studies on Motivational Learning Environment (SoLE/MoLE) as well as on Learning Climate Research in schools, universities, and/or other workplaces (Bolte, 1996; 2004; Fraser, 1985; 2012).

In addition, our model also focuses on elements of

- the Theory of Teachers' Professional Knowledge according to Shulman (1987) and
- the Theory of the Academic and Professional Self-concept of Teachers and Teacher Students as introduced by Dickhäuser et al. (2002).

2.2 Work-related Behavioral and Experiential Patterns (AVEM) in the course of Science Teachers' and Science Teacher Students' Continuous Professional Development

The AVEM theoretical framework is based on a personality-diagnostic construct, which focuses on three theory-based dimensions (professional commitment, coping capacity and subjective well-being) represented by eleven empirically documented scales (see Fig. 2): 1. Significance of the job, 2. Professional ambitions, 3. Willingness to sacrifice, 4. Pursuit of perfection, 5. Ability to distance oneself, 6. Tendency towards resignation, 7. Offensiveness of handling problems, 8. Inner balance, 9. Sense of achievement in the job, 10. Satisfaction with life, 11. Experience of social support.

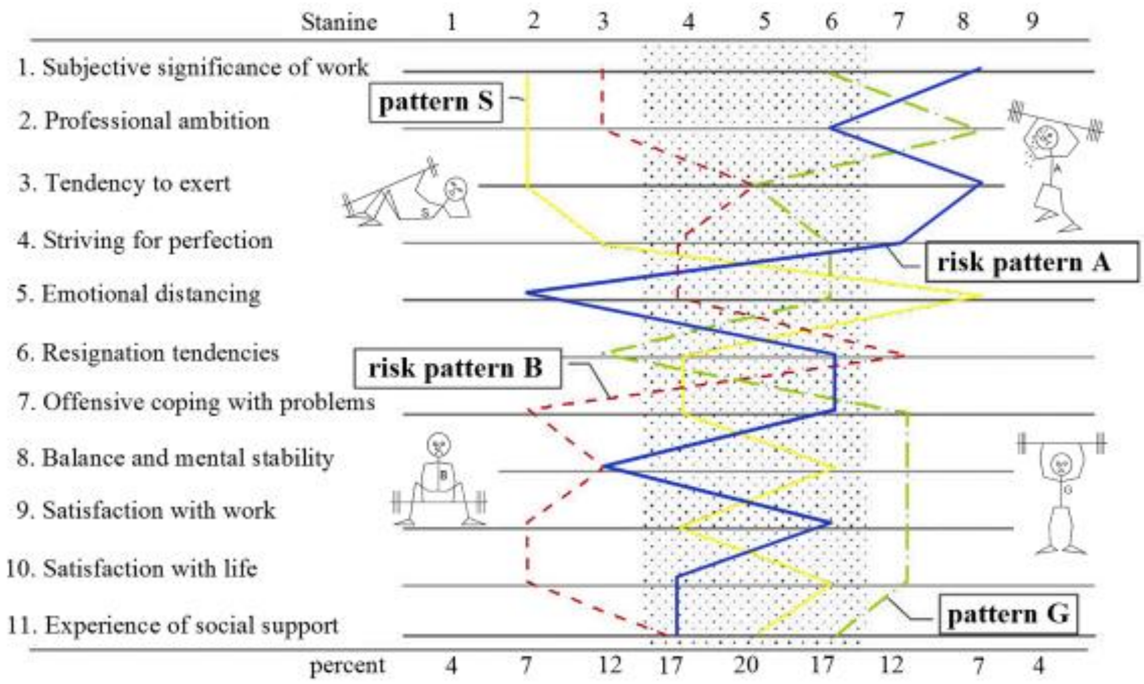


Figure 2. Distinction between the four (AVEM) reference patterns and the eleven scales to reconstruct the work-related behavioral and experimental pattern
(Schaarschmidt & Fischer, 2008, 11)

The interdependence of the 11 AVEM scales is expressed in the four work-related behavioral and experiential patterns and their corresponding prototypical profiles (reference patterns). The four work-related behavioral and experiential patterns, both empirically re-constructible and statistically secured, are labeled as:

- the pattern G (good health),
- the pattern S (self-protection),
- the risk pattern A (risk of being over ambitioned in the sense of the risk of overexertion), and as
- the risk pattern B (risk of burnout in terms of the risk of chronic fatigue and/or the risk of giving up and resigning).

Insights from AVEM-analyses can be used for individual diagnosis to determine the similarity of each person's profile with the four reference patterns. In doing so, a distinction is made between full, accentuated and tendential patterns as well as pattern combinations (Schaarschmidt & Fischer, 2013, 5 - Emphasis added in the original, see also Table 1).

2.3 Questions of Research

On the basis of our theoretical framework, we try to answer the following research questions:

1. How do teacher students with at least one natural science teaching subject perceive their career-related challenges associated with the one-semester internship?
2. To what extent do the colleagues in the internship schools provide a buffer for the new requirements that the teacher students are faced with so that they may feel professionally supported and socially involved in the teaching staff? In addition:
3. To what degree do the teacher students experience themselves as autonomous and self-effective individuals?
4. How do the students mentally process what they experience in the one-semester internship?

Finally, we are interested to prove how the teacher students' assessments change because of the experience gained during the one-semester internship.

3. Research methods

In order to answer our research question, teacher students studying at least one school science subject were presented with a questionnaire that includes specially adapted but also specifically designed items or scales for the evaluative assessment:

- Scales of the MoLe^{+} questionnaire (with 20 items) according to Bolte (2016); supplemented by
- Scales (18 items) from the field of Self-Determination Theory (SDT) based on Deci and Ryan (1985), as well as
- 3 Scales (with 4 items per scale) of teachers' and/or teacher students' concerns regarding their professional self-concept according to Shulman (1987) and Dickhäuser et al. (2002) and
- 11 Scales of the AVEM-44 questionnaire (4 items per scale) developed by Schaarschmidt and Fischer (2008).

The data collection is organized online via the platform "Unipark" (2016). The AVEM software (version 3.2.0.0) and the SPSS Statistics 24 program are used for data analysis.

Before the participants' responses were subjected to *descriptive* and *variance statistical analyses*, the *scientific quality of the adapted scales was tested by means of reliability and factor analyses* (Eid, Gollwitzer & Schmitt, 2015). The identification of the *work-related behavioral and experiential patterns* of the participants (AVEM patterns) and the estimation of their similarity with the respective reference samples of the AVEM standard sample is carried out with the AVEM software, taking into account the calculated Stanine values (Amelang & Zielinski, 1994).

4. Results

The *random sample* of the study consists of 52 students from the science teacher education master program. The participating students studied at least one science subject. During the one-semester internship, all participants were involved in teaching at least one science subject in their internship schools. Within this sample of 52 participants (in total) involved in our study at the beginning of the first one-semester internship, we were able to collect data from a specific sub-sample at the end of their one-semester internship. This sub-sample consists of teacher students (N = 16) who chose chemistry as one of the two teaching subjects that a teacher student has to study in Germany. The pre-post-test data of this sub-sample served as a basis to investigate how the teacher students' perception of the learning environment and their professional experience changed during the one-semester internship (see Fig. 4 to 6). Below, we present some selected results of our *data analysis*.

Regarding the *quality assessment* of the scales adapted for this study, it can be stated that all scales have satisfactory reliability coefficients (Cronbach's $\alpha > .07$), and that the results of the factor analyses speak for the validity of the constructs (Bolte, 2019).

Focusing first on the findings of the AVEM analyses of the teacher students participating in the first one-semester internship (N = 52), we find the following distribution of the AVEM prototypes (see Tab. 1 and Fig. 3).

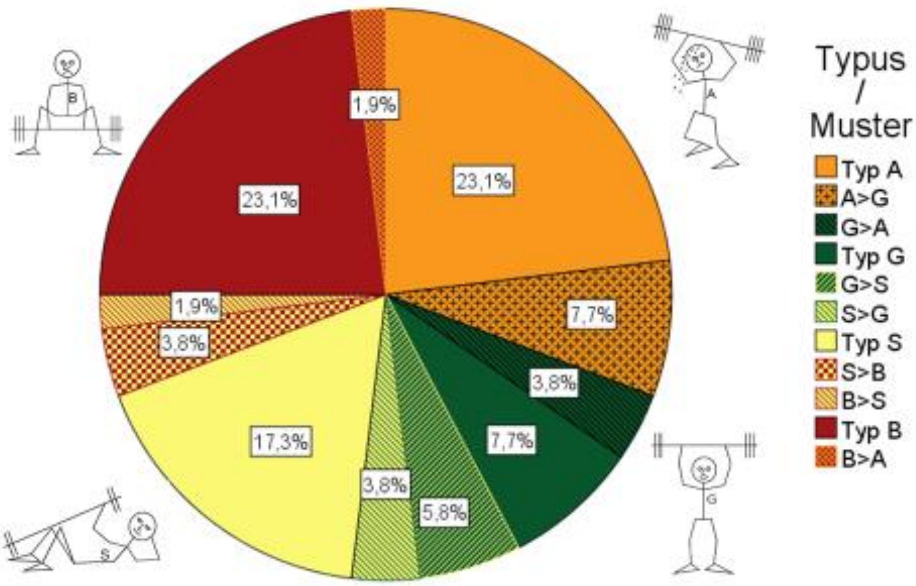


Figure 3. Distribution of 52 teacher students with at least one science subject at the beginning of the one-semester internship (in our 1^{st} survey)

Table 1 summarizes the empirical reconstruction of the AVEM patterns of the science teacher students and the comparison of these patterns with the four AVEM reference patterns. A closer look at Figure 3 and/or Table 1 offers insights in the distribution of the 52 participants of this survey (teacher students with at least one science subject). The AVEM analyses reveal that nearly three quarters of participants resemble a prototypical AVEM pattern (G, S, A or B type) while 28.7% must be assigned to a combination pattern. Furthermore, it should be mentioned that at the beginning of the internship, 57.7 % of the science teacher students belonged to the A or B affinity type.

Table 1. Profiling and distribution of feedback on the four AVEM reference patterns at the beginning of the one-semester internship.

Pattern	N	%	Expression
G	4	7.7	(1/2/1)
S	9	17.3	(4/5/0)
A	12	23.1	(4/3/5)
B	12	23.1	(3/3/6)
$\sum_{\textbf{Prototype}}$	**37**	**71.2**	(full/acc./tend.)

Combo	*N*	*%*	***Combo***	*N*	*%*
G>S	*3*	*5.8*	*G>A*	*2*	*3.8*
S>G	*2*	*3.8*	*S>B*	*2*	*3.8*
A>G	*4*	*7.7*	*B>S*	*1*	*1.9*
B>A	*1*	*1.9*	$\sum_{\textbf{Combo}}$	***15***	***28.7***
			$\sum_{\textbf{whole}}$	**52**	**100 %**

Unfortunately, we could not collect data of the total sample at the end of the one-semester internship for the post-test analyses. But luckily, we had the opportunity of doing so in a specific sub-sample: the chemistry teacher students involved in this study. Consequently, we only concentrate on this sub-sample and focus on those students (N = 16) who chose chemistry as one of the two teaching subjects.

Focusing on the results of the sub-sample of the *chemistry teacher students*, the distribution of the AVEM prototypes in this group changed as follows (see Fig. 4):

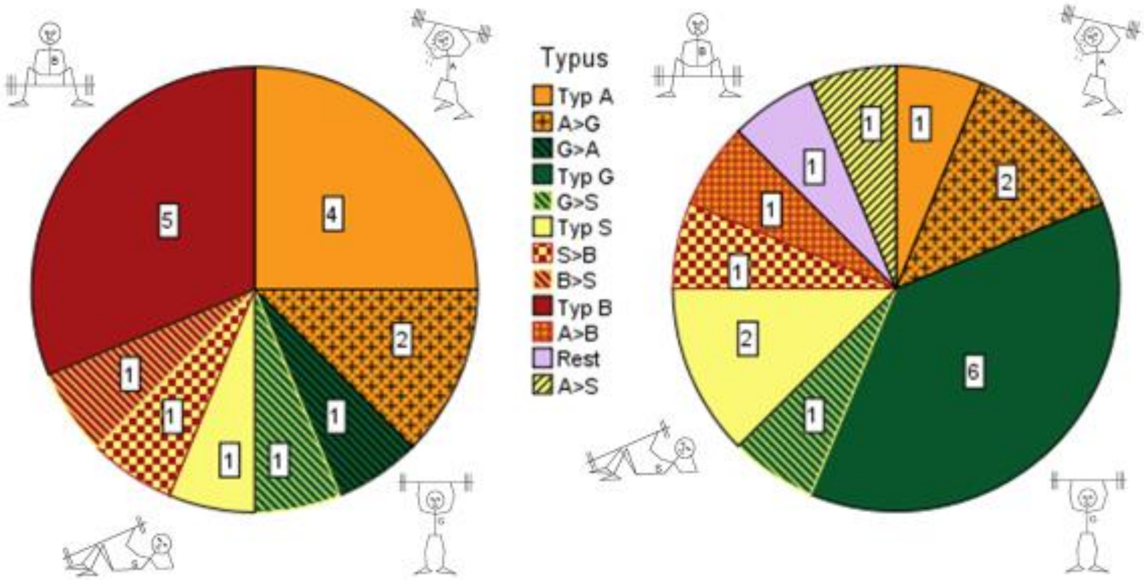


Figure 4. Distribution of the 16 chemistry teacher students
at the beginning and at the end of the one-semester internship (in our 1st survey)

In the 1st survey, 75.0 % of the 16 chemistry teacher students identified as A or B affinity type at the beginning of the one-semester internship. This finding – we conclude – is and should be alarming!

