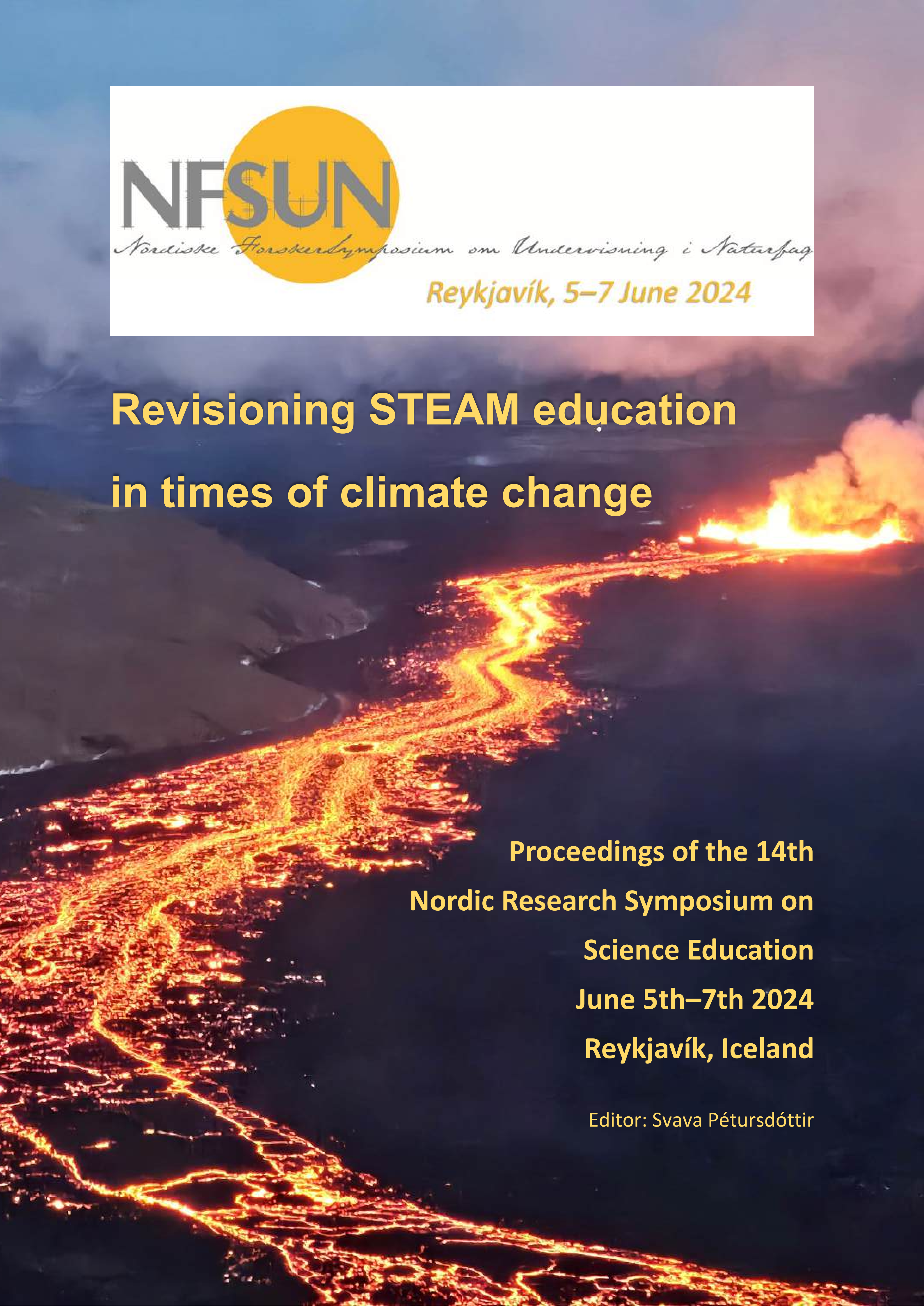

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Revisioning STEAM education in times of climate change

Proceedings of the 14th Nordic Research Symposium on Science Education
June 5th–7th 2024
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Editor: Svava Pétursdóttir

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Preface

Revisioning STEAM education in times of Climate Change

This volume contains the papers presented at NFSUN2024: Nordic Science Education Research Conference 2024 held on June 5-7, 2024 in Reykjavik.

In Reykjavik we contributed to the ongoing discussions about revisioning STEAM- education, how we think, research, and respond to Climate Change. The research contributions discussed the challenges and suggested solutions to revisioning STEAM education. These included conceptual understandings of how we frame these issues, and interdisciplinary views on how to research challenging contexts.

The Nordic Research Symposium on Science Education is a forum for the presentation and discussion of research on Nordic science education. The symposium links research and development and welcomes researchers, as well as teachers from all levels of education. The symposium functions as a meeting point and a platform for establishing networks within science education research. The first NFSUN symposium was held in 1984.

Read more about NFSUN and earlier conferences at https://nfsun.org/

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FOLLOW-UP RESEARCH RELATED TO *SCIENCE KIDS* – A PRESCHOOL SCIENCE PROJECT

Andreas Redfors, Lotta Leden and Marie Fridberg

Kristianstad University

Abstract

In this presentation, we report on a municipality's experiences of partaking in a professional development programme called *Science Kids*. We aim to develop knowledge about how participation in such programmes can contribute to the development of science teaching in preschools. The research is done in cooperation with a mid-sized Swedish municipality and empirical data is collected in terms of pre- and post-questionnaires, focus-group discussions, and interviews. Content analysis is used supported by frameworks of curriculum emphases and professional development. The analysis is ongoing and results and discussion related to current and future science teaching in preschool will be presented at the conference. Preliminarily we can say that the participants display a positive attitude towards science in preschool and that they highlight the importance of everybody's participation. There is a pronounced focus on the importance of children being able to understand and discuss science content among themselves. Not so much about decision-making, science in society, and other aspects of science.

1 Introduction

The presentation has its background in that the national curriculum stipulates natural science as content in Swedish preschool, i.e. children should be given the opportunity to develop an understanding of "simple chemical processes and physical phenomena" and the ability to discuss natural science. At the same time, many educators in preschool experience science as a difficult area to teach. In line with these difficulties, the Swedish Schools Inspectorate reports that science in preschool is often treated in isolation without connection to the children's own investigations or everyday life (Swedish Schools Inspectorate, 2018). The need for the development of science teaching is emphasised in the same report. The non-profit association BUNT, leads the project *Science Kids*, which aims to develop science teaching in preschool based on children's questions. Free web-based teaching materials are developed in collaboration between science centres and preschools. We are collaborating with a mid-size municipality taking part in *Science Kids* to analyse experiences made.

We aim to develop knowledge about the processes associated with the development of material for preschool science teaching. In particular, the focus is on how workteams' participation in *Science Kids* can contribute to professional development in relation to science teaching in preschool. The research questions are:

- What kind of science content can be identified in the empirical data?
- How do participants discuss their work with children's questions?
- How can participation in a project like *Science Kids* contribute to the professional development of workteams regarding science teaching?