However, at the end of the one-semester internship, the same chemistry teacher students gave feedback on their emotional state. Their work-related behavioral and experiential patterns changed in a positive manner: at the end of the one-semester internship the number of students belonging to a A or B affinity type decreased from 75 % to 31.2 %. Nevertheless, although the number of risk-type teacher students decreased, six out of sixteen teacher students remained in this group. On the other side, the number of teacher students who in the end pertain to the "good health" type increased from two to seven out of sixteen.

With regard to the *descriptive-statistical* analyses of the MoLE^{+} scales (see Fig. 5) and the selected SDT scales (see Fig. 6), it can be noted that the mean-scores of the scales of either the pre-test or the post-test are higher than the theoretical mean-score of the respective scale. This shows that all variables are perceived as being positive by the chemistry teacher students.

Concerning the pre-test findings, we have to state that, although the motivational learning atmosphere in the preparatory science education course (in which teacher educators prepare the teacher students concerning the tasks and challenges they have or might have to face in the one-semester internship) has been assessed as positive, many teacher students had serious concerns in the first weeks they spent in school as science teacher trainees as the AVEM analyses proved (see Fig. 4).

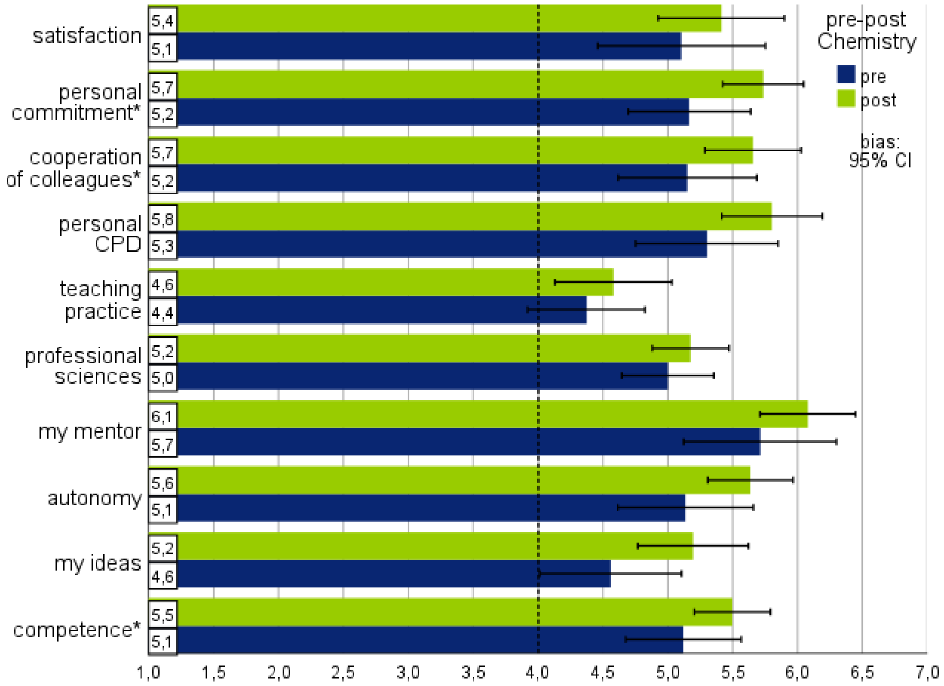


Figure 5. Mean scores focusing on the assessment of the Motivational Learning Climate (MoLe+) scales [scale/value: 1 (negative assessment) to 7 (positive assessment)]

Focusing on the post-test results of our MoLE+ analyses, the findings show mean-scores which are higher than those of the pre-test. Therefore, we can conclude that the learning climate in the university courses (in which the teacher students receive support on how to deal with the problems and challenges of teaching science the first time) as well as the learning atmosphere they perceived in the meetings they had with their mentors in the internship schools, has been assessed by the trainees as being more positive and supportive compared to the situation they had evaluated at the beginning of the internship.

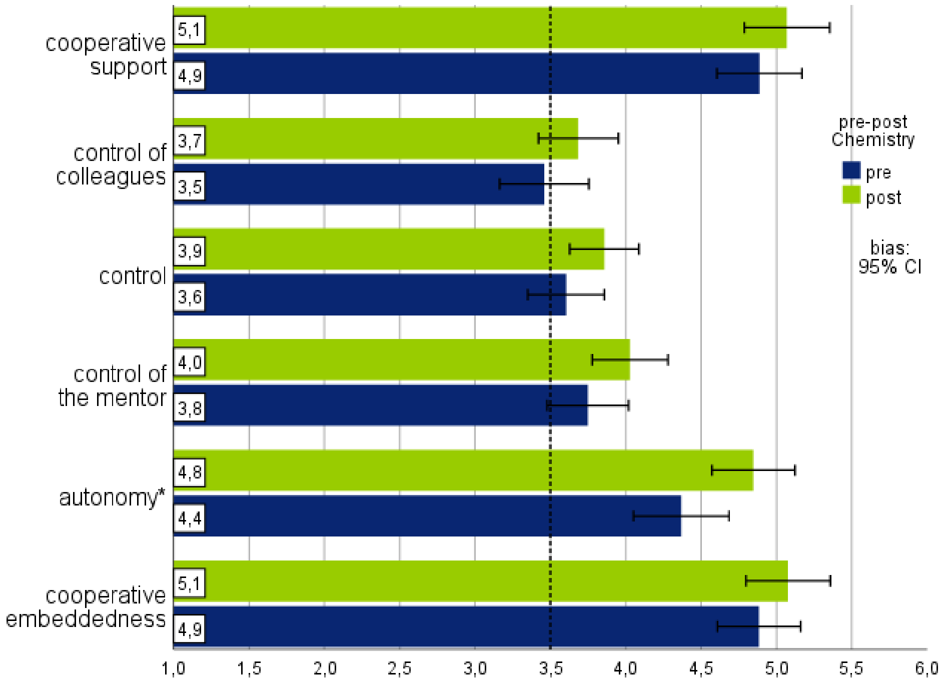


Figure 6. Mean scores focusing on the assessment of the selected Self Determination Theory (SDT) scales [scale/value: 1 (negative assessment) to 6 (positive assessment)] at the beginning of the one-semester internship

Taking into consideration the results of the different fields of our theoretical framework, we can ascertain that the positive and supportive motivational learning environment in the preparatory courses and the increase of the variables' values during the internship lead to the decrease in the number of teacher students who assessed the situation of being a science teacher trainee and of teaching science classes for the first times as being very or too ambitious, or even as (too) stressful.

5. Discussion and conclusion

Our results indicate that the motivational learning climate in the one-semester internship and the selected SDT characteristics were, on the whole, positively perceived and assessed by the students. However, the large number of students attributed to the two AVEM risk patterns (sample A and sample B) is also noticeable; this group represents almost half (46.2%) of all participants. Focusing on the risk pattern B results, it can be seen that almost every fourth student in the practical semester feels exposed to chronic exhaustion and resignation. Only 7.7% of the students show the desired pattern G.

In the sub-sample of the chemistry teacher students, the situation is even more critical at the beginning of the internship. However, at the end of the internship the critical situation has changed in a significantly more positive manner. However, although we are lucky of being able to reduce the number of teacher students who assessed themselves as being excessively committed or even stressed while teaching science in school during their internship, we still have to take care of approximately a third of the chemistry teacher students' sample who remained in the A or B affine AVEM prototype group. Those teacher students seem to need special support, attention and supervision.

In this study we could only focus on the assessments and feedback we received from teacher students with a science subject who participated in a new program of teacher education in Berlin. In addition, it was the first time the program was realized after the implementation of this reform in the field of the first period of teacher education. We are aware that the sample was and still is quite small and because of it being the first round and the first survey, maybe not representative. Therefore, the question as to which teacher (student) training conditions produce positive or negative AVEM patterns still requires more attention and further clarification in subsequent studies.

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Concerns of Science Teachers and Chemistry Teacher Students Regarding the Requirement to Foster Pupils' Competence to Deal with Socio-Scientific Issues

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Abstract

According to reforms in the German national education standards (KMK 2005), science teachers are required to foster competence not only concerning scientific principles and concepts, but also in the field of dealing with socio-scientific issues reflectively and making informed decisions. The fulfilment of this requirement presented new challenges to teachers, and it still seems to be the source of serious difficulties in school practice today. Therefore, fostering the competence which enables students to scientifically assess and evaluate various issues in society, still needs attention. Therefore, we asked: 1st How do prospective and active teachers regard the professional challenges and opportunities regarding the fostering of socio-scientific-issues (SSI) assessment and evaluation skills of students? 2nd In which manner do prospective or active teachers' concern to implement approaches for the enhancement of students' ability to make informed decisions in the field of socio-scientific issues change when they participate in a specific teacher education course which deals with the topic of how to foster students' reflective judgement abilities? In order to pursue this question, we conducted a pre-post-test study combined with a treatment-control-group design. For this purpose, we used the "Stages of Concern model" (SoC) by Hall and Hord (2011), a model to analyse the concerns of professionals to implement educational innovations. In a first step, we applied existing SoC-Questionnaires to our subject and the focus of our research. We adapted scales and tried to improve them in terms of language, semantics, and reduction of item number as well as by strengthening the theoretical connection of items and scales. Our study consists of 52 (pre- and in-service) science teachers for the pre-test. After the treatment course, we were able to collect post-test data of 42 teacher students who participated in the tailored teacher education course. Our pre-test data analyses show the SoC-Profile of the “Cooperator” in both sub-samples, and no statistically significant differences between the data of the pre- and the in-service science teachers involved. In contrast, the post-test data analyses show an even more positive SoC-Profile, the profile of the “Converter”, because comparing the scores of the SoC-scales “actuality” and “task management”, the U-test analyses lead to statistically significant differences after the treatment course.

Keywords: Stage of Concern (SoC), Teachers’ Continuous Professional Development (CPD), Socio-Scientific-Issues (SSI), Implementing Educational Reform, Teachers’ Attitudes

1. Introduction

The successful implementation of curricular innovations and reforms are mainly influenced by the acceptance of those affected by such changes (Fullan 2000; Coburn 2003). The introduction of national educational standards in Germany by the Standing Conference of the Ministers of Education and Cultural Affairs [in German: Kultusminster Konferenz; in short: KMK] (2005 a-c) presented teachers with new challenges, requiring them to foster not only subject specific competences, but also student competence in the areas of methods for the acquisition of scientific knowledge, communication skills, and the competence to deal with socio-scientific issues (SSI) in a reflected and responsible manner. In light of this fact, we suspect that, even fifteen years later, the implementation processes of the KMK agreements (2005) are still far from complete.

Above all, we still see a great need for action, particularly in the area of fostering students’ ability to assess and evaluate scientific issues and to critically reflect on their effect on society with respect to goals for sustainability. For this reason, we are investigating the question: How do (pre- and in-service) science teachers assess the professional challenges and opportunities that they face concerning the implementation of the KMK Standards (2005) in general and the requirement of fostering students’ competences regarding SSI assessment and decision-making?

2. Theoretical Framework

To pursue this general question, we use the Stages of Concern (SoC) model by Hall & Hord (2011). The SoC model is a proven model for analysing the willingness of individuals to implement educational innovations. According to Hall & Hord (2011), the successful adoption of an innovation takes place over seven different development stages (so-called SoC; fig. 1).

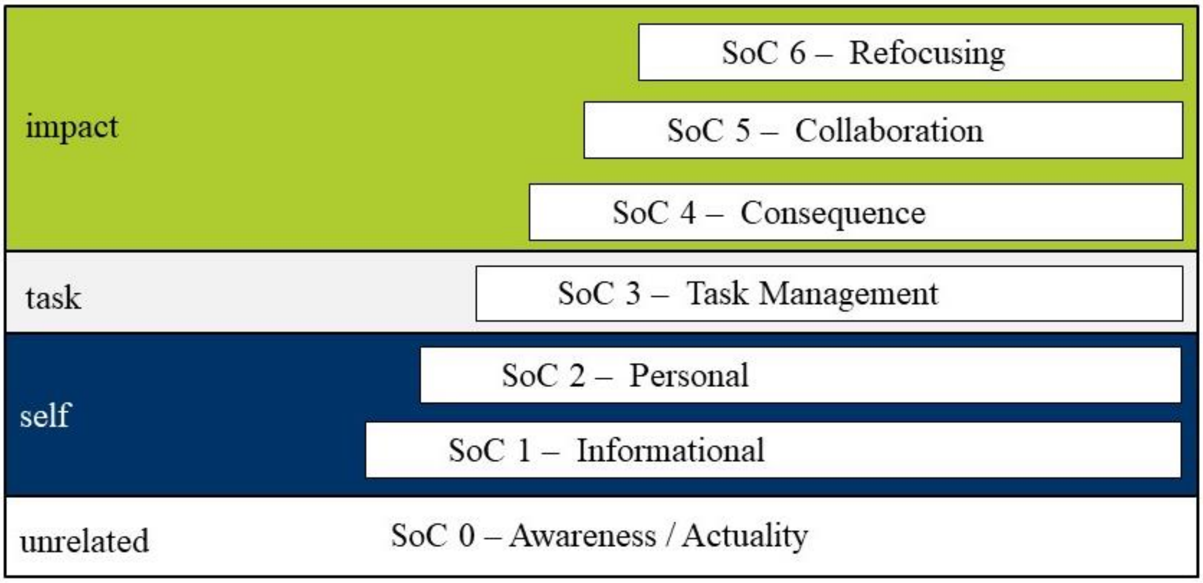

Figure 1. Stages of Concern model according to Fuller (1969) and Hall and Hord (2011).

The SoC-Model of Hall and Hord (2011) has already been successfully used in various implementation studies (George et al. 2008; Pant et al. 2008; Oerke 2012; Kwok 2014; Pöhlmann et al. 2014; Böse et al. 2018; Teerling et al. 2018; Bolte & Schneider 2014; Bolte, Schneider & Schürmann, 2014). While Pant et al. (2008) have already applied the model to the implementation of national educational standards in general, the competence area of how to enhance students' abilities to deal with socio-scientific issues (SSI) and to make informed decisions has not yet been explicitly considered. This lack of research is surprising, because the promotion of this competence is generally regarded as a particularly demanding task (Menthe et al. 2016; Bolte & Gauckler, 2018), which confronts many teachers with challenges that they often face with uncertainty (Alfs et al. 2012; Mrochen & Höttecke 2012).

Therefore, we decided to adapt the questionnaire by Hall and Hord (2011) using the German translation by Pant et al. (2008) as well as the adaptation of these items for science educational research in accordance to Bolte and Schneider (2014) and to apply the corresponding scales to the issue of fostering the students' competence to make informed decision concerning socio-scientific issues in science lessons.

Beside these objectives of adapting the existing SoC-Questionnaire, we have also tried to shorten the original questionnaire in terms of the number of items, and to semantically optimize the combinations of the scales and the corresponding items concerning a stronger connection to educational theories.

Research Question

From our theory-based considerations, we arrived at the following research questions:

1st To what extent does our adapted SoC questionnaire fulfil the criteria of scientific quality?

If our adapted SoC questionnaire provides satisfying psychometric features compared to other studies (e.g. Pant et al. 2008; Böse et al. 2018; Teerling et al. 2018; Bolte & Schneider 2014; Bolte, Schneider & Schürmann, 2014), we also want to investigate whether we can find the typical "SoC-Profiles" according to the studies of Bitan-Friedlander et al. (2004). In this context we ask:

2nd To what extent do (pre- and in-service) science teachers SoC-Profile show one (or more) of the typical SoC-Profiles and to what extent do the SoC-Profiles of in-service science teachers and the chemistry teacher students differ?

3rd In which manner do prospective or active teachers' concern to implement approaches for the fostering of students' abilities to make informed decisions in the field of socio-scientific issues change when they participate in a specific teacher education course which deals with the topic of how to foster students' reflective judgement abilities?

3. Method

In order to identify typical SoC-Profiles in general and to test differences between pre- and in-service science teachers, we involve at least two (sub-)samples, a selection of pre- and in-service science teachers, to examine our research questions.

In addition, we created a specific science education course for teacher students studying at least one school science subject (e.g. chemistry) in order to prepare these teacher students to cope with the challenges they we will experience when they will teach science classes with a special emphasis on enhancing their students' abilities to make informed decisions. The participants of this science education course serve as the treatment group while the participants of the pre-test represent the control-group samples.

For statistical analysis, the basis of data includes a) data of fully qualified teachers with a at least one science subject, and b) of chemistry teacher students before the treatment. Furthermore, we collect data c) of the same chemistry teacher students after the treatment. To identify differences within the two sub-samples of the control group and between the pre-post-test data of the chemistry teacher students at the beginning and at the end of the treatment, we adapted a German questionnaire version of the SoC according to Pant et al. (2008) and Bolte and Schneider (2014). In the context of this adaptation, we reduced the number of items to 28 (four items per scale). Each item has a 7-point Likert scale from "Not true of me now" (1) to "Very true for me now" (7). Furthermore, if the content of an item is absolutely irrelevant for the participant at the moment, there is the possibility to choose the option "irrelevant" (0) (George, Hall & Stiegelbauer, 2008, p. 80).

In order to identify SoC-Profiles according to Bitan-Friedlander et al. (2004) or in accordance to Böse et al (2018) and to describe identified Concerns-Profiles in different sub-samples as well as before and after the treatment, we checked the reliability for the seven SoC-scales using Crombach's alpha approach and we used a seven-component factor analysis to assess the construct validity of the adapted questionnaire version (Eid & Schmidt 2014). Furthermore, we calculated Mann-Whitney-U-Test a) to identify possible statistically significant differences between the two sub-samples of the control group and b) to test statistically significant differences b) in the pre-post-test data of the control and the treatment sample.

4. Results

The sample of the first survey consists of 62 participants in total; 31 in-service science teachers and 31 chemistry teacher students (mainly in the master program and having had their first experiences in teaching chemistry classes within a one-semester internship).

The analyses of reliability provided by Cronbach's alpha coefficients are for all SoC-scales higher than .70 and indicate an at least acceptable reliability, and in the majority of the SoC-scales a good or very good level of reliability ($.72 < \alpha < .91$). The factor analysis using principal component analysis and varimax rotation shows that the items loaded high on the factors to which they theoretically should belong in the SoC-model. In addition, the results of the Mann-Whitney-U-test show *no* statistically significant differences between the two sub-samples of the control group at the beginning of our investigation.

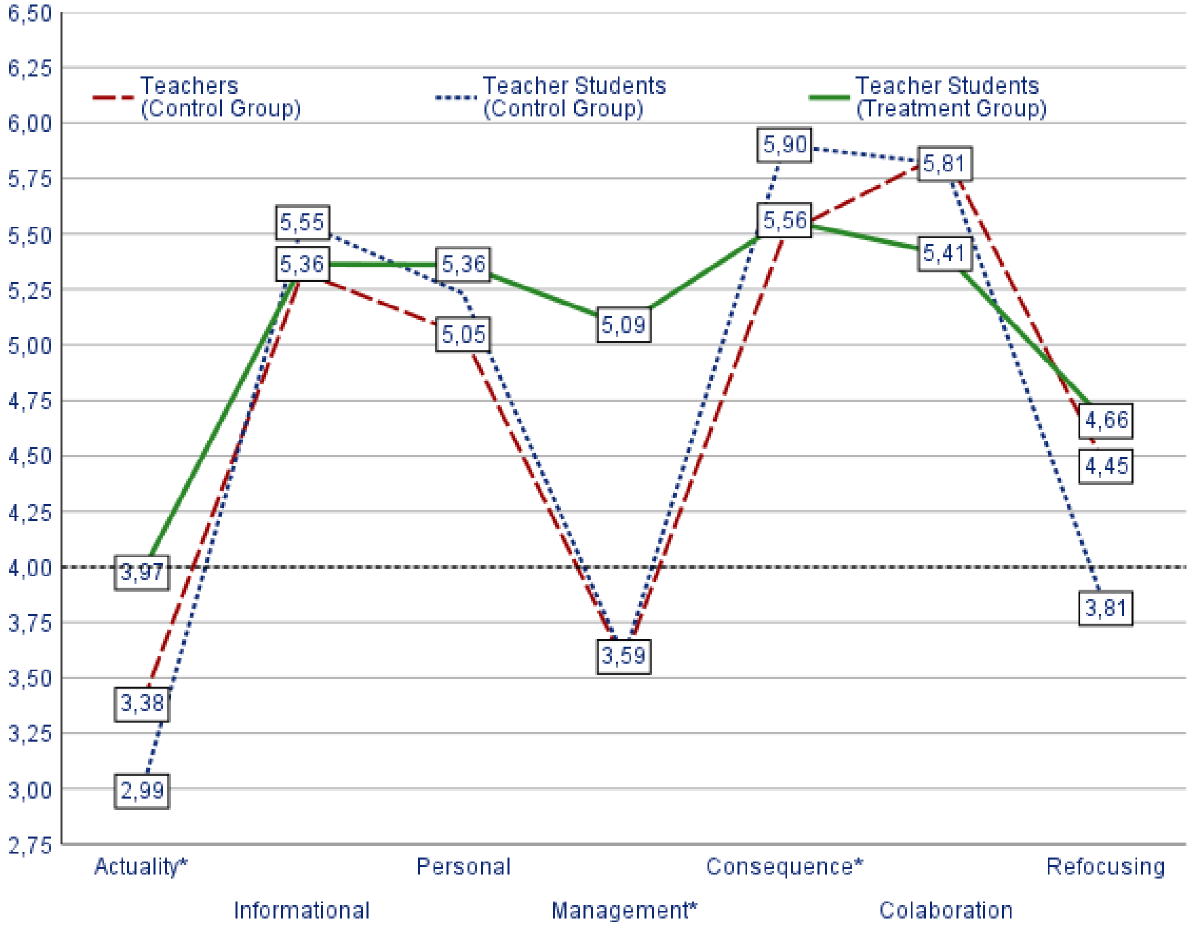

Figure 2. SoC-Profiles of three different (sub-)samples before and after the treatment course aiming to improve of professional skills of chemistry teacher students, preparing them to support pupils in chemistry classes to foster their abilities to make informed decisions concerning socio-scientific issues

Comparing the identified SoC-Profiles at the beginning of our study with those identified in other studies we can conclude that the SoC-Profiles of both sub-samples are quite similar to the one discovered by Bitan-Friedlander et al. (2004), and which they termed the Profile of the "Cooperator" (see Figure 2).

Finally, we compared the findings of the treatment-group (N=48) with the results of the control-group analyses at the end of the treatment course. The U-test-analyses show two statistically significant differences; these differences emerge regarding the variables "actuality" und "(task) management". According to the studies of Böse et al. (2018), we identify in the post-test analyses another SoC-Profile. This SoC-Profile was termed by Böse and his colleague as the "Converter" and professionals belonging to this prototype can be described as colleagues who changed their point of view from the question "how does the innovation affect *myself*" (self-reflection) to the question "how can I manage *the tasks* correlating with the educational reform" (task orientation).

5. Discussion and conclusion

Our study shows that the adapted SoC-questionnaire version is theoretically sound and the scales are reliable. In our analyses of both pre-test sub-samples (control group) we could not find any statistically significant differences regarding the mean scores of the seven different SoC-scales. Furthermore, we identified the SoC Profile of the "Cooperator" (Bitan-Friedlander et al. 2004) in both the teacher students and the in-service teacher. This demonstrates that both groups show interest in the implementation of the requirement to foster students' ability to deal with SSI in a reflected and responsible manner, but they are still very much concerned with how this will have an (negative) impact on their personal situation. Following the SoC-theory, this is likely the reason why the participants at this stage are not focussing on the issues of how to manage the challenges related to this educational goal and/or how to improve their lesson plans in order to fulfil the tasks related to the desired innovation.

In addition, after the treatment course – the tailored preparation course for chemistry teacher students focussing among other issues on how to cope with challenges which may occur when they will teach chemistry classes and try to enhance the students' abilities to make informed decisions – the participants provide the feedback that some concerns changed. Of course, these participants are more aware of the educational aim to foster students' judgement competences (see SoC-scale "actuality"). Nevertheless, the changes regarding their concerns of how to manage the challenges when they try to enhance the students' abilities to make informed decisions are statistically significant too. This can be seen as a positive change in the teacher students' professional attitudes towards a higher willingness to care for this educational aim in the future.

As there are no statistical differences between the teacher and the teacher student groups in the pre-test, we can conclude that there is still a need for teacher training in this field. Furthermore, the effect of the treatment course verifies that change in the teacher students' concerns is possible. These results make us feel optimistic, that a successful transfer from the field of pre-service teacher training to the field of in-service teachers professional development courses becomes possible and likely.

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Notions about invisible things – Student (pre-)conceptions about themes of radioactivity and ionizing radiation

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Abstract

Preconceptions about scientific terms and natural phenomena that students bring into lessons have a substantial influence on the learning process and thus, it is imperative that they be given consideration in science classes. Studies concerning students' preconceptions have formed an important part of science education research for more than 40 years. Numerous examples of results can be found, for example, in the bibliography of "Students' and Teachers' Conceptions and Science Education" by Pfundt and Duit (2009). Research concerning learners' preconceptions about the "Radioactivity and ionising radiation" are very rare in comparison with other subject areas. This is surprising, because the scientific concepts of "Radioactivity and ionising radiation" is certainly not easy to teach, and for students difficult to learn. Furthermore, it is obvious that opportunities and risks rising from the use of radioactivity in fields such as medicine, or energy supply are the subject of many controversy and emotional debates in the society. Therefore, we surveyed altogether 238 students from grade 10, using a specially designed questionnaire aimed at assessing conceptual understanding of the terms "radioactivity", "ionising radiation" and "radioactive substance." In this publication, we will present the research design and questionnaire, as well as results of our study.

Keywords: students pre-conception, radioactivity and ionizing radiation

1. Introduction

Science and technology are fundamental in shaping our society and cultural identity. On the one hand, the continuous translation of scientific findings into new technologies and products brings progress in many areas, while on the other hand, technical innovations always involve unintended risks that "must be recognized, evaluated and controlled" by society and the individual (KMK 2005 a-c, 6). Dealing with the risks and evaluation of innovative technologies, such as the use of radioactive substances in research, technology and medicine, is therefore increasingly at the centre of social discussions. In order to be able to participate rationally and responsibly in discussions of socially important topics, scientific literacy is indispensable (Duit, Häußler & Prenzel 2001; Prenzel et al. 2003, Bolte 2003; Bolte 2014) and is therefore a major focus of contemporary science education (Bolte & Schulte 2014; Bolte & Gauckler 2018; Gräber et al. 2002, KMK 2005).

2. Theoretical Framework

There is a consensus in the national and international scientific teaching community that the ideas about scientific terms and concepts that students bring with them into the classroom have a significant impact on the learning process. For more than 40 years, numerous studies on content and domain specific student conceptions have made an essential contribution to the formation of theories about science teaching (for example, see the bibliography from Pfundt & Duit, 2009). It is noteworthy that, compared to other topics, very few studies have been published about pupil conceptions concerning radioactivity, and that they come predominantly from either Great Britain (Eijkelhof & Millar, 1988; Eijkelhof et al., 1990; Millar, 1994; Boyes & Stanisstreet, 1994, Prather, 2005) or the Netherlands (Lijnse et al., 1990; Eijkelhof, 1990). The findings of these studies suggest that students have undifferentiated and largely naive ideas concerning the concept of radioactive matter and radiation, and that the term elements are often inappropriately linked to the concept of radioactivity.

Therefore, the aim of our study is to work out which ideas students from different school forms associate with terms such as radioactivity, radioactive matter and radiation at the end of their compulsory schooling, and to what extent their ideas are consistent with the scientific concepts.