2 Background

Research on science in preschool often uses Eshach's (2006) description of science as two knowledge domains. The first includes facts and science theories with concepts. The second includes scientific and investigative approaches such as questions, observations, experiments and discussions, i.e. the processes that have been used to arrive at the facts and theories addressed in the first domain. Both domains can be related to the knowledge area *Nature of Science* (NOS) (cf. Lederman, 2007; McComas, 2020). Important aspects of NOS possible to illustrate in preschool are, for example, different types of scientific methods and tools as well as human aspects linked to the knowledge processes such as curiosity, creativity, and collaboration (cf. Hansson et al., 2020; Leden et al., 2022). An analytical tool that can be used in the analysis of science content is Roberts' curriculum emphases (Roberts, 1982).

Furthermore, the preschool teacher's own attitude towards science is important for the children's opportunity to learn science; if the teacher has a positive attitude, it can affect the children positively (Fleer, 2009). In addition to aspects linked to the scientific content, research has shown the importance of preschool teachers making an effort to adapt to children's perspectives – a prerequisite for maintaining mutual simultaneity and intersubjectivity in teaching (cf. Fridberg et al., 2019).

According to Timperley (2019), teachers need to operate and be challenged within new frameworks and have access to new knowledge in order to develop new forms of practice. Furthermore, the importance of everyone's participation is emphasised. In other words, a workplace does not seem to "get further due to the development of a few individuals. Instead, the "whole" gains from everyone's participation. Results from a previous professional development project on science teaching in preschool showed that it was indeed imperative that all staff participated (Fridberg et al., 2021).

3 Research methods

The project is ongoing (2022-2024). Empirical data is collected in collaboration with two preschools in the municipality. Three workteams participate, each with a group of ten children (3-5 years old). *Science Kids* has an appointed process leader who collaborates with the three workteams together with a project manager from the Science Centre. A lecturer from the municipality supports the process.

The structure of *Science Kids* will be repeated in four periods: autumn 2022, spring 2023, autumn 2023 and spring 2024. Each period begins with a visit from the project manager from the Science Centre to the relevant children's group. The visit is organised around pre-selected science materials. The process leader and the workteam pay attention to the children's questions and interests and, based on this, choose a science content area for further work.

The empirical data consists of pre- and post-surveys and focus groups with the workteam and the municipal lecturer. In addition, the documentation of the process leader is collected, and follow-up interviews are conducted with the process leader, the project manager, the municipal lecturer, and the principals at the two preschools. Data is analysed by using both conventional and directed content analysis (Hsieh & Shannon, 2005).

4 Results – ongoing analysis

The analysis is ongoing and will be intensified and completed by the end of 2024. One of the interests of the study is to get an insight into what science content comes into focus in this type of project. This is studied by analysing how the participants talk about their didactic choices related to science and children's questions about science. The analysis uses the seven curriculum emphases (Roberts, 1982). *Solid foundation* is about learners getting a stable foundation for future studies. *Correct explanation* focuses on factual knowledge and the value of knowledge for its own sake. *Everyday coping* focuses on the benefits children/students can derive from science to understand everyday life. *Science, technology and decisions* focuses on the role of science in society and how science knowledge can be used to make informed decisions. *Self as explainer* is based on the need and desire to be able to explain phenomena one is curious about in the here and now. *Scientific skill development* focuses on scientific methods and procedures to enable learners to investigate things themselves. *Nature of science* focuses on knowledge of how science works and what characterises scientific knowledge. The curriculum emphases as a theoretical framework enable an analysis of both what is emphasised and what is not in the participants' discussions. Thus, it is possible to draw conclusions about what should be emphasised or adjusted in professional development processes.

Furthermore, we analyse the development of workteams and the role of management according to Timperley's (2019 p. 42) three levels (basic level, development level and integrated level). Three perspectives, motivation to participate, knowledge and skills, and the role of leaders are analysed based on the three levels. For example, motives for participating in a professional development project can be analysed based on 1) basic level: new ways of teaching science in preschool, 2) development level: teaching science through investigative approaches and 3) integrated level: teaching science through investigative approaches based on children's questions. The three levels move towards an increasingly specific and engaging rationale for active participation. Similarly, the other two perspectives move from the basic to the integrated level.

Preliminarily we can say that the participants display a positive attitude towards science in preschool, even though some refer to negative experiences in their own schooling. They discuss difficulties if the entire workteam is not part of the process. The curriculum emphases that come into focus are related to the importance of children being able to understand and discuss science content among themselves. There is quite a strong focus on providing children with correct facts and language. There has so far been few discussion of decision-making and science in society. We also notice that stereotypes of scientists might be confirmed in that the project manager from the science centre is dressed in a lab coat.

5 Discussion and conclusion

Results related to science content and aspects of professional development will be presented at the conference and discussed in relation to published research and future professional development projects.

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A DUAL IMPLEMENTATION OF INQUIRY-BASED SCIENCE EDUCATION (IBSE) IN SCIENCE TEACHER EDUCATION

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Abstract

In Norway, Inquiry-Based Science Education (IBSE) is a component of the science teacher education curriculum yet lacks explicit guidance on its integration. This presentation synthesizes findings from three distinct studies within my PhD-project to propose recommendations for the implementation of IBSE in science teacher education. IBSE should be implemented with a dual perspective on student teachers as learners (*Inquiry-Based Learning, IBL*) and future teachers (*Inquiry-Based Teaching, IBT*). However, research indicates that student teachers encounter challenges in transitioning between these roles. Consequently, I propose the incorporation of *didactic teacher reflections* following IBL activities to facilitate the student teachers' transition from IBL to IBT. Moreover, I advocate the teacher educators to develop a progression plan outlining how IBSE is incorporated into their program. This ensures that student teachers acquire experience with the dual perspectives of IBL and IBT. In the presentation, I will illustrate an example of how to construct such a progression plan.

1 Introduksjon og teoretisk bakgrunn

I Norge har utforskende arbeidsmåter (UA) en eksplisitt plass i de nasjonale retningslinjene for grunnskolelærerutdanningen i naturfag, og lærerstudenter skal få læring om og ferdigheter i hvordan de kan arbeide utforskende med elever (UHR-Lærerutdanning, 2018). Det innebærer at lærerstudenter må utvikle kompetanse innenfor UA, og det kan gjøres gjennom to perspektiver: student- og lærerperspektivet. I studentperspektivet skal lærerstudenter erfare UA på campus, der de inntar en elevrolle for å forstå fagkunnskap og naturvitenskapelige prosesser i sitt egen læringsforløp om naturfagets produkter og prosesser (Crawford & Capps, 2018). Dette konseptet definerer jeg som som *utforskende læring (UL)*. I lærerperspektivet skal studentene utvikle ferdighetene for å anvende UA i undervisning for kommende elever. Dette konseptet definerer jeg som *utforskende undervisning (UU)*. Det omfatter ulike utforskende tilnærminger som studenter tar i bruk og får erfaringer med når de tar i bruk UA som et pedagogisk verktøy (Anderson, 2002). For å gi studenter gode overganger fra campus til praksis, anbefaler Lunenberg, Korthagen, and Swennen (2007) at lærerutdanningen modellerer god naturfagundervisning, og at det knyttes til didaktiske valg og videre til didaktisk teori.