Research Question

Based on the objective of this study, we deal with various questions. At the centre of this proposal, we focus on the following question:

To what extent do 10th grade students successfully differentiate between the terms radioactivity, radiation and radioactive particles in a scientific manner?

3. Research methods

In order to answer this research questions, we used a specifically developed questionnaire, according to Millar (1994), for the systematic analysis of the conceptual understanding of terms.

The questionnaire consisted of six structurally similar tasks with nine items combined with a closed answer format. The six different scenario of the questionnaire are dealing with phenomena or situations which people do (or likely) experience situations related to the topic of ionisation radiation and radioactivity; however they do not get aware – in many cases or maybe most of the cases – that the situation or the scenario is connected or even based on this scientific concept. The scenarios are focussing on:

[1] Food Irradiation,

[2] Paper Thickness Measurement,

[3] Radioiodine Therapy,

[4] X-ray Diagnosis,

[5] Scintigraphy,

[6] Level Sensor Measurement)

All tasks are introduced by a brief description of the scenario or the possible application of ionizing radiation technology (e.g. irradiation of strawberries to prolong shelf life (see example/scenario #1). After this introduction, the participants of the study are asked to assess subsequent statements (items) according to their scientific correctness.

To provide an example, we choose scenario #1 to illustrate the systematic of how we try to investigate students' (pre)conceptions. In this scenario (the irradiation of food (in this case of strawberries), the statements to be assessed asked whether the object (here: the irradiated strawberries) are considered in this application as …

1. containing (a) many, (b) few, or (c) no radioactive particles; and/or as
2. containing; or if the object (in this case the strawberries)
3. are (a) strongly, (b) weakly, or (c) not at all radioactive.

In order to avoid misunderstandings at this place, no distinction were made between the choice of a (a) or (b) statement, because who will or can scientifically answers the questions if a substance contains (a) a many or (b) a few radioactive particles or (a) a lot or (b) a little (bite of) radiation or if a substance is (a) strongly or (b) weakly radioactive.

The six tasks we constructed in order to investigate our research question focused on three medical and three technical applications of ionizing radiation. Two of the six tasks concentrated on the phenomenon of contamination and four of the six tasks focused attention on the phenomenon of irradiation.

Sample Group

The questionnaire was used at the end of the 2015/2016 school year in ten 10th grade classes from five Berlin schools of different school types (preparatory or non-academic public high school and advance academic public high school). In total, 238 students participated in the 1st survey (M_{age} = 15.49, SD_{age} = 0.59).

4. Results

The data collection was carried during a regular physics lessons, and the data were analysed by means of descriptive analyses (frequency distributions) and by using of dependency analysis methods (e.g. chi-squared test, t-test for independent samples). Table 1 shows the absolute and relative approval frequencies in relation to all statements differentiated according to tasks.

Among other things, the table shows that in five out of six group of tasks between 77.3% and 81.9% of the students agree with the statement (a) "contains a lot of radiation" or (b) "contains little radiation", although these statements are technically incorrect. Only within task [2] do these statements receive slightly less approval, at 55.9%.

Table 1. Absolute and relative agreement frequency with respect to all statements differentiated according to task.

The scientifically correct statements are printed in **bold**.

Task	*Group*	*a*	*b*	*a or b (%)*	*c (%)*	*Missing*
[1] Food Irradiation	1	76	119	195 (81,9)	**32 (13,5)**	11 (4,6)
	2	72	112	184 (77,3)	**43 (18,1)**	11 (4,6)
	3	19	142	161 (67,7)	**66 (27,7)**	11 (4,6)
[2] Paper Thickness Measurement	1	28	108	136 (57,1)	**89 (37,4)**	13 (5,5)
	2	30	103	133 (55,9)	**92 (38,6)**	13 (5,5)
	3	17	88	105 (44,1)	**120 (50,4)**	13 (5,5)
[3] Radioiodine Therapy	1	94	124	**218 (91,6)**	15 (6,3)	5 (2,1)
	2	58	137	195 (81,9)	**38 (16,0)**	5 (2,1)
	3	30	110	**140 (58,8)**	93 (39,1)	5 (2,1)
[4] X-ray Diagnosis	1	41	105	146 (61,4)	**86 (36,1)**	6 (2,5)
	2	62	127	189 (79,4)	**43 (18,1)**	6 (2,5)
	3	15	97	112 (47,1)	**120 (50,4)**	6 (2,5)
[5] Scintigraphy	1	101	105	**206 (86,6)**	26 (10,9)	6 (2,5)
	2	55	135	190 (79,8)	**42 (17,6)**	6 (2,5)
	3	44	122	**166 (69,8)**	66 (27,7)	6 (2,5)
[6] Level Sensor Measurement	1	49	111	160 (67,2)	**67 (28,2)**	11 (4,6)
	2	48	130	178 (74,8)	**49 (20,6)**	11 (4,6)
	3	40	107	147 (61,8)	**80 (33,6)**	11 (4,6)

In the next step of the analysis, cross-tabulations and contingency analyses were used to investigate the connections between the concepts of "something contains radioactive particles" and "something contains radiation," and determine to what extent these ideas are associated with the idea of "something is radioactive".

The results for the task [1] (see Table 2) should serve as an example for the results of all tasks.

Table 2. Cross tabulation with subsequent contingency analysis of the exercise example of food irradiation [1].

The scientifically correct statements are printed in **bold**.

	The strawberries contain radiation.	*The strawberries do not contain radiation.*	***Total***
The strawberries contain radioactive particles.	164	31	195
The strawberries *do not* contain radioactive particles.	20	**12**	32
Total	184	43	227

	The strawberries are radioactive.	The strawberries are *not* radioactive	***Total***
The strawberries contain radioactive particles.	148	47	195
The strawberries *do not* contain radioactive particles.	13	**19**	32
Total	161	66	227

	The strawberries are radioactive.	The strawberries are *not* radioactive	***Total***
The strawberries contain radiation.	143	41	184
The strawberries *do not* contain radiation.	18	**25**	43
Total	161	66	227

For the three variable pairs of task [1] the Pearson chi-square test points to statistically significant relationships ($\chi^2 > 3.85$, df = 1, $p < .05$). However, the values of the phi coefficients of .192, .270 and .309 indicate only weak to medium correlations for the respective tests of the variable pairs (compare to Backhaus et al., 2006). Similar results are also shown by the contingency analyses for the other five tasks (without tabular listing).

5. Discussion and conclusion

The test instrument we developed seems to be fundamentally suited to the systematic investigation of the conceptual relationships between the terms radioactivity, radiation, and radioactive particles. The results of this (pilot) study confirm the findings of previous interview and questionnaire studies, according to which, secondary school students have undifferentiated notions of radiation and radioactive matter.

Our results show that the notions "something contains radioactive particles," "something contains radiation," and "something is radioactive" are connected on a statistically significant level. Analyses of the response patterns suggest that a majority of the surveyed students use the term "something contains radiation" to express that radiation has been (permanently) absorbed.

Since the initial study, we have completed the questionnaire with two additional tasks in the context of contamination. We are currently working on the conception of a lesson sequence and its evaluation, as well as the optimization of the questionnaire and its adaptation for the purpose of international comparative studies.

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Demonstration Experiments in Cognitive Psychology Research Focus

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Abstract

Our contribution focuses on the question: Under which conditions are students in a position to perceive presented experimental phenomena in such a way that these phenomena can best be used throughout the course of their acquisition of knowledge? Two theoretical frameworks serve as the basis for our research: First theory-based impulses were taken from the Gestalt psychology research of Schmidkunz during the 80s and 90s. In addition, innovative research methods such as eye tracking technique were adapted. To answer our research questions, 135 grade 8 students from 6 classes participated in this study. The participants were divided randomly into four groups. The participants of each group were asked to watch carefully one of the four different versions of a video documentation of a typical chemistry experiment on a computer. The chemistry experiments were differentiated with respect of the laws of Gestalt-Psychology. While the students observed their version of the presented experiment, the movements of their gaze and fixation were recorded. Furthermore, after the presentation of the experiment, the students were asked to complete a pre-structured laboratory report. Both, the assessment of the laboratory reports produced by the students as well as the results of the eye-tracking analysis present unexpected findings.

Keywords: Gestalt psychology laws, demonstration experiments, eye tracking analysis, chemistry instruction, chemistry teacher student education

1. Introduction

In the seminar ”Research-based Analysis and Evaluation of Chemistry Classes” (FUB, 2015), students of chemistry education were made familiar with scientific methods of evidence-based reflection in processes of chemistry-related learning and teaching. A project group decided to explore the research question: “Under which conditions are students in a position to perceive presented experimental phenomena in such a way that these phenomena can best be used throughout the course of their acquisition of scientific knowledge?”

2. Theoretical Framework

The first theory-based impulses for this research project were taken from the Gestalt psychology motivated works of Schmidkunz (1983; 1990; 1991; 1992; 2007). In addition to these, a new cognitive psychology method – namely the eye-tracking research technique - was adapted (Rayner, 1992; Havanki & VandenPlas, 2014).

2.1 Works motivated by chemistry education and Gestalt psychology from Schmidkunz

In the 1980s, Schmidkunz had already proved that elements from Gestalt psychology theory (Wertheimer, 1985) [1925], Fitzek, 2014) could contribute to the explanation of chemistry-related learning processes with his case studies oriented towards chemistry education. In the course of his studies, Schmidkunz looked at various laws of Gestalt psychology; among others the law of continuity (2007; cf. Treatment 1), the law of figure-ground contrast (1991; cf. here Treatment 2), and the law of symmetry (1992; cf. here: Treatment 3). The results of his studies suggest that the disregard of the principles described in the Gestalt laws during the presentation of chemistry demonstration experiments leads to impairment of the learning success on the part of the pupils involved - at least in comparison to the learning growth in the classes to which the optimum possible experimental arrangement (here: Treatment 4) was presented (Schmidkunz, 1983, 1990, 1991, 1992, 1997, 2007). The experimental design which avoided the violation of the three laws (treatments) mentioned, and thus corresponded to the "state-of-the-art" didactic example of recommendable experimental practice, served as a control variant (control group: state of the art; see fig. 1 and Image 4 in fig. 2).

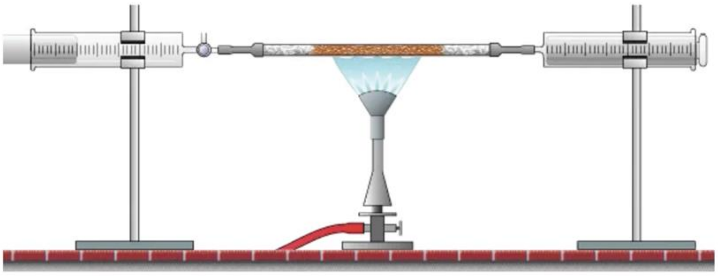

Figure 1. Experimental apparatus for the quantitative determination of the oxygen content in ambient air (Source: Lehrwerk Online - Prisma Chemie, Ernst Klett Verlag GmbH. URL: https://static.klett.de/software/shockwave/prisma_chemie_ol/pc_pcni02an202/index.html)

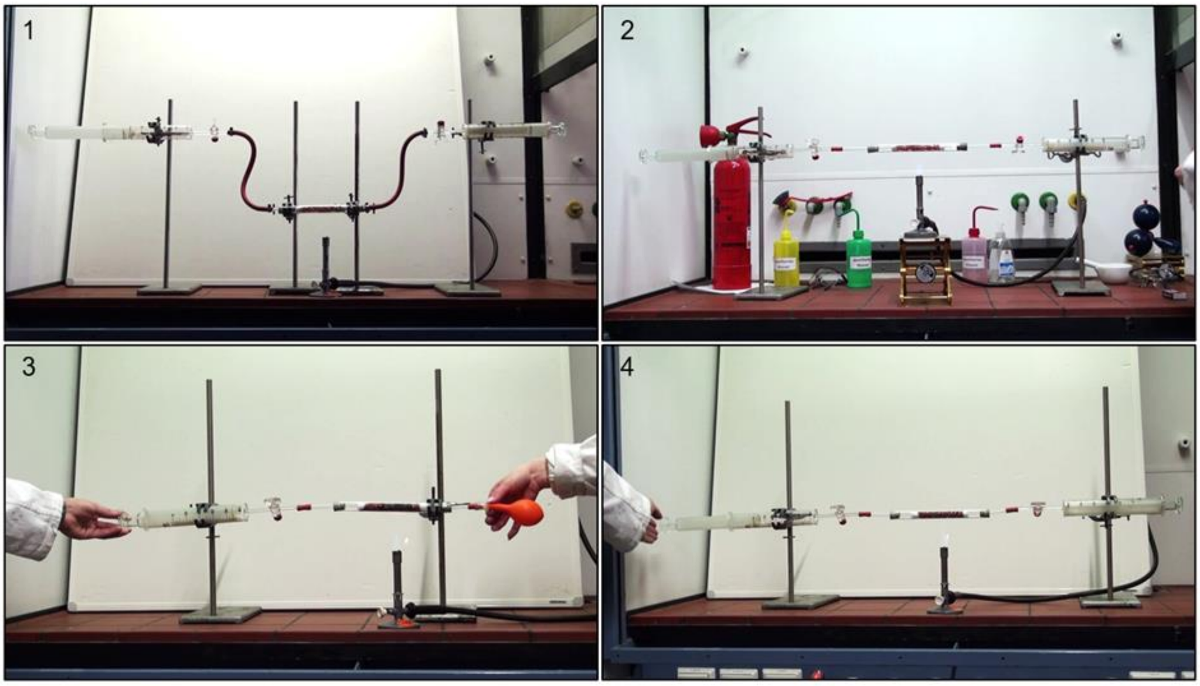

Figure 2. Four variants of the video-documented demonstration experiment. Image 1: Violation of the law of the continuous straight line (Treatment Group 1); Image 2: Violation of the figure-ground contrast law (Treatment Group 2); Image 3: Violation of the law of symmetry (Treatment Group 3); Image 4: "State of the Art" (Treatment Group 4, Control Group)

2.2 Subject-specific teaching and cognitive psychology motivated works from the field of eye-tracking research

In the field of neuropsychology and cognitive psychology, studies are increasingly being conducted by means of the eye tracking method (Ravner, 1992; 1998; Auer et al., 2005; Havanki & VandenPlas, 2014). With the help of special software and hardware, visual fixations are recorded in the millisecond range allowing the reconstruction and visualization of the corresponding movements of gaze. In this way, attention and concentration as well as perception processes can be quantified. This in turn allows conclusions to be drawn about the triggered cognitive processes and the learning of selected facts. For some time, eye-tracking studies have increasingly found their way into studies motivated by science education and specifically chemistry education (Gnoyke, 1997; Fäth, Watzka & Girwidz, 2013; Hofmann, 2011; Richtberg & Girwidz, 2013; Rohde et al., 2013; 2015).