Det eksisterer flere empiriske studier som fokuserer på UA i naturfaglærerutdanningen (Strat, Henriksen, & Jegstad, 2023), men som meg bekjent, foreligger det ingen oversikt hvordan UA bør integreres som et helhetlig perspektiv i lærerutdanningen. Gjennom mitt doktorgradsprosjekt har jeg gjennomført og skrevet frem fire studier om UA i naturfaglærerutdanningen (Jegstad & Strat, I review; Strat, I review; Strat et al., 2023; Strat & Jegstad, 2022). Målet med doktorgradsprosjektet er å karakterisere og videreutvikle bruken av UA til naturfaglærerutdanning, basert på resultater fra disse studiene. Her i denne presentasjonen ønsker jeg å gå ta utgangspunkt i resultater fra tre av studiene for å besvare følgende forskningsspørsmål:

1. Hvilke resultater kan trekkes ut fra de tre studiene om hvordan UA bør implementeres i naturfaglærerutdanningen?

2. Basert på disse resultatene, hvordan bør UA implementeres i lærerutdanningen?

2 Mål, metode og resultater/konklusjoner i de tre studiene

De presenterte studiene tar i bruk ulike kvalitative forskningstilnærminger som tilfredsstiller de unike målene for hver studie (Cohen, Manion, & Morrison, 2018). En oversikt over disse aspektene, samt en kompakt presentasjon av studienes resultater og konklusjoner, er oppført i Tabell 1.

***Tabell 1**: Mål, metode og resultater/konklusjoner i de tre studiene.*

	STUDIE 1 (S1):	**STUDIE 2 (S2):**	**STUDIE 3 (S3):**
Tittel	**Inquiry-Based Science Education in science teacher education: a systematic review** (Strat et al., 2023)	**Inquiry-based teaching and learning in science teacher education: Norwegian teacher educators' views and experiences** (Strat & Jegstad, 2022)	**Naturfags-lærerstudenters beskrivelser av UA i skolen** (Strat, I review)
Mål	Identifisere og kategorisere UA-perspektiver i eksisterende forskning.	Undersøke prioriteringene til lærerutdannerne i implementering av UA.	Undersøke lærerstudenters oppfatninger av UA.
Metode	Systematisk litteraturgjennomgang av empiriske studier (N=142) mellom 2000 og 2022.	Fokusgruppeintervjuer av lærerutdannere (N_{tot}=29) fra 7 studiesteder.	Skriftlige besvarer fra åpne refleksjonsnotater fra lærerstudenter (N=86).
Resultater og konklusjoner	UA implementeres både som UL (N=69) og som UU (N=73). Det er få studier som undersøker overgangen mellom UL og UU. Noen av disse studier diskuterer ulike tilnærminger som kan tas i betraktning for å minimere overgangen, som didaktiske refleksjonssekvenser eller micro-teaching.	Implementeringen av UA viser seg på forskjellige måter og med varierende intensitet. Det legges særlig vekt på UL gjennom konkrete og kontekstspesifikke eksempler, med mål om å gi studentene økt fagkunnskap og erfaring med naturvitenskapelige praksiser. IBT ble mindre prioritert, på grunn av begrenset undervisning. Det ble påpekt at studentene selv kan håndtere overgangen fra campus til praksis, basert på erfaringsgrunnlaget de har tilegnet seg under campusbasert undervisning.	Lærerstudenter retter sitt fokus mot praksiser relatert til idemyldring, spørsmålsformulering og datainnsamling. Imidlertid er det en lavere grav av vektlegging på praksiser knyttet til kunnskapsbygging og hvordan elever skal jobbe for å kritisk komme fram til et svar og hvordan de skal argumentere for svaret på det som er undersøk.

3 Resultat, diskusjon og konklusjon av forskningsspørsmålene

Resultatene fra de tre studiene avslører en variasjon i implementering av UA i naturfaglærerutdanningen. I S1 avdekket litteraturgjennomgangen at nesten halvparten av de inkluderte studiene ble kategorisert som UL, der lærerstudentene har en elevrolle for å forstå fagkunnskap og naturvitenskapelige prosesser (Strat et al., 2023). Dette indikerer at erfaring med UA som UL er en integrert del av lærerstudentenes utdanning. Videre viste analysen fra fokusgruppeintervjuene i S2 at UL-perspektivet ble prioritert av lærerutdannerne, for flere beskrev at UA ble tatt i bruk i konkrete aktiviteter knyttet til faglige temaer, med særlig vekt på kunnskapsbygging i undervisningen med lærerstudentene (Strat & Jegstad, 2022). Imidlertid viser resultater fra S3 en forskjell mellom lærerutdanneres prioriteringer og lærerstudentenes egen oppfatning. Mens lærerutdannere fokuserer på kunnskapsbygging gjennom UA, legger lærerstudentene mindre vekt på dette aspektet i sine beskrivelser. Det antyder en uoverensstemmelse i oppfatningen av UA mellom lærerutdannere og studenter, og viser viktigheten til Lunenberg et al. (2007) anbefaling om at lærerutdanningen må modellere god naturfagundervisning, og at det knyttes til didaktiske valg og videre til didaktisk teori.

S1 indikerer også at UU blir inkludert i lærerutdanningen, for litt mer enn halvparten av studien ble kategorisert som UU (Strat et al., 2023). S2 viser imidlertid betydelig variasjon i prioritering av UU mellom ulike studiesteder i Norge. Noen lærerutdannere uttrykker at overføringen fra lærerstudentenes erfaringer med UL på campus å praktisere UU med elever er noe studentene kan håndtere selv (Strat & Jegstad, 2022). Det står i kontrast med resultater fra Studie 1. Her er det flere studier som peker på ulike utfordringer som lærerstudentene står overfor i å gjennomføre UU (Strat et al., 2023). Lærerstudentene må bli trygge på hva som kjennetegner UA og hvilke nødvendige støttestrukturer man kan ta i bruk for å lykkes med dette i klasserommet.

Basert på resultatene fra studiene, fremhever jeg behovet for en dobbel fokusert implementering av UA i lærerutdanningen. Lærerstudenter må utvikle kompetanse innen både UL og UU (Crawford & Capps, 2018), og det kreves støtte for å lette overgangen mellom disse to perspektivene (Strat et al., 2023). Jeg anbefaler at denne overgangen støttes gjennom *didaktiske lærerrefleksjoner* etter utforskende aktiviteter på campus, i samsvar med anbefalingene fra Baxter, Jenkins, Southerland, and Wilson (2004) i S1 og Lunenberg et al. (2007). Slike refleksjoner gir studentene mulighet til å diskutere undervisningsopplegg som fremtidige lærere, være kritiske til utforskende aktiviteter og reflektere over hvordan disse aktivitetene kan tilpasses skolepraksis og fremtidig undervisning.

Lærerutdannerne i Studie 2 erkjenner utfordringen med å inkludere alle UA-perspektivene på grunn av begrenset undervisningstid (Strat & Jegstad, 2022). Til tross for dette, anbefaler jeg at lærerutdannere utarbeider en progresjonsplan for å sikre at lærerstudenter får erfaring med både UL og UU. Dette doble fokuset kan være et nyttig verktøy for å utforme en progresjonsplan. Basert på resultatene og konklusjonene fra studiene vil jeg presentere en slik progresjonsplan. Den er utarbeidet ved naturfagsseksjonen på mitt universitet. Målet med en slik plan er å skape en oversikt over hvordan studentene gradvis utvikler sin kompetanse innenfor UL og UU gjennom ulike emner, samtidig som de bygger ferdigheter for å integrere UA i sin fremtidige undervisning. De vil utvikle fagdidaktisk kompetanse om *hva* UA er, *hvordan* man arbeider utforskende og *hvordan* UA kan brukes inn i egen undervisning. De utforskende aktivitetene, som lærerstudentene gjennomfører, er valgt ut til å være overførbare til skolen, samtidig som at undervisningen legger opp til at studentene skal oppnå en dypere forståelse av naturfaglig fagkunnskap enn det som er forventet av elever i skolen.

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AUGMENTED REALITY IN EDUCATION FOR SUSTAINABLE DEVELOPMENT IN PRESCHOOL – THE IMPORTANCE OF ‘PLACE’

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Abstract

In this paper, we report on a STEM project and two Swedish preschool teachers’ descriptions of their teaching of sustainable development goals through augmented reality technology. Their statements about thematic work, children’s agency, teachers’ perspective, and augmented reality are analysed through a theoretical framework based on *transduction* and *place*. The importance of children’s agency in their exploration of local places associated with the sustainable development goals is elaborated on, together with the value in treating augmented reality as a ‘what’, or content, in teaching before it can be used as a ‘how’, or tool, for teaching about another content. Transducing meaning between different representations, such as physical places and the sustainable development goals in augmented reality applications, creates possibilities for fruitful discussions about, e.g. democracy aspects and source criticism between children and preschool teachers working with STEM. Future studies aim to contribute knowledge about children’s and preschool teachers' communication during teaching, including sustainable development and augmented reality technology.

1 Introduction

Digitalisation is nowadays a natural part of society, and as a result, it has gained an increasingly prominent place in early childhood education around Europe. The use of Augmented Reality technology (AR) has increased in the field of education. However, only a very limited number of studies for educational purposes have been carried out in preschool (Albayraka & Meryem Yilmaz, 2022; Aydoğdu, 2021). Furthermore, studies reporting on preschool teachers’ view on work with AR and STEM is lacking.

In the latest version of the Curriculum for preschool in Sweden, there is an increased focus on sustainable development (SD). Examples of what the preschool should provide each child with conditions to help them develop, and related to the present study, is *active participation in society and an understanding of how different choices people make in everyday life can contribute to sustainable development* (Swedish National Agency of Education, 2019). In 2015, all the countries in the United Nations adopted the 2030 Agenda for Sustainable Development. The 17 Sustainable Development Goals (SDG:s) in the agenda seek to end poverty and hunger, realise human rights, and ensure the protection of natural resources on the planet.

The aim of this study is to contribute knowledge about thematic teaching of AR and SD in the preschool setting, with a special focus on place-based education/learning. The research questions guiding the analysis are:

- How do preschool teachers describe thematic teaching, including AR and SD?
- What is the role of place and transduction in the teaching and learning process?

2 Theoretical backgrounds

The theoretical perspectives framing the analysis of the study are *place* and *transduction*. Places are profoundly pedagogical as centres of experience, where identities are shaped and where we learn about how the world works (Grünewald, 2003a). Grünewald describes the problem with traditional schooling not recognising the importance of place and how a failure to consider places as products of human decisions makes us view them as inevitable. Places are produced by people but at the same time, places produce and teach certain ways of thinking about the world. The critical pedagogy of place, proposed by Grünewald (2003b), aims at teachers and students taking social action to improve the social and ecological life of both local and distant places, and can thus be viewed as a pedagogy for sustainable development.

Different representations convey different aspects of a phenomenon, hence increasing variation and opportunities for children to experience the teaching content (Fridberg et al. 2018, 2019, 2020; Redfors et al. 2022). Tytler and Prain (2022) discuss the role of the teacher in guiding students to link, confirm, and expand meanings across representations, which is fundamental for students to learn concepts and processes in e.g. science. Transduction in this study refers to the process where children transduce meaning of specific content based on the experience of several different representations of that content that teachers help them link.

3 Research methods

The study focuses on work in two preschools in Sweden. They applied for and received a grant for an innovation project, with the aim of developing teaching of AR and SD. The researchers collected and analysed two preschool teachers' pedagogical planning documents and their final written report on the project. The content in these documents served as a foundation for a follow-up interview conducted with the two preschool teachers by one of the researchers. The interview was audio-recorded and transcribed in full. A double-blinded conventional content analysis (Hsieh & Shannon, 2005) was conducted by the two researchers. Ethical considerations were made according to guidelines from the Swedish Research Council (2017).

4 Results

Examples of the preschool teachers’ descriptions of how children’s understanding of SDG:s is transduced between different representations and places are presented in four themes. The first theme is *AR and SD: Thematic teaching,* and here, the preschool teachers e.g. stress the need to treat AR as a ‘what’ (content) in teaching situations before using it as a ‘how’ (tool) to learn about SD. The second theme is *AR and SD: Children’s agency*. Examples of this include children’s initiative in writing to the municipality and interactions with their local neighbourhood. *AR and SD: Teacher perspective* encompasses the preschool teachers' view on, e.g. structural prerequisites and knowledge needed for the teaching of AR and SD. Finally, *AR: What is real and what is not?* includes descriptions of children’s initial confusion around augmented reality technology.

4 Discussion and conclusion

The results of this study point to five key points in thematic teaching of AR and SD in preschool, discussed in the paper:

- *There is value in learning AR first before using it as a tool for ESD*. An initial more multidisciplinary approach, with content separated in time, could be fruitful in thematic teaching that involves digital content previously unknown to the children.
- *Children's own ideas, self-generated images and familiar places are important motivational factors when learning AR and ESD,* and children's agency should be a crucial part of the teaching of the same.
- *Teachers need structural prerequisites* to be able to prepare and develop knowledge and consciousness about teaching AR and ESD.
- *A varied individualised teaching is crucial* for children in a group to be able to link and transduce the meaning of ESD between different representations.
- *Children's linking and transducing of different representations, especially in terms of what is real and not, requires active teaching.*

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LITERARY TEXTS IN UPPER SECONDARY SCIENCE TEACHER EDUCATION

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Abstract

This presentation discusses why and how literary texts could be incorporated in science teacher education as a step towards increasing the relevance of school science. Previous research has suggested that using literary texts in science teaching can facilitate science learning as well as contribute to enhanced social justice in various ways. The presentation describes and evaluates experiences from a non-mandatory book-club project that was implemented in science teacher education. Five upper secondary pre-service science teachers took part in the book club (1 year, 4 meetings) and shared their experiences in a focus-group interview at the end of the project. The analysis of the interview shows that the pre-service teachers expect the same kind of benefits from using literary texts in their teaching as suggested in previous research, but that these expectations do not fully align with their ideas of how their future teaching might be orchestrated. We discuss how the incorporation of literary texts in science teacher education must be accompanied by opportunities for didactic analysis related to different choices for teaching and the consequences of such choices for students' possibilities to learn and take part in science.