2.3 Research Question

Following the two research strains outlined above, the project group addressed the following research questions:

1. To what extent can the findings presented by Schmidkunz be replicated?
2. What causes for the successful and/or unsuccessful chemistry-related learning can be derived from the results of our eye-tracking analysis?

3. Method

In order to answer our research questions, school classes from the 8th grade (with their teachers) were invited to a project day in the student-laboratory of the Division of Chemistry Education of FU Berlin. The project day was planned and conducted by the authors. Out of the classes that took part in the project day, four groups were formed by random sampling, each of which in turn was randomly assigned to one of the four experimental treatments (see above).

The students were familiarized with the experimental setting of the eye-tracking laboratory in the workspace of the Neuropsychology Division of FU Berlin. Afterwards, one of the four taped chemistry experiments was played on the computer. During the introduction, students were asked to observe the experiment carefully in order to be able to complete a pre-structured lab report at the end.

The lab reports were evaluated according to specially developed evaluation criteria. In the course of this grading process, cumulative and relative solution frequencies were calculated. As long as the necessary (sub)sample size was reached, a group-specific statistical significance test was performed (Eid, Gollwitzer & Schmitt, 2015) and the obtained results were compared with those from the Schmidkunz studies.

In this regard, we expected (in agreement with Schmidkunz's studies) that the students which could recall the experimental procedure that followed the Gestalt laws (Treatment Group 3), compared to the other three treatment groups would achieve the best comparable results with regard to recording the experiment (see research question #1). In addition, eye fixations and movements of the subjects were recorded and analysed using eye-tracking software and hardware during the four different sets of experiments (see fig. 3 and 4).

Figure 3. Basic equipment setup of an eye tracking laboratory space

Figure 4. Workspace in the eye-tracking laboratory of the FU Berlin

Theory-compliant results from the analysed lab reports as well as those which – in contrast to our expectations – deviated from Schmidkunz's findings, were examined and discussed in detail, using the eye tracking findings.

With regard to our eye tracking analyses, we expect (no) statistically significant deviations that indicate differences in perception and/or attention differences when considering the four different experimental demonstrations.

4. Results

The **sample** of our study consisted of 135 pupils from the 8th year, which came out of six classes from two different schools. The students were assigned to the four experimental sub-samples (treatment groups) and distributed as follows: Treatment #1 (solid line): N1=34 / Treatment #2 (basic figure contrast): N2=33 / Treatment #3 (standard arrangement): N3=32 / Treatment #4 (Symmetry): N4=36.

Table 1. Results from the analyses of the pupils‘ completed (pre-structured) lab reports – differentiated according to treatment groups.

Treatment	N	Sketch Experiment Setup	Describe Experiment Procedure	Note Obser-vations	Explain Observatio ns	Answer Research Question	**Average Overall Score**
#1: Continuity	34	10,26	2,26	1,88	0,62	0,26	15,29
#2: Contrast	33	9,06	1,91	1,55	0,67	0,27	13,45
#3: Symmetry	36	10,19	1,67	1,28	0,08	0,08	13,31
#4: Standard	32	8,53	1,63	1,72	0,69	0,22	12,78
∑	**135**	**14**	**5**	**6**	**7**	**6**	**38**

The **results** of the analysis of the pre-structured test protocols prepared by the students can be found in Table 1, differentiated according to the experimentally different sub-samples and treatment settings.
Selected findings from the eye tracking analysis – differentiated by the four treatment groups – are summarized in Table 2.

Table 2. Selected findings (mean dwell time) from the eye tracking analyses - differentiated by treatment group and observation sector.

Treatment	N	Gas Syringe (left)	Reaction Tube	Gas Syringe (or Object) (right)	Bunsen Burner	Neutral Sector	Distracting Sector	∑ ***(off)***	∑ **(on)**
#1: Continuity	34	29,6	28,7	21,6	2,1	*17,9*	*1,1*	***19,0***	**82,0**
#2: Contrast	33	19,3	30,0	19,0	3,3	*28,0*	*6,5*	***34,5***	**71,8**
#3: Symmetry	36	36,1	11,3	29,9	1,9	*20,6*	*/*	***20,6***	**79,2**

#4: Standard	32	26,7	29,8	19,1	4,1	*20,2*	/	***20,2***	**79,7**
∑ / Mean	**135**								

4. Interpretation

The performance-based findings from the Schmidkunz case studies (see above) could not be replicated in our investigation. This may be due to the various experiment designs and evaluation processes as well as the different sample groups. The results of the analyses related to content and learning growth, based on the pre-structured lab reports of the pupils, suggest that the pupils involved were evidently capable of compensating for shortcoming in the presentation of the demonstration experiments. Contrary to the theory-based expectations, the best results were not achieved by the treatment group to which the supposedly best trial demonstration was presented (see tab. 1). – The findings of our eye-tracking analyses (see tab. 2) suggest that the planned deviations from the Gestalt psychology laws were not as compelling as the previous case studies from Schmidkunz would have us assume.

5. Discussion and conclusion

Overall, the design of our pilot study proved itself useful. Despite being demanding on time and organization, eye-tracking studies provide numerous interesting, scientifically valid and subject-relevant insights into the learning of scientific material; further studies – even more strongly and systematically differentiated – should therefore be taken up promptly.

6. Acknowledgements

A very special thank you goes out to Dr. Sascha Tamm (from the eye tracking laboratory in the Department of Neuropsychology at the FU Berlin) for his support throughout our survey and evaluation of the eye tracking data. We would also like to thank all the students who participated and their teachers who supported us during our tests. Furthermore, we sincerely thank Dr. Sabine Streller (from the Chemistry Education Department of the FU Berlin), for her support in the planning and implementation of the project days for the participating school classes.

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Alignment between teachers' practices and political intentions in the CONTEXT of a reformed modelling-oriented science curriculum in Danish lower secondary school

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Abstract

Danish lower secondary science education was reformed with a new curriculum commencing in the school year 2015-2016. The theoretical and political intentions behind the new curriculum include substantial changes to how teachers should address models and modelling (MoMo) in their practice. The purpose of this study is to analyse the alignment between the intentions and arguments for integrating MoMo into science education, on the one hand, and teachers' practices and rationales for integrating MoMo into their teaching practice, on the other. Data were generated by means of semi-structured interviews (n=6; among three pairs of teachers). Our findings suggest that: (1) teachers' practices and rationales for integrating MoMo into their teaching were characterized by a product-oriented approach focusing on MoMo as a mean to facilitate learning of subject-specific knowledge; (2) teachers prioritize engaging students in MoMo activities for descriptive rather than predictive purposes; (3) the dynamic process of designing, evaluating and revising models based on students' own inquiry only plays a minor role; and (4) a content-heavy curriculum and multiple-choice exam are counterproductive to teachers' efforts to undertake a more competence-oriented approach to MoMo. Finally, based on the results, we make a number of suggestions for how to enhance teachers' possibilities of teaching for modelling-competence.

Keywords: modelling, modelling competence, models, science curriculum reform, science teachers' practices and rationales, scientific practice

1. Background and research questions

Models play a central role in science. It could even be argued that science is first and foremost a ‘modelling enterprise’; that modelling thus ought to be the core scientific practice in school science; and that this would facilitate the use of other scientific practices in teaching (Lehrer & Schauble, 2015). In addition, models and processes of modelling are also important for science teaching because models and modelling (MoMo) can facilitate the learning of science concepts, develop the capacity to engage in scientific reasoning processes and inquiry, and strengthen awareness of how science works (Gilbert & Justi, 2016).

Furthermore, it is argued that the dominant enactment of scientific inquiry in classrooms as a self-contained step-by-step procedure, combined with a teaching practice focused on content knowledge no longer corresponds to the way science is actually practiced (Lehrer & Schauble, 2015; Passmore, Gouvea & Giere, 2014). Indeed, the increasing efforts to engage students in a wide range of scientific practices also represent a shift in the key learning goals of science education, from students acquiring knowledge to students acquiring and *using* that knowledge (Berland et al., 2016). Along the same lines, the trend towards scientific practices taking an increasingly prominent role in science education curricula is often embedded in a wider shift towards competence-oriented curricula (Ananiadou & Claro, 2009).

In 2015-2016, a new national science curriculum for lower secondary education (grades 7 to 9) was initiated in Denmark. One significant change relates to the teaching approach. The new curriculum is guided by four main competences (modelling, inquiry, communication, and ‘perspectivation’) that are transversal to the three science disciplines – physics/chemistry, geography and biology.

Furthermore, the new curriculum contains significant changes related to the characteristics of *what* and *how* to address models in teaching. Most importantly, there is a change from largely approaching models as a product of knowledge used for visualization and explanation - to a more process-oriented approach focusing on students’ application of different elements of knowledge to different aspects of modelling practices, i.e. evaluating, comparing and selecting between multiple models, designing and revising.

Likewise, the new curriculum reflects a shift from a hegemonic view of the scientific method (i.e. field and laboratory investigations as the main inquiry practice) to a broader view involving modelling (Nielsen, 2018). The introduction of so many major changes is a demanding task for teachers.

Indeed, recent science education research, has demonstrated that how teachers enact MoMo in their teaching and their rationale in this regard, is a primary factor in whether the potential benefits of working with MoMo are realized or not (Krell & Krüger, 2016; Miller & Kastens, 2018; Nielsen & Nielsen, 2019, 2021). Likewise, teachers are challenged in how to make the concept of competence operational for teaching and assessment—a challenge that seems to be a general trend in the shift towards a competence-oriented curriculum (Dolin, Nielsen & Tidemand, 2017).

Consequently, our research questions guiding this study were:
What characterises science teachers' perceived practices and rationales for integrating MoMo into their teaching practice? – and how is this aligned with a competence-oriented teaching approach to MoMo?

2. Theoretical framework

While the noun 'model' could be perceived as the product of a scientific process, the verb 'modelling' can be viewed as the conducting of a scientific process or practice that involves: (a) developing models by embodying key aspects of theory and data into a model; (b) evaluating models; (c) revising models to accommodate new theoretical ideas or empirical findings; and (d) using models to predict and explain the world (Baek & Schwarz, 2015).

Applying the concepts of competence and action to students' engagement with MoMo implies a reflective and applied use of different aspects of knowledge and practices purposefully directed at solving a subject-specific problem or task in different situations (Nielsen & Nielsen, 2019).

In our previous work, we argue that the different *aspects of modelling practice* provide an *action* dimension in teaching around students' engagement with the modelling process, and therefore ought to be at the heart of a competence-oriented approach to models and modelling

(Nielsen & Nielsen, 2019). In the same work, we argue that using models descriptively as a means of describing, explaining or communicating a phenomenon is not sufficient in a competence-oriented teaching. Indeed, a competence-oriented teaching ought to include using models predictively as tools for inquiry, problem-solving, sensemaking or as hypothetical entities representing different ideas of the referent.

3. Research methods

We examined the research question through the use of explorative semi-structured interviews (Kvale, 2006) with teachers (n = 6; in three pairs).

The teachers participating were employed at three schools, located in urban and suburban areas of the Capital Region of Denmark. The teachers had different teaching experiences (from two to over 20 years). All teachers taught physics/chemistry, all except one taught biology, and three taught geography as well. In the presentations of the data, each teacher is given an individual code in the form of a letter (A, B, C). In addition, the teachers are identified by school, by a number (1 to 3).

The interviews were designed as reflection sessions. To facilitate the discussion and teachers' reflection, the interviewer placed a range of labels with pre-formulated statements on a table and these were regularly picked up during the sessions. The statements were formulated as suggestions on how and why to address MoMo and engage students in different kinds of modelling practices in their teaching. The teachers were asked to elaborate on how the statements reflected the use and function of MoMo in their current teaching. In addition, the teachers designed a poster that was placed on the table during the session and intended to illustrate their ranking of the statements with regard to frequency of use in their current teaching.

The transcribed interviews were analysed using Braun and Clarke's (2006) inductive six-phased tool for thematic analysis with the support of NVivo software. The aim of the analysis was to find crosscutting, consistent and prominent themes that emerged from the teachers' talk.

4. Results

The findings are ordered in two main parts: (1) teachers' perceived ways of engaging students in MoMo activities, and (2) teachers' rationales for integrating MoMo into their teaching.

Teachers' perceived ways of engaging students in MoMo activities

Teachers' perceived ways of engaging students in MoMo activities reflected an approach by which MoMo activities were treated as the product *of* a scientific process rather than part of a scientific process. This approach manifested itself in in several ways.

First, our data indicate that the most common MoMo practice for all teachers was students' use of models for the more product-oriented aspects of practices also identified in the former curriculum (i.e. for description, communication and explanation). In contrast, the more process-oriented MoMo practices such as prediction, selection, evaluation and design were used to a lesser extent. In this way our data reflect a teaching that mainly provides students with opportunities to engage in the descriptive functions of modelling and only offered minor prospects for using models for predictive and problem-solving purposes.