1 Introduction

Science educators around the globe advocate science education that highlights critical citizenship, the role of science in society and values of democracy and ethics. To meet these demands, science teacher education must contribute with broad images of science and a broad variety of ways to reflect on and approach science teaching. Previous research has suggested that the incorporation of literary texts (e.g. novels, short-stories, biographies, poems and comic books) might contribute to a broader school science by adding perspectives and contexts that might make it more relevant to the students. With a point of departure in such suggestions, this presentation describes the design, outcomes and experiences from a book-club project where literary texts were incorporated in upper secondary science teacher education.

2 Background

Science education studies have produced three main arguments for including literary texts in science teaching. The first group of arguments revolve around the potential of literary texts to increase students' interest and engagement in relation to science (Avraamidou & Osborne, 2009), which in turn is seen as an important factor in facilitating science learning (Klassen & Froese Klassen, 2014). The second group of arguments is related to the potential of literary texts to contribute to social justice by becoming a bridge between different forms of knowledge creating connections between students' everyday life, science and school science. These connections can make room for various discourses to meet and be negotiated, thus helping students navigate various communities (Moje et al., 2004). Moreover, the connections are believed to contribute to young people's identity building and to create a relation to science for students who do not normally position themselves within science (Boswell & Seegmiller, 2016; Moje et al., 2004). The third group of arguments is related to the responsibility of all school subjects to contribute to students' development of general literacy and reading abilities (Bradbury, 2014).

Few studies in the field have focused on pre-service science teachers and teacher education. It has, however, been argued that teacher education has an important role to play in enhancing pre-service teachers' competence and self-confidence in incorporating literary texts in science teaching (Avsar Erumit & Akerson, 2022).

3 Research methods

The aim of the project was to explore how book club discussions can contribute to develop pre-service science teachers' views of science teaching and lay a foundation for continuous collegial learning. Participants were five second- and third-year pre-service secondary science teachers. They were invited to join a non-mandatory on-campus book club through a notice on their digital learning platform. The general idea for the book-club meetings was that each meeting should contain two parts, one connected to the personal reading experience and one to the development of didactic competence. The project leaders were a science educator and a university librarian. Both project leaders had a joint responsibility to moderate the discussions of the personal reading experiences. The librarian was also responsible for providing ideas on how to find relevant literature, while the science educator was responsible for guiding discussions in connection to science teaching. The discussions related to science teaching reconnected to the pre-service teachers' previous courses in didactics of science. During these courses, they had, for instance, developed knowledge related to teaching about *Nature of science* and *Socioscientific issues*.

The project lasted two semesters and consisted of four book club meetings (2 hours each) and a focus-group interview at the end of the last meeting. The focus-group interview dealt with the pre-service teachers' experiences from taking part in the book club and their ideas of opportunities and difficulties connected to including literary texts in secondary science. The focus group interview was transcribed and coded in relation to three analytical questions that were created to provide different perspectives on the main research question: *Why and how might literary texts be incorporated in science teacher education?* The analytical questions were: a) How can preservice-science teachers learn about the role of literary texts in science teaching?; b) What did they learn/gain from participating in the book club?; c) What role did they assign to literary texts in their future teaching? The focus group interview was analysed by using conventional content analysis (Hsieh & Shannon, 2005). A summary of the resulting themes is presented in Table 1.

***Table 1**: Summary of themes for each analytical question*

How did they learn?	What did they learn/gain?	Literary texts in future teaching
Collaborative learning and shared experiences	Personal *reading experiences/habits*	Facilitate learning of *science concepts*
Balance informal/formal, non-mandatory/mandatory, reading experience/didactic discussion	Broader view of and *ideas for science teaching*	Connect science to *everyday life and democracy* (focus on SSI and NOS)
		Enhance *reading abilities*
		Include literary texts in a *non-extensive fashion.*

4 Results

In summary, the pre-service teachers claimed that the book club contributed both to their reading of literary texts and to reflections on school science. They deemed the combination of discussions about their personal reading experience and the discussions about teaching to be imperative in creating a feeling of openness not only about books but also about science teaching. New ideas, a feeling of co-learning, and gaining insights from each other's perspectives grew from the combination. Furthermore, they all claimed that the book club influenced their own reading habits in various ways. They had, for instance, all been reading more books and other books than they would normally choose.

Moreover, the pre-service teachers discussed three main goals that they expected to reach by using literary texts. These goals align with goals and suggestions in previous studies (see section 2): literary texts as a way to facilitate and increase the learning of science (mainly due to contextualisation); literary texts in science class as a contributor to students' reading abilities; literary texts as a connection between science and everyday life, thus becoming a contributor to democracy. The latter was the most commonly discussed goal during the focus-group interview.

However, when the pre-service teachers tried to envision how literary texts might be incorporated in science teaching, the focus on democracy diminished in the light of difficulties in accommodating literary texts with teaching traditions they had encountered during work placement. In light of these experiences, they argued that the incorporation of literary texts would mainly be for inspirational purposes in relation to science concepts.

4 Discussion and conclusion

Previous research has shown that science teacher education has an important role to play in preparing pre-service (and in-service teachers) to incorporate literary texts in science teaching in fruitful ways (Avsar Erumit & Akerson, 2022).

Experiences from the book-club project presented here have provided insight into some aspects that could be of importance when incorporating literary texts in science teacher education, such as sharing of perspectives and balancing between discussing reading experience and teaching approaches. These experiences do not have to apply only to a non-mandatory book club format but ought also to be beneficial in mandatory coursework. In the focus group interview, a discrepancy between the pre-service teachers' own ideas of overarching aims and expected benefits connected to the incorporation of literary texts in science teaching was noticed. Here, science teacher education has an important role to play in working with these discrepancies and using them as a basis for didactic reflections in ways that develop pre-service science teachers' abilities to perform a didactic analysis – that is, their didactic competence (c.f. Englund, 1997).

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TEACHER STUDENTS' PRIOR KNOWLEDGE OF WATER PATHWAYS AND WHAT THEY THINK IS ESSENTIAL PUPILS' KNOWLEDGE

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Abstract

This study aims to investigate the prior knowledge of students in teacher programs regarding the path of water through the body as they begin their science courses and their intentions are, i.e. what they think or believe is important knowledge, as they will later teach. The empirical data for this study were collected from a group of teacher students specializing in grades 1-3 and grades 4-6. Data are collected from a drawn figure where the students draw and describe what they think is happening in the body from when they drink water until the liquid is urinated out. Additionally, the survey includes knowledge questions with multiple-choice alternatives and open-ended questions that are related to their future profession as teachers The initial results indicate that the prior knowledge of teacher students aligns with findings from previous studies, showing that connecting more than two organ systems is challenging. However, the pre-service students state that the most important thing they want to teach their pupils is about the function of water in the body. Regarding the importance of drinking water, 12 out of the 48 provided a more scientific explanation. The teacher's students do not frame lack of interest as a challenge.

1 Introduction

Students in Swedish schools and internationally find it challenging to describe what happens to the water from when a person drinks water until the person urinates out the liquid. The problem is that the description of the process itself, even at a macro level, requires that the person understand the connection between several organ systems (at least the digestive, circulatory, and excretory systems). It has also been shown that there are several different non-scientific explanatory models that students and adults use to explain what happens to the water in the body. Other studies show that the transitions between organ systems make understanding problematic, not least because the explanation requires a knowledge of the invisible, i.e., micro-levels. This study has focused on the pre-service teacher student's prior knowledge they have brought with them into teacher education and their expectations about teaching science in grades 0-6. This study focuses on determining at what level students can perceive the body as a system. The process of water flow through the body serves as a scenario for exploring how students perceive the connections between different organs and organ systems (e.g Granklint Enochson et al 2015; Granklint Enochson & Redfors 2012; Tunnicliffe 2004) and that even university students find it challenging to acquire this knowledge (Granklint Enochson 2023; Clément 2003). Students have had the opportunity to learn about the body and its organs from preschool through upper secondary school. A large part of the curriculum and textbook content at all stages in the mandatory school system is focused on the human body (Skolverket, 2018), and some of the upper secondary school courses (Skolverket, 2013).

The news in this study is to see how the knowledge about the water pathway corresponds with the students' knowledge of the importance of water in the body. Also, what kind of teaching challenges do the students highlight before they enter the science course at the university?

2 Theoretical backgrounds

The knowledge itself is built on by adding further knowledge, i.e. knowledge that we have previously acquired is the basis for generating new knowledge (Ausebel, 1968). However, to build upon this knowledge, the child needs help to understand explanations of different phenomena around them, and they need opportunities to develop their understanding. Students' answers could be interpreted as misconceptions, but sometimes the student's answers can be related to the science that the students are being taught in school does not harmonize with the ideas that are prevalent in their everyday culture (Phelan et al., 1991; Aikenhead, 2006; Lemke, 2001). It's also possible that the students haven't been introduced to the topic in a way that allows them to develop a scientific approach to the content (Vygotsky, L., 1934/1986).

3 Research methods

Sample

The participants in the survey are 48 prospective pre-service teachers. The students are enrolled at a Swedish university and are admitted to getting a degree in Master of Arts in Primary Education, either in School Years 4–6 or Pre-School or School Years 1–3. All the students are in year three of a four-year education. The data was collected on their first day of the science course, none of the students had previously taken university-level biology courses.

Tab 1. The students as participants in the study.

Pre-service teachers with the aim to teach in:	Number of participants	Female/Male
Grade 0-3	25	20 female, 5 male
Grade 4-6	23	13 female, 10 male

Empirical collection

The empirical data are based on a questionnaire comprising two parts; one consisted of a non-gender-specific human body on which students could draw the path of water through the body, and the other had open questions about their intentions to explain the passage of water through the body to the preschool children. Another open-ended question was included concerning the importance of drinking water and the intentions of the pre-service teachers to convey this information to a pupil.

Analysis

Analysis of the collected material was categorized according to a system, as described by (Granklint Enochson and Redfors, 2012, 2015), which is based on how closely the pre-service teachers' sketches and text were analyzed

A. No answer, or answer not related to the question.
B. Non-scientific descriptions based on alternative ideas of the organ system.
C. Descriptions following a scientific explanatory model – important parts were missing.
D. Descriptions following a scientific explanatory model – important parts included (at least 3 organ systems – digestive, circulation, excretion).

The open-ended questions reflected the pre-service teachers' levels of knowledge about the water pathway, including their understanding of the connections between organ systems and the function of water."

4. Results

Preliminary results show that category B (Non-scientific descriptions based on alternative ideas of the organ system) and C (Descriptions following a scientific explanatory model – important parts were missing) were the most common answers.

***Table 2**: The categorization of the teacher students' knowledge*

Pre-service teachers with the aim to teach in:	Category				
	A	B	C	D	Sum
Grade 0-3	4	7	7	7	25
Grade 4-6	5	7	9	2	23
In total	9 (19%)	14 (29 %)	16 (33%)	9 (19%)	48 (100%)

There is no direct correlation between the students' knowledge of the water pathway and the function of water but there are some statements made by the students that are worth noting. For example, 12 of the 48 gave a more scientific explanation 3 of the students misconceived the function of water and believed that the water was a part of the breakdown process.

***Table 2**: Some of the teacher students believes about the waters function in the body*

Water breaks down nutrients	The function of water in the body such as transportation of nutrients or regulation of temperature
A: 0 B: 1 student C: 1 student D: 1 student In total 3 students	A: 2 students B: 4 students C: 4 students D: 2 students In total 12 students

The students' question: “What difficulties/restrictions can occur in connection with teaching about the water found in the body, i.e. what problems can arise in the teaching situation?” In response to this question, most teacher students indicated general academic reasons. Quite a few were worried about their ability. However, there were only a few students – 2 in F-3 and 4 in F-6 – who indicated disinterest in the subject as a challenge.

The multiple-choice questions will be analysed until the conference takes place.

5 Discussion and conclusion

According to previous studies, there are more non-scientific explanations among the students in this study than it is among grade 9 students (Granklint and Redfors, 2012) but less than in a study done with pre-service students taught in pre-school (Granklint Enochson, 2023). It is also interesting tat the students themselves do not see a challenge with the lack of interest when they in the future shall educate pupils. Hofstein et al., (2011) and others frame the lack of interest as a huge challenge in teaching.

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PRESCHOOL CHILDREN’S AGENCY IN PLAY-ACTIVITIES WITH SCIENTIFIC CONTENT

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Abstract

The Swedish preschool educational tradition is based on a holistic view where care, play, learning, and teaching are intertwined. Previous research argues for the need to develop teaching approaches that simultaneously direct focus towards content and children´s perspectives. This presentation describes a study that explored how preschool children’s agency can be supported in activities that integrate play and scientific content. The empirical data consists of video-observations of teachers’ and children’s (2-4-years) participation in activities that integrate play and scientific content. The theoretical framework of Play-Responsive Early Childhood Education and Care (PRECEC) is used. Here, teaching and play are understood as a mutual activity. In these mutual activities, teachers and children are constantly shifting back and forth between *as if* (pretending) and *as is* (knowledge of the world as it is) (Pramling et al., 2019). Three narratives have been chosen that exemplify different ways in how children’s agency is supported in activities that integrate play and scientific content. That is, teachers took an active role in play to support children’s agency. The teachers showed responsiveness to the children’s initiatives, which contributed to the development of the *as if*-dimension of play, and exploration of science content in terms of *as is*.