Second, the product-oriented approach was reflected in the rather restricted way in which students were involved in modelling as scientific practice. For instance, the dynamic process of designing, evaluating and revising models based on students' own inquiries and data played only a minor role in teachers' practices. Particularly, the process of revising models as described in the new curriculum (e.g. testing a model against reality, revising models to fit the referent) had no or a very limited role in teachers' practice. For example, one teacher asserted that: *"I never do that…I don't identify that practice [revising] at all in my teaching"* (E3). The data, however, also reveal an interesting point with respect to students' involvement in inquiries. It emerged that while the teachers did not prioritize the scientific process with regard to modelling, they did have another approach to laboratory work and field work. Not only was this kind of activity enacted and perceived as an important part of their teaching but the process was considered a central element in this regard. In the same vein, our findings indicate that teachers found it both manageable and meaningful to use what they called 'model experiments', 'table micro worlds' and to engage students in laboratory work illustrating sub-processes in 2D cycle models. Moreover, some of these modelling activities went beyond a solely descriptive use.

Third, when process-oriented aspects of MoMo practice were enacted in classrooms, they were often enacted in a product-oriented fashion. The following extract is illustrative of the way the teachers generally enacted the design aspect of practice: "*I want the students to look at illustrations* *and read the text in the book […] then they make a small stop-motion-movie with plasticine showing the protein synthesis […] in this way they will build a dynamic model*" (D1).

In this manner, our data suggest that the teachers mainly implement the practice of design as the construction of different kinds of model based on accepted models or knowledge. In this fashion, students' design of models is reduced to replications of what is already known or solely changing the kind of model.

Teachers' rationales for integrating MoMo into their teaching

Our data show that models played an important and valued role in all the participating teachers' teaching. All teachers, however, primarily justified engaging students in MoMo activities by referring to models as key teaching and learning artefacts that facilitate students' learning of subject-specific content knowledge. Furthermore, meta-knowledge of MoMo was not perceived as an important part of the teaching. Likewise, models were mainly viewed as a result of *the* scientific method and not as a scientific method in itself.

Moreover, our data suggest that the priority given by teachers to content knowledge is related to the limited time that is available for teaching. This point is illustrated by this exemplary quote: "*It's not realistic to improve a model and make a new one… It's not like a writing process back and forth… rewriting, we don't have enough time for details like that*" (C1).

The data also suggest that the heavy content knowledge load in the curriculum, as well as in the external assessment system, seemed to work against a teaching that prioritizes the more process-oriented practices over 'root performance':

"*I feel I must go through all the subjects in the text book to make sure we cover all the curriculum goals* [….] *It's a typical final exam question* [i.e. in a multiple-choice test mainly testing content knowledge,] *that's what I teach them, they should all be able to pass the exam*" (D1).

In other words, the data suggest that the teachers still feel there is a need to use their time to teach students the subject-specific content knowledge even though the intentions of the new curriculum are to change teaching towards a more competence-oriented approach.

5. Discussion

The participating teachers' product-oriented approach to modelling implies a teaching practice in which there is a focus on subject-specific content knowledge. It is difficult to see how this type of practice is competence-oriented. Indeed, according to Kind and Osborne (2017), a product-oriented approach will mainly provide students with lower-order cognitive challenges. This knowledge generation is considered passive and is not very fruitful at contributing to competence-oriented teaching where the emphasis is on reflection and on solving a specific problem or task. In addition, when models are solely introduced into the classroom as representations of what is known rather than as active tools for inquiry, students' prospects for engagement in applied scientific practice and problem-solving will be reduced (Passmore et al., 2014). From this perspective, the participating teachers' approach to MoMo also reflects former approaches to science education dominated by content knowledge of the models without developing an understanding of the processes that led to the knowledge embedded in the model, or the purposes, value and utilisations of MoMo in science – all important aspects of teaching for modelling competence (Nielsen & Nielsen, 2019).

In this way, our data suggest a lack of alignment between teachers' treatment of modelling, and the political intentions and theory of what to include in a modelling competence-oriented teaching. Our results thus mirror previous findings with regard to teachers' low priority given to the process of modelling compared to their prioritization of the content knowledge of the models (Miller & Kastens, 2018).

6. Implications

Whereas our findings show critical areas for the continued development of teachers practice in realising the curricula intentions, our results also point to potential actions that could be taken to develop teachers´ possibilities in this regard.

Our findings suggest that teachers had experience with involving their students in 'model experiments' and 'table micro worlds'. We believe that if teachers could identify elements in their existing practice that could be extended this would be more manageable, as opposed to enacting entirely new aspects of modelling that do not resemble their existing practice at all. In this light and inspired by Windschitl, Thompson and Braatens’ (2008) “Model-Based Inquiry” framework, we suggest that teachers’ descriptive approach to MoMo as well as restricted use of modelling as scientific practice could be expanded by combining MoMo with teachers’ valued and well-established practice around inquiry related to students´ field and laboratory work.

This could, for instance, be undertaken through students’:

- use of established models to inform their questions and hypotheses to be tested;
- crafting of testable predictions based on models representing students’ own ideas about a phenomenon;
- crafting of testable predictions based on established models representing core causal explanations related to the curriculum content knowledge;
- empirically testing of sub-processes in models against own data form observations or experiments, field- or laboratory observations;
- evaluating and revising their own ‘table models’ or tentative 2D models based on empirical data, new theoretical considerations, advanced learning or new purposes;
- considerations of *what* and *how* to represent their data using different types of model; and
- students’ comparing and evaluating each other’s models representing the same referent but based on different kinds of data or different tasks to be solved.

Such efforts would not only add to a more predictive and process-oriented approach to MoMo but would also raise awareness among students of how models are used as an inquiry tool in science to make sense of the world. In addition, this kind of teaching would contribute to students´ understanding of the interaction between subject-specific knowledge, data and models. Furthermore, the use of models as representing content knowledge could help students to connect laboratory work with theoretical knowledge and, at the same time, enrich the way in which teachers perceive the scientific method. Moreover, the use of models as artefacts for inquiry would go beyond the conventional use of models in science teaching for describing and explaining by representing important aspects of modelling as a scientific practice (Baek & Schwarz, 2015). Likewise, our suggested approach has the potential to facilitate students’ development of subject-specific knowledge, modelling practices, and meta-knowledge about MoMo by intertwining all three elements in an applied use targeted at a specific task (Nielsen & Nielsen, 2021).

Aside from our suggestion for moving forward by combining modelling with the well-established practice around laboratory and field work, our findings also suggest a wide range of other potential steps that can be taken: Take advantage of, and extend, teachers' established modelling practice by highlighting models' predictive functions and the dynamic process of designing, evaluating, and revising models to make it more process-oriented; Elaborate on how to select, evaluate and revise models based on the purpose or task; Rework the curriculum to match the number of teaching hours (or *vice versa*); and, Ensure better alignment between external assessments and curriculum intentions.

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Science culture and continuing training of science teachers

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Abstract

This study investigates a model for vocational training for science teachers, which is conducted as an interaction between theoretical training at the teacher education institution and practice by the science teacher at the local school. The interaction was planned to secure optimal transfer, but the results indicate, that vocational training of science teachers demands extra effort in relating school practice to the educational context, compared to teachers from other subjects, trained by a similar model. Analysis from quantitative and qualitative data lead to the conclusion that the team of science colleagues in the local school in many cases has failed to support the teacher in vocational training. The study discusses the concept of science culture as being applicable for explaining the results.

Keywords: in-service science teacher training, transfer, science team, science culture

1. Introduktion

UC Nordjylland, like other UC' s, has trained science teachers in 2016-20, so that they have acquired formal teaching competence in one or more of the science subjects. The training took place under the same framework conditions and according to the same template as teachers who have been trained in other subjects in primary and lower secondary school. The framework includes a supportive effort from the school's management and the collegial science team. Evaluation of the participants' assessment of the course has taken place. The evaluation has been carried out as a questionnaire survey and on the other hand this research project has used the quantitative data for subsequent interviews of selected science teams at participating schools. The problem of research project:

To what extent has the North Jutland educational model promoted the professional and pedagogical competence development of science teachers compared to other professional groups and how has the concept of science culture been integrated into the course model?

2. Theoretical framework

The course is inspired by sociocultural theory, where a teacher's competence development is considered as the result of a social construction, based on dialogue, reflection and study together with teachers and colleagues (Desimone, 2009). The strength and relevance of the construction is enhanced by establishing a link between the training and the teacher's daily practice. Continuing education of experienced teachers should involve participants in the choice of content in relation to perceived needs in the teacher's practice, and the link between training and practice is optimal through the teacher's participation in teamwork as an integral part of the training course. The supporting team collaboration is important for the teacher's competence development both before and during the course, and implementation of the learned is ensured by maintaining the supporting team collaboration after completion of the formal training programme (Sunesen, 2016).

In order to ensure transfer (Wahlgren &Aarkrog, 2012) between education and practice, the teacher must be given the opportunity to translation of the teaching content of the programme, i.e. to be able to transform the didactical and scientific content of the learning context for teaching in the practical context with the characteristics that characterize it. The organisation of the training, including the supporting team collaboration, should provide strategies for the teacher to test new teaching practices at the school, including inquiry based science teaching, interdisciplinary teaching, etc.

The research project has been particularly interested in examining whether differences can be observed between science teachers' experience of the value of the programme and the experiences of other groups of teachers. In addition to the content of the subjects, the practice of science teachers is characterized by both a physical and resource framework for their work and the working methods of the subjects. Something that can be described through a concept of professional culture. The school as an organization and the practice of science culture by the science team (Sillasen, Sørensen &Valero, 2010) must be integrated by the teacher during the programme, and science culture should therefore be included in the organisation of the programme.

3. Research methods

The study of quantitative data bases is used for a combination of survey methods according to a mixed-methods approach (Creswell &Clark, 2007), where data from the survey inspired a more in-depth qualitative study. The study was based on a continuous evaluation of the North Jutland project, which was carried out by UCN in collaboration with the Danish Evaluation Institute. This evaluation was not subject-specific, but was widely aimed at teachers from all disciplines, and therefore did not identify any challenges for the model associated with specific teaching subjects. Examination of data were divided into two parts. First, the questionnaire-based survey (SurveyXact) of the competence development course, where the answers of science teachers were isolated and compared with the residual population of teachers from other subjects. In this study, the questionnaire for the population of science teachers was supplemented by a number of questions asking specifically about the practice development of science teachers and the schools' benefits from the course. This is in order to identify particularly significant factors, which formed the basis for more in-depth focus group interviews by science teacher teams. This first subprocess was completed in the fall of 2018.

The second subprocess was inspired by design based research (Christensen et al., 2012), where the research process is iterative and context-dependent. The level of cooperation and development of teachers and schools will be unique and the process adapted to the situation. This subprocess was completed in spring 2019, where transcripts from semi-structured focus group interviews (Kvale &brinkmann, 2015) were analyzed based on key theories about transfer and cooperative learning. The analysis was carried out on the basis of code theory (Olsen, 2001), where the codes are defined in advance to some extent (deductive coding) based on the research questions, but where the study of the data material has also given rise to the identification of new codes (inductive coding). For the focus group interviews, an interview template was constructed based on a comparison of questionnaire responses (SurveyXact) sent to teachers 4 months after the completion of their competence lifting course (October 2018), where they have returned to general school practice. The population of science teachers (teachers who have followed courses in either biology, geography, physics/chemistry or nature/technology) who had completed this questionnaire was identified (N = 29) and isolated from the rest of the population of teachers in courses in 2017/18 who had answered the same chart.

4. Results

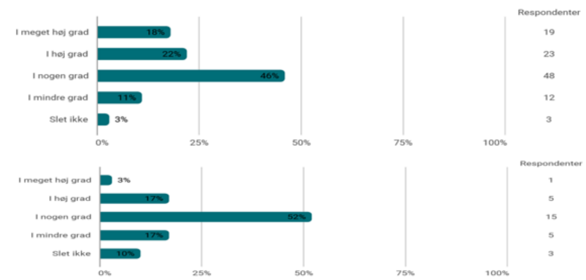
When the responses of participants in the science classes was pulled out of the total population in the above mentioned subprocess 1, two comparable populations appeared – science teachers and the residual group of teachers from all other subjects. A review of responses showed that the population of science teachers (biology, geography, physics/chemistry and nature/technology) generally were less positive about their own competence lifting process than the residual population of teachers from all other subjects.

Example:

To what extent do you agree/disagree with the following statements regarding the practical applicability of the course: - Following my course of study, I have changed my teaching practice

Rest population

Science teachers



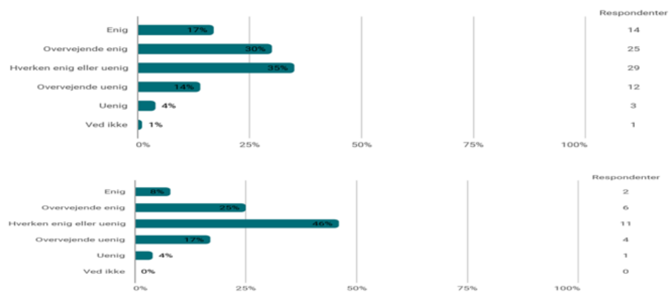
- Here, almost twice as many science teachers (27% vs. 14%) answer "to a lesser extent" or "not at all", while half as many science teachers (20% vs. 40%) have responded to a very large or large extent.

(Elmose & Wogensen, 2019)

Indicate to what extent you agree/disagree in the following statement regarding the importance of the competence development process at UCN for your work in the subject team – We share more experience from the teaching with each other.

Rest population

Science teachers



- 50% of the rest population here responds "agree" or "basically agree", whereas 30% of science teachers.

(*ibid*.)