1 Introduction

There is an ongoing discussion about how teaching approaches that direct focus towards a learning object, and simultaneously incorporate children’s perspectives can be orchestrated (see Thulin, 2011) and the concept of teaching needs to be clarified without compromising the preschool tradition of play-based education (Williams & Sheridan, 2018). In relation to science teaching, Hansson et al. (2020) argue that more research is needed regarding what science content in early childhood education can entail, and possible ways for preschool teachers to approach it. A study conducted by Henriksson et al. (2023) reports that it is possible to both teach science and have play in focus if a responsive preschool teacher takes an active part in the activities. It is common that science in preschool is described as focusing either on detached facts (a facts-tradition) or on detached investigative activities (a doing-tradition). However, both traditions omit questions concerning how knowledge has been developed and human involvement in the process (Hansson et al., 2021). In relation to why science should be taught in preschool, the arguments have long been about children's rights to gain an understanding of the world around them (Eshach & Fried, 2005; Siraj-Blatchford, 2001). Moreover, Hansson et al. (2021) argue for the need to expand the understanding of what science teaching in preschool entails in relation to democracy, justice, and children's agency. An educational practice, that integrate play, learning and care with science teaching, has the potential to prepare children for future citizenship (Larimore, 2020). This presentation suggests that Play-responsive teaching (Pramling et al., 2019) has the potential to bring the preschool's tradition of a play-based education and science teaching together, as play and teaching become a mutual activity, where preschool teachers and children are equally engaged (Pramling et al., 2019). However, Play-responsive teaching in relation to science teaching and children’s agency is still an under researched area, where more empirical studies are needed. The overarching aim of the study that this presentation is based on, is to contribute with knowledge about how children's agency is promoted in activities that integrate play and scientific content.

2 Theoretical background – Play-Responsive Early Childhood Education and Care (PRECEC)

Play-responsive early childhood education and care (PRECEC) developed by Pramling et al. (2019) advocates a view where play and teaching are defined as a mutual activity, where both teachers and children are equally important. Teaching is defined as something that take place in interaction between participants, when you want someone else to see or realise something. In play-activities, teachers and children are constantly shifting between the imagination and fantasy dimension of play, and conventional knowledge of the world. These shifts can be described in terms of *as if* and *as is* (see Henriksson et al., 2023; Pramling et al., 2019). Teachers can also create space for co-narration in the play, such as introducing characters that challenge children's imagination in terms of *as if*, or by asking problem-solving questions that aim to evoke children's interest in content in terms of *as is.* This way of directing someone else's attention towards content is referred to as *triggering* (Pramling et al., 2019). In this presentation, the concepts of *as is/as if* and *triggering* are used to understand how teachers show responsiveness to preschool children's initiative, as a way of showing agency, in activities that integrate play and scientific content.

3 Research methods

The empirical material consists of four video-observations (in total approx. 2h). Data were generated at one preschool during a three-month period. One preschool teacher and one school-age educator participated during all video-observation sessions together with four to six children at a time (2-4-years). To integrate scientific content with play, the teachers acquired inspiration from the fairytale *Torsten's journey out into the wide world* (Swedish: *Torstens resa ut i vida världen*, Holmgren, 2010). In the book, a boy named Torsten and his grandmother fly around the world sitting in her rocking chair. The fairytale deals with environmental issues in relation to human life (i.e., climate crisis, extinction of animals, and lack of water).

The study follows the Swedish Research Council (www.vr.se) ethical guidelines for research. All participants, teachers and the children's guardians were given consent forms and information about the study. Before and during each video-observation session, consent was considered through children's verbal- and non-verbal expressions, and they could choose to leave the session at any time.

A qualitative content analysis was performed (Hsieh & Shannon, 2005), with a focus on how children's agency was supported by teachers in activities where play and science content are integrated. Video-sequences of activities that incorporated play and scientific content were transcribed (verbal- and non-verbal expressions). This highlight information about what scientific content (environmental issues) that was central. Secondly, initiatives made by the children, as well as how the teachers responded to these, were highlighted. From this analytic process, three excerpts were chosen to provide perspectives on how teachers navigate between various possibilities for promoting children's agency.

4 Results

The first narrative is built around a child's initiative to use an abacus as a representation of an engine for the rocking chair to be able to fly to different continents, in the play activity. The child's initiative is accepted by the other participants and becomes a permanent feature in all following play-activities. The teachers further develop the initiative by focusing on sustainability issues connected to fuel. This narrative shows how children's agency is promoted by giving space to their initiatives in ways that enrich both play and the connections to science.

The second narrative is built around another child's initiative to travel with the rocking chair to a country where turtles live. The child shares factual knowledge about turtles, an initiative that is not fully utilized by the teachers. This narrative is an example of how teachers need to navigate and choose between different initiatives that take place in both the *as is*- and *as if*-dimension of play, something that does not always promote the individual child's agency.

The concluding narrative is built around an initiative from a child to travel with the rocking chair to Greenland, where an investigation about ice, icebergs, and polar bears take place. In this play-activity, the participants use representations such as images on a carpet and a projector screen to support play and the scientific content. This narrative shows how a wide range of representations are used to communicate and share a mutual focus, representing science (*as is*), *triggering* the activity *as is*- and *as if*-dimension*,* which facilitated children's ability to act with agency.

5 Discussion and conclusion

This presentation intends to discuss, based on three narratives, how Play-responsive teaching (Pramling et al., 2019) has potential to integrate play, learning, and science teaching as a mutual activity, and how they merge in promoting children's agency. The narratives show how children's initiatives were used to direct focus towards science related contents and issues (*as is*), and to develop the fantasy-dimension (*as if*) of play. The teachers were able to include children's initiatives into the activities *as is* and *as if*-dimension, by showing responsiveness to the suggestions and at the same time have the scientific content in focus. Implications for promoting in-service and pre-service preschool teacher knowledge about integrating play and science will be discussed during the presentation.

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ENVIRONMENTAL CITIZENSHIP - SWEDISH UPPER SECONDARY STUDENTS INTENDED ENGAGEMENT, ATTITUDES, SUBJECTIVE NORMS AND PERCEIVED CONTROL

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Abstract

To solve ongoing environmental crisis not only knowledge is needed but also citizen being motivated to act for change. The aim of this study was to increase our understanding about upper secondary students' engagement for an environmentally sustainable society. The theory of planned behaviour and the concept environmental citizenship were used as theoretical frameworks. A questionnaire including 15 items concerning current and future engagement and 13 motivational items relating to subjective norms, attitudes and perceived control was developed and administrated to Swedish upper secondary students (*n* = 194). Further, a teaching activity connected to the questionnaire was evaluated. Individual activities in the private sphere, such as saving energy, were deemed as likely by most students while fewer students deemed collective activities in the public sphere, such as participate in a demonstration, as likely to engage in. Engagement was significantly predicted by social norms (β = .42, p < .001) and attitudes (β = .0.41, p < .001) but not by perceived control. The teaching activity connected to the questionnaire did put the limelight on the dilemma to care for the student's privacy and at the same time implementing the curriculum goal that students shall take active part in the society.

1 Introduction

Although scientific knowledge related environmental challenges such as the climate crisis and loss of biodiversity is extensive recommended effort to address them are still not implemented to a sufficient extent. To solve ongoing environmental crisis citizen being motivated to act for change is critical and schools play a crucial role in supporting and encouraging active environmental citizenship (e.g., Hadjichambis et al. 2020; ENEC, 2018; UNESCO, 2021; Swedish National Agency for Education, 2011).

Several studies have shown that students have a desire to engage in society (Manni & Knekta, 2020; Sass et al., 2021; Swedish National Agency for Education, 2016). However, it has also been observed that the school's teaching does not always provide them with sufficient prerequisites to do so and that knowledge and attitudes not always are sufficient for action (Kollmuss & Agyeman, 2002; Manni & Knekta, 2020; Wetering et al., 2022). To effectively encourage active environmental citizenship a better understanding of which factors that could explain engagement in environmental issues is required. The aim of this study was to increase our understanding about upper secondary students current and future engagement for an environmentally sustainable society.

Research question 1. In what type of activities do upper secondary school students intend to engage to contribute to an environmentally sustainable society?

Research question 2. How are upper secondary school students' intentions to act for a more environmentally sustainable society related to their attitudes, subjective norms, and perceived ability to act?

Research question 3. What are possibilities and challenges of using a self-reflective questionnaire with a focus on current and future engagement for an environmentally sustainable society, in Science studies teaching?

2 Theoretical backgrounds

In this project we used the definition of environmental citizenship provided by the European Network for environmental citizenship (ENEC): *Environmental Citizenship* is defined as "the responsible pro-environmental behaviour of citizens who act and participate in society as agents of change in the private and public sphere, on a local, national and global scale, through individual and collective actions, in the direction of solving contemporary environmental problems, preventing the creation of new environmental problems, achieving sustainability as well as developing a healthy relationship with nature" (ENEC, 2018).

The theory of planned behaviour (TPB; Fishbein & Ajzen, 2010) was used as theoretical framework to understand students' indented and actual pro-environmental behaviour. According to TPB students intended behaviour can be predicted from their attitudes towards (appraisal of the behaviour), subjective norms regarding (perceived social pressure), and perceived control over (perceived ease or difficulty) the actual behaviour.

3 Research methods

The questionnaire used were development based on the theory of planned behaviour questionnaire described by Pavalova and Silbereisen (2015). First the students were asked to consider how likely it was that they were to engage in 15 different activities that could contribute to a more environmentally friendly society. The activities were inspired by Stern (2000) and by International Civic and Citizenship Education Study (IAE, 2016) and chosen to represent engagement in the private sphere (save energy or eat less meat for the sake of the climate) and the public sphere such as talk to others about environmental issues or participate in a demonstration. By answering these items, the students did also get prompted with many specific examples of pro-environmental behaviour. Next set of items considered attitudes towards (4 items), subjective norms (3 items), perceived control over (3 items) and behaviour intentions related to (3 items) pro-environmental behaviour.

Before final adjustments the questionnaire was pilot tested by two upper secondary teachers in two classes. The questionnaire was completed by 194 students at five upper secondary schools. Seven different upper secondary programs were represented.

Data was first analysed by means of descriptive statistics to get an overview of students' current and intended pro-environmental behaviour as well as attitudes, subjective norms, and perceived control. Secondly relationships between behaviour, subjective norms, and perceived control were analysed by means of correlations and linear regression.

4 Results and Discussion

Students' engagement in different activities that could contribute to a more environmentally friendly society: A relatively large variation was found with respect to how likely it as that the students were to engage in the different activities included in the questionnaire. In line with findings from Sass et al. (2012) the activities most students thought they were likely to engage in the future were individual activities in the private sphere such as saving energy (53% agreeing) or consciously consume less for the sake of the environment (45% agreeing). Fewer students deemed it likely that they would engage in collective activities in the public sphere such as participate in a demonstration (10% agreeing), create a group to work for change in the society connected to the environmental issues (5% agreeing), or take contact with a politician (9% agreeing). Overall, future engagement was deemed as likely by far more students compared to current engagement where only between 2 and 27% of the students responded that they already are or have been engaged in the activities. The correlations between the different types of activities were moderate to high (Spearman's ρ = .40 – .68) for most activities.

Relationship between indented engagement and attitudes, perceived control, and subjective norms: Moderate to high correlations (Spearman's ρ = .50 - .72) were found between intended engagement and attitudes, perceived control, and subjective norms, with lowest correlations for perceived control. The subjective norm item "People that are important to me try to act for an environmentally friendly society" had the highest correlation to intention to act for an environmental friendly society (Spearman's ρ = .72). A linear regression ($R^2 = .73$, $F(3, 142) = 130$, $p < .001$) based on scale mean score showed that indented engagement was significantly predicted by subjective norms (β .42, $p < .001$) and attitudes ($\beta = .0.41$, $p < .001$). That attitudes and not perceived control explains intended behavior are in opposite to prior studies (Pavalova & Silbereisen, 2015).

Possibilities and challenges of using a self-reflective questionnaire: Teaching activities relating to active engagement in environmental issues in society was uncommon for both participating teachers and thus challenged them to go outside their comfort zone. To ask the students to reflect on their own actions in relation to environmental issues did put the limelight on the dilemma to care for the student's privacy in a classroom and at the same time implementing the curriculum goal that all students shall individually show respect and care for the environment as well as take active part in the society.

Didactical implications of the results for environmental citizenship education will be discussed.

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DELVING INTO "THE NEXT BLACK BOX" – A STUDY ON STUDENT SELF-ASSESSMENT IN UPPER SECONDARY SCHOOL

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Abstract

Students' ability to self-assessment can have a significant impact on their academic performance and deeper learning. Self-assessment pertains to the ability of students to gather information about their own performance and use that information to evaluate and reflect on the quality of their learning process and products. Although there's a growing body of empirical research investigating student self-assessment, a research gap has been identified concerning the cognitive and affective mechanisms involved. Additionally, research findings underscore how contextual factors may affect students' implementation of self-assessment. The present study aims to address this research gap by investigating what factors predict the intentions and practices of students' self-assessment in science in upper secondary school, and potential correlations between students' self-assessment practices and their approaches to learning. The sample comprises 968 upper secondary students who responded to a survey regarding self-assessment and learning approaches in science. The preliminary findings indicate a correlation between the distinct predictors and students' self-assessment intentions and practices, as well as a correlation between students' self-assessment