The interviews from subprocess 2 revealed possible reasons by the science teachers to the differences between the two populations, which the survey did not capture.

Interviewer: *Why has the program not contributed to more collaboration in the team?*

Respondents (each line shift indicates a new respondent):
I do not necessarily think that it is the program as such that has failed, because it depends on whether you have had good team cooperation in advance when you start the course.
I'm thinking it's the structure of the school teams – which team you belong to.
For example, a colleague and I on the course had the 9th graders together in a project day on Wednesdays, where we were always 2 or 3 teachers together around the classes with joint planning and where we could also meet during the day and talk about how things were going. That provided a great cooperation.

But in terms of biology, I'm the only biology teacher in the 9th year, so talking about planning the teaching will not happen, but it has nothing to do with the course, it has something to do with the school. (ibid.)

The responses can be analyzed by the concept of science culture (Sølberg, 2006; Sillasen, Sørensen &Valero, 2010), which includes 3 major elements in the pedagogical practice of science teachers. Practical resources at the school such as laboratory and outdoor facilities form possibilities and boundaries. The existing science education practice in the school, which the new science teacher can be inspired by and socialized into and thirdly organizational conditions at the school, such as how the lessons are organized in the weekly schedule and the amount and sort of cooperation between science teachers also have big impact on the practice.
The analysis showed that the support organization behind the individual teacher's competency boost had not functioned as expected – and in some cases had not existed. In this way, the academic and professional dialogue and reflection have lacked as a basis for the teacher's professional and practice development.

We were one of the schools, which lacked a science team from the start of the course. It appeared – a little reluctantly – late in the spring semester (the course started in august in the fall semester, authors comment). *The prerequisite for formation of our science team was a change of structure for subject teamwork in our school, so in that perspective has the education not contributed to the teaching practice.*(Elmose & Wogensen, 2019)

Moreover, there are indications that in some cases the training did not ensure transfers between the context of the training and the practice context, so that the teacher had to abstract unnecessarily much in order to create meaning and relevance to practice – which has been called *far transfer* (Aarkrog, 2011).

I had to implement it (the content, authors comment) *in two different ways. First, I copied some of what my instructor did, and the I found out what didn´t work when I was confronted with a 7th grade class. Then I changed the plan for the next session, and this functioned better.* (Elmose & Wogensen, 2019)

Here the teacher suggests that course had not included the practice conditions in the particular7th grade.

The science teachers in the interview generally justified the less positive experience of the educational outcome on the grounds that there are special organisational conditions for the science subjects in school practice that the course had not taken sufficient account of. This applies, for example, to conditions for science teachers in the 7th, 8th and 9th grades (lower secondary), who are expected to engage in compulsary interdisciplinary cooperation in the science subjects.

The most important new development in the science subjects is the joint exam in the 9th grade between the three science subjects and this news have we used too little effort on in the course. This initiative we all need to develop competencies to meet, so we can go home and develop our practice, and this has been neglected. (ibid.)

The teachers also expressed a balance between disciplinary theory and practice in the laboratory and in the field, which was shifted too much in favor of the disciplinary theory.

I would have liked more time to be spent on long-term experiments, which there is usually no time to do in school teaching. Instead of reviewing the theory that the teacher could expect to be prepared from home, you could reduce the review and spend more time on the practical. (ibid.)

There are thus several indications of lack of inclusion of important aspects of science culture in the model of in-service teacher education. Once more the difference between science teachers involved in a professional development and teachers from other subjects is illustrated by this remark:

I think it is more demanding to change practice for science teachers than for other subject teachers. Because of the framework – physically and economically. It is great to try out all the new equipment at the university college, but we can not afford it in the school.
If the geography teacher after the course returns to the same old ragged maps and globes, practice probably won´t change much. (ibid.)

Interviewer: What do you mean by subject identity in science?
I don't think I can feel the culture, but you wish it were there. I don't think it's most prevalent in our school.
One would like us to take some more science initiatives. I think it drowns in too many other tasks. As a teaching group, I think we feel like science teachers. But getting it out to the students so that we could become a more science profile school and they could engage more in it, I don't think so.

At the program, the very concept of science identity or culture was not addressed, but there was argued for strengthening the science team collaboration

5. Discussion and conclusion

Therefore, the answer to the problem formulation's question about the extent to which the model has promoted the development of the competence of science teachers must be less so than teachers from other subject groups. According to the above, part of the explanation may be the way the subjects and subject teams are organized in the schools. All respondents in the interview have met the objectives of the training and have passed their exams, but the question is whether the training has contributed to changes in practice, when transfers have not been used systematically by either the educational institution or the school as an organization to mediate the development of teachers' competences.
Science culture as a didactical and empirical concept suggests valuable perspectives to investigate the way science is perceived, practiced and distributed between teachers in a team and between teachers and students.
The answer to the question of how science culture has been integrated into the course must be, that science culture only implicitly has been implemented and not explicitly integrated.
It therefore seems relevant for providers, purchasers and students alike to ensure the ability of different continuing training models to meet the needs of teachers in order to acquire the science

culture in order to develop a continuing training model that better accommodates transfers between education and teacher practice. So far very little international research on teachers´ development of science culture has been published. There has been some research on the concept of science capital development (King & Nomikou, 2018; King, Nomikou, Archer & Regan, 2015) and the two concepts seem to overlap. Most of the research investigates the efforts of the teachers to develop science capital among students, but what should characterize the science culture/capital of a teacher in order for this teacher to develop the science culture/capital of the students?

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In-service and Preservice Teachers' Conceptions of Nature of Science

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Abstract

Nature of science (NOS) is an important component of scientific literacy. Science teachers can have naïve conceptions and misconceptions of NOS which is detrimental to their students' science learning. The aim of research was to examine in-service and preservice science and mathematics teachers' understanding of NOS conceptions using open-ended VNOS-B instrument online anonymously. 13 in-service teachers from Finland, Norway, and Russia and 21 preservice teachers from Finland participated in the research which was organized in the context of the international *BeTech!* project seminar in Finland in September 2019. Qualitative analysis of data from the questionnaire indicated that the conceptions of NOS were adequate in two aspects of NOS: tentative nature of scientific knowledge and creativity of scientists. Understanding the distinction between scientific theory and law, and theory-laden nature of scientific knowledge was interpreted naïve in both groups. The results of in-service and preservice teachers were very similar showing that the practice of teaching profession does not implicitly improve teacher's understanding of NOS. In-service and preservice training using explicit reflective instruction is necessary to raise the awareness of the importance to teach NOS at schools, and to increase in-service and preservice teachers' pedagogical content knowledge with respect to teaching NOS.

Keywords: Nature of science, qualitative research, VNOS-B, in-service teachers, preservice teachers

1. Introduction

Nature of science [NOS] is considered as an essential component of scientific literacy in science education. Scientific literacy requires a wider understanding of science than what is attainable by focusing only on the products of science (e.g. facts, laws, and theories). John Miller (1983) divides scientific literacy into three aspects of what is needed to have understanding of a) the norms and methods of science (NOS and scientific inquiry [SI]), b) key scientific terms and concepts, and c) the impact of science and technology on society. Today scientific literacy is often connected with global problems of ecological, social, and economic sustainability such as climate change (see e.g. Hodson 2003; Holbrook 2009). This study examines the understanding of NOS aspects of those in-service science and mathematics teachers whose students participated in the international seminar in Oulu, Finland, organized by the Kolarctic Cross-Border Collaboration [CBC] project (KO 2071) *Development of common approaches to involve youth into science and technical sphere – BeTech!*. All the participating preservice science and mathematics teachers were from Finland because many of them were mentoring and assisting students in the activities of the project.

NOS is often defined as "the epistemology of science, science as a way of knowing, or the values and beliefs inherent to scientific knowledge and its development" (Lederman, 2007, p. 833). Lederman, Antink & Bartos (2014) have discussed what is an appropriate level of understanding of NOS in K-12 science classrooms: Scientific knowledge is subject to change (tentative), based on and/or derived from observations of the natural world, subjective, inevitably involves human inference, imagination and creativity (invention of explanation), and it is socially and culturally embedded. Scientific knowledge is obtained through observing natural phenomena that are directly accessible to senses, or extensions of the senses, or through inference about phenomena that are not directly accessible to senses (i.e. atoms, genes, gravity, etc.). Many individuals are known to hold an elementary, hierarchical view of the relationship between theories and laws where laws have a higher status than theories. Theories and laws are different kinds of knowledge which cannot develop into the other: Laws are statements or descriptions of the relationships among observable phenomena and theories are inferred explanations for observable phenomena. Scientific theories direct investigations, produce new research problems, and explain observations (Lederman et al., 2014).

Research has shown that science teachers' understanding of NOS is typically inadequate (e.g. Dogan & Abd-El-Khalick, 2008). According to Glough and Olsen (2012), the NOS misconceptions held by science teachers impact their students' attitudes towards science and understanding of science content. They argued that firstly, understanding of NOS helped students to understand and work from the assumptions that underlie scientific knowledge; secondly, understanding of NOS raised student's interest in science thus improving the motivation to learn science content; thirdly, the construction and reconstruction of ideas became clear helping students to understand that some of their ideas were once held by scientists. (Glough & Olsen, 2012) On the other hand, it is also widely recognized that teacher's informed understanding of NOS does not automatically translate into classroom practices. Teachers often regard NOS less important component of science education than traditional subject matter (Lederman, 2007). According to Vesterinen and Aksela (2012), teacher's commitment to teach NOS has at least three prerequisites: Internalizing the importance of NOS as valued instructional outcome, understanding NOS concepts, and possessing pedagogical content knowledge to transfer NOS ideas into practice. Research has demonstrated that explicit, reflective instruction in teaching NOS is more effective than implicit instruction through experiences with simply "doing" science (Lederman, 2007).

Research questions are:

1. What is in-service and preservice teachers' current understanding of NOS?
2. What are the differences in the NOS views between in-service and preservice teachers?

2. Method

Anonymous online questionnaire was used as a data collecting technique. The instrument was "The views of the Nature of Science questionnaire" (VNOS-B) (Lederman, Abd-El-Khalick, Bell, & Schwartz, 2002). The VNOS-B consists of seven open-ended questions that help identify understandings of the tentative, empirical, creative, subjective, theoretical, cultural, and social nature of science. The VNOS-B has been reported as a reliable and valid measure of NOS aspects when combined with some interviews, but interviews were not included in this research due to the anonymity of the respondents.

13 in-service teachers responded the questionnaire in September 2019: three from Finland, four from Norway, and six from Russia. All the preservice teachers were from Finland. Neither in-service nor preservice teachers had got any training in various aspects of NOS; their understanding of NOS has been built implicitly within their science discipline and science education studies. Researchers read each response carefully and gave 1, 2, or 3 (integers) points by interpreting the respondents into three groups of informed (mean 2.35-3.00), intermediate (mean 1.68-2.34), and naïve (mean 1.00-1.67). A rubric with characteristic views for informed, intermediate, and naïve responses (Kartal et al., 2018) together with an original article presenting VNOS-B (Lederman et al., 2002) were used to aid the classification of teachers into three groups. Intermediate describes the participant holding to both informed and naïve beliefs, views, and understandings of a specific aspects of NOS, simultaneously. Inter-rater reliability measure, Cohen's Kappa, is **k =** 0.80 indicating substantial agreement according to Landis and Koch (1977).

3. Results

Table 1. Comparison of in-service and preservice teachers' responses to the VNOS-B. Mean values of the assessed responses in a group are given in parentheses.

Aspects of NOS in VNOS-B Questionnaire	In-service teachers	Preservice teachers
1. Tentative nature of scientific knowledge	Informed N=13 (2.92)	Informed N=21 (2.71)
2. Observation, inference, and theoretical entities in science	Intermediate N=13 (2.00)	Intermediate N=21 (2.00)
3. Distinction between scientific theory and law	Naïve N=13 (1.31)	Naïve N=21 (1.48)
4. Creative and imaginative nature of scientific knowledge; subjectivity	Intermediate N=13 (2.00)	Naïve N=21 (1.48)
5. Creative and imaginative nature of scientific knowledge	Informed N=10 (2.48)	Intermediate N=18 (2.17)

6. Empirical nature of scientific knowledge	Intermediate N=11 (1.82)	Intermediate N=20 (2.15)
7. Theory-laden nature of scientific knowledge; subjectivity vs. objectivity, social and cultural influences	Naïve N=10 (1.50)	Naïve N=20 (1.60)

4. Discussion and conclusions

Preservice and in-service teachers got very similar results. Only in two questions (4. How are science and art similar? How are they different? and 5. Other than the planning and design of experiments/investigations, do scientists use their creativity and imagination during and after data collection?) in-service teachers gave more adequate responses than preservice teachers. Those questions mainly refer to the creative and imaginative aspects of NOS. Both groups agreed that science and art require creative thinking but among preservice teachers there was a stronger belief in the objectivity of science and subjectivity of art: "*Art is about impressions and feelings, science is all about the facts".*

All respondents indicated that theories change (question 1) and "*the accumulation of new evidence"* was the main reason for theory change; "*new technology"*, "*identifying new effects out of existing theories"*, and "*contradictions"* were also mentioned as reasons. Respondents seemed to understand well the tentative nature of scientific knowledge (Table 1). Responses in the context of question 3 (Is there a difference between a scientific theory and scientific law?) revealed, however, that many teachers from both groups thought that laws don't change while theories are subject to change, for example one in-service teacher wrote that "*theory is more a presumption and scientific law is the rule in force"* and according to one preservice teacher, "*law is law and theory is just a thought"*. Only three in-service teachers and two preservice teachers viewed scientific theories and laws as distinct but equally valid forms of scientific knowledge. Two in-service teachers and five preservice teachers believed that scientific theories become laws when proven through repeated testing.

Especially preservice teachers (question 7. How is it possible that scientists can draw different conclusions when they look at the same experiments and data?) expressed the view that researchers can make different interpretations of the same data due to *"different views"* or "*lack of information"*. Some of them implied that these interpretations are researchers' opinions which "*we* *just have to believe"*. Some in-service teachers also thought that "*there is not enough data to create scientific law from universe"* or "*researchers have different incompetency"*. Responses for questions 3 and 7 were assessed naïve for both groups. Teachers did not provide examples or explanations where they would have expressed the theory-laden nature of observations, investigations, and data interpretations as a justification to their response.

When asked what an atom looks like (question 2), three in-service and three preservice teachers responded that either they themselves or scientists knew/had seen the structure of the atom exactly. One in-service teacher responded: "*Before seeing an atom, scientists had to create many theories and equipment – a scanning tunneling microscope. Person can look now beyond the unknown. Erwin Muller saw first an atom. Its shape is close to spherical."* Five in-service teachers and twelve preservice teachers, however, understood the inferential nature of scientific models.

Inservice science teachers had an informed view of NOS regarding tentativeness, creativity of scientists and imaginative nature of scientific knowledge. Views of distinction between scientific law and theory and theory-laden nature of scientific knowledge, on the other hand, had not developed in teaching practices being at the same inadequate level with those of preservice teachers. Training using explicit reflective instruction is needed to achieve changes in both in-service and preservice teachers' conceptions of NOS. It is essential that science education provides pupils with opportunities to build their understanding of the purposes of scientific work, of the nature and status of scientific knowledge, and of science as a social enterprise (Driver, Leach, Millar, & Scott, 1996).

5. Acknowledgement

We express our gratitude to participating in-service and preservice teachers. The project is funded by the Kolarctic CBC, EU, Russia, Norway, and Finland. The contents of the article are in the sole responsibility of the writers and do not reflect the views of the European Union.

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Programming in the curriculum for compulsory school: How is it represented in Nordic countries?

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Abstract

In recent years, international school development initiatives have acknowledged the importance of digitalisation in modern society, and school policy documents in many countries have been revised to incorporate digital competence, computational thinking (CT) and programming. The aim of this study was to examine and compare how and in what contexts Nordic curricula, Swedish and Norwegian in particular, embody aspects of computational thinking and programming. The texts have been analysed using a framework for computational thinking practices and a broader framework for digital competencies. Results show similarities with respect to the implementation of programming in the sense that it is primarily recognized as a method and tool for learning other subject content, and not as a knowledge domain on its own. Furthermore, it appears unclear to what extent and in what subject children should learn the fundamentals of programming. The results also indicate a fragmented approach to the wider notion of computational thinking, only parts of the practices defined in the CT framework used could be explicitly identified. In conclusion, the time and teacher competence required for providing students with functional skills in programming is under-communicated, leaving schools and teachers with major challenges.

Keywords Programming, Computational Thinking, Compulsory School, Curriculum Analysis, Nordic countries

1. Introduction

Computational thinking (hereafter referred to as CT) as part of general education has received increasing attention in recent years, though the concept is not new (Wing, 2006). As a result, school policy documents in many countries, the Nordic included, have been revised to incorporate skills considered to be of great significance for future generations. CT is associated with, but not restricted to, skills in and understanding of programming (Voogt et al., 2015). There is a wide range of definitions and models for what CT means (Shute et al., 2017), and in a recent report about the Nordic approach to CT (Bocconi et al., 2018) two focus points stand out: *solving problems* and *digital competence*. Still, programming as part of general education lacks traditions, and it is not clear how it may best be incorporated in school subjects. In the case of Sweden, previous research has shown that teachers are faced with a range of intrinsic and extrinsic challenges in incorporating programming in their teaching (Vinnervik, 2020). The present study investigates under what circumstances CT skills and strategies are manifested and put into concrete terms as learning goals in the main curriculum documents in Nordic countries, since these govern teachers' work in the classroom. The research question is:

In what ways are programming and other aspects of computational thinking represented in curricula for subjects in Nordic compulsory education?

The presentation of results focuses on Sweden and Norway. The curriculum documents are analysed using a framework for CT (Weintrop et al., 2016) and the Digital Competence Framework, DigComp, from the EU Science Hub (Carretero et al., 2017).

2. Theoretical framework

Weintrop et al. (2016) have developed a framework for CT in terms of five interrelated practices (table 1). These relate to familiar conceptualisations of practices in science and technology in the sense that data practices and modelling and simulation practices have similarities with recent development in how scientific practices are described as part of the science curriculum (Crawford, 2014). In addition, systems thinking practices have similarities with how systems form part of curricula for technology (Svensson, 2017).

Table 2. Computational Thinking Framework (Weintrop et al., 2016)

Data practices	Modelling and Simulation Practices	Computational Problem Solving Practices	System Thinking Practices

Collecting Data	Using Computational Models to Understand a Concept	Preparing Problems for Computational Solutions	Investigating a Complex System as a Whole
Creating Data	Using Computational Models to Find and Test Solutions	Programming	Understanding the Relationships within a System
Manipulating Data	Assessing Computational Models	Choosing Effective Computational Tools	Thinking in Levels
Analysing Data	Designing Computational Models	Assessing Different Approaches/Solutions to a Problem	Communicating Information about a System
Visualising Data	Constructing Computational Models	Developing Modular Computational Solutions	Defining Systems and Managing Complexity
		Creating Computational Abstractions	
		Troubleshooting and Debugging	

CT further involves strategies and skills for handling data, modelling, problem solving and so forth by means of digital technology. This dimension connects CT to digital competence. In this paper, we draw on the Digital Competence Framework, DigComp 2.1, from the European Commission. The framework describes the key components of digital competence in terms of five areas (Carretero et al., 2017):

1. Information and data literacy
2. Communication and collaboration
3. Digital content creation
4. Safety
5. Problem solving

For each competence area eight proficiency levels are defined, ranging from foundational to highly specialised. The proficiency levels elaborate on the competences (knowledge, skills, attitudes) for each area and provide examples of what they may mean in practical terms. The framework developed by Weintrop et al. (2016) is useful for analysing the competences involved in each area. Comparison suggests that CT practices are primarily connected to areas 3 and 5 in the Digital Competence Framework.

3. Research methods

The investigation is undertaken by qualitative content analysis (Krippendorff, 2004) of curriculum documents. The focus is on the main curriculum documents rather than on underlying policy documents about digitalisation strategies and so forth, since the purpose of the study is to throw light on the results manifested in the documents teachers are most likely to use in their work, not the process that has led to these results. The analysis has focused on how, and in what contexts programming and other aspects of CT appear in the documents, particularly within formulated intended learning outcomes.

4. Results

Investigation of current curricula for compulsory education shows a variety among the Nordic countries in how programming and CT are placed with regards to subjects.

In Finland, Sweden and Norway, programming has found its way into the syllabus for Mathematics, in particular in terms of algorithms. Programming also appears in the Swedish Technology subject (Teknik), and in Finland in Crafts. In Norway, programming is mentioned in the syllabi for Science, Music and Arts, and Crafts.

In Denmark, digital competence is attended to in many contexts and subjects, but there is little about programming in the curriculum for compulsory school. The syllabus for Mathematics, refers to the use of computer programs but not how they are made. In Science (Natur/Teknologi), there is a strong focus on modelling competence, but computer programs are not mentioned. However, a new subject called "Technology understanding" is currently being piloted in many Danish schools. This subject includes CT as an explicit part of the content, with a broad understanding in line with Weintrop's (2016) model and that contains programming.

Iceland has a discrete subject "Information and Communication Technology" that covers a broad range of competences under the concept of information and media literacy. Learning to use technological tools and computer programs is central. Programming is mentioned once in the competence criteria for Grade 10, where students are supposed to *Use software for programming and communication in a creative manner*. Programming does not form part of the stated learning outcomes in Mathematics, Science, or other subjects.

In the following we present in more detail how programming is represented in the curricula in Sweden and Norway.

4.1 Sweden

In the Swedish context, programming is intended to be a means of developing both digital competence as well as subject specific competencies. The programming message in its entirety is communicated through several texts. The main message is conveyed in the formal written curriculum and specifically in the Mathematics and Technology syllabi. Additional information about, for example aims and content choices made, is provided through, non-governing, commentary materials. Here, programming is represented as an interdisciplinary subject content that encompasses all components of digital competence.

In the Mathematics syllabus, programming is tied to digital tools and is presented as such, to be used to "explore problems and mathematical concepts, make calculations and to present and interpret data". In the dedicated commentary material for Mathematics, it is stated that the subject should cover the "programming fundamentals". These 'fundamentals' are captured in condensed syllabus content statements linked to algebra, starting from unambiguous step-by-step instructions, and ending with the process of creating, testing, and improving algorithms for problem solving. For example, "How algorithms can be created and used in programming". In the Technology syllabus, programming is solely addressed through short core content statements. Here, programming is primarily tied to technological systems, methods of control and regulation of technological objects, construction work and electronics. For example: "Technical solutions that use electronics and how they can be programmed". In the dedicated commentary material for Technology, it is ambiguously suggested that "programming fundamentals" learnt in Mathematics could scaffold the programming experience in Technology.

Following a northern continental curriculum tradition, the formal curriculum is designed in such a way that the reader is expected to possess adequate knowledge to understand the educational implications of each statement. The subject syllabi do not explicitly specify what the fundamentals of programming are in terms of practices or concepts, besides 'algorithms'. There are no competence aims in the subject syllabi that explicitly address knowledge of 'programming fundamentals' and how it may evolve over time. Some information about the progression of knowledge is provided in the additional commentary materials and is mainly expressed in terms of transitioning from block-based to text-based programming environments or working with more complex programmable technological objects.

In terms of CT, the commentary materials provide a short remark in which it is suggested that competences related to CT are reflected in the curriculum as a whole. Using the CT framework by

Weintrop et al. (2016) as template, it is possible to identify possible ways to approach some of the practices presented in the framework. Data practices and Computational Problem Solving Practices could be covered in both Mathematics and Technology. In Mathematics, programming is explicitly meant to function as a tool or a "computational model to understand a concept". Most of the System Thinking Practices could be targeted in Technology education.

4.2 Norway

The new Norwegian curriculum K20[1] emphases digital skills in every subject alongside basic skills in reading, writing and so forth. Programming is mentioned in descriptions of the subjects Mathematics, Science, Music, and Arts and Crafts, but it is elaborated to a varying degree in the competence aims for each subject. Digital competence in terms of being a critical user (area 1 in the Digital Competence Framework) is highly represented in Social science, but this subject does not contain programming.

To a large degree, we find programming positioned as a tool for working with other subject content. For example, in Science students are to "explore, make and program technological systems with parts that work together (grade 5-7), and "use programming to explore natural phenomena" (grade 8-10). In mathematics, the curriculum contains some specific knowledge elements in programming, and the concepts algorithms, variables, conditions, loops, and functions are mentioned in grades 5 and 6. However, in higher grades, programming is positioned mainly as a tool, as students are to "use programming to explore data in tables and data sets" (grade 7) and "explore mathematical properties and relationships by means of programming". In Music and Arts and Crafts, the curriculum states that students are to use programming in creative processes in the subjects. In Arts and Crafts, this is specified in a competence aim as "use programming for creating interactivity and visual expressions".

In terms of the CT framework by Weintrop et al. (2016), the 'programming as a tool' approach as presented in the curriculum, interpreted in a somewhat narrow way, covers only parts of Data practices and Modelling and Simulation practices. Correspondingly, of the Computational Problem Solving Practices, only Programming is covered.

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[1] https://www.udir.no/laring-og-trivsel/lareplanverket

5. Discussion and conclusion

Results show a variety of solutions to how programming should be approached in general education in Nordic countries. Both the Swedish and the Norwegian curriculum link programming to algorithms in Mathematics. This integration represents a fragment of the Computational problem solving practices described in the framework by Weintrop et al. (2016). There is a risk that the teaching about algorithms will be correspondingly fragmented in young people's education. In Sweden, mathematics is positioned with the responsibility to provide for *basic programming skills*, but in the curriculum, the essence of these skills in terms of practices and concepts is not made clear. The Norwegian curriculum places programming in several subjects, mostly represented as a tool for learning subject matter. For this to work, students will need extensive training in programming skills, which is partly covered in Mathematics. However, it is not likely that schools and teachers will give it considerable priority. To realise the potential carried by the curriculum, teachers will need good examples for how programming can be constructively incorporated in various subjects and across subjects, and opportunities to create their own solutions locally. This means that considerable resources must be put into teacher professional development in order to make programming a natural and constructive part of the curriculum.

As a whole, curriculum documents in both countries include elements of all the five broad competence areas described by DigComp (Carretero et al., 2017). It was also found for both countries that programming is seen as a tool, not only for problem solving but for learning content from the traditional subjects. This implies that programming, or CT more generally, is not fully acknowledged as a domain of knowledge in itself. Further, failing to explicitly combine programming with Data practices in terms of scientific processes rather than content, is a missed opportunity to represent a wider range of the practices that form part of CT as represented in the framework by Weintrop et al. (2016).

With a deliberate effort, it is possible to interpret the curriculum more broadly, and intentionally cover many aspects of CT, as shown in teaching resources developed as part of the Norwegian school science education development project Kretek[2]. However, with the limited teaching time available and extensive curriculum aims to cover, alongside limited domain specific teacher knowledge, it is likely that teachers will approach the topics relating to programming in a narrower way. It is therefore a risk that programming is treated as an isolated part of the subjects, with a main

[2] https://www.ntnu.no/skolelab/kretek

focus on coding skills and that broader, and more difficult to assess, competencies are overlooked (Åkerfeldt, Kjällander, & Selander, 2018).

Neither the Norwegian nor the Swedish curriculum make it explicitly clear how and in what subject context children should learn the programming principles, practices, and actual coding skills. The time and teacher competence required for providing students with functional skills in programming as a tool is hence under-communicated, and leaves schools and teachers with major challenges in realising the curriculum.

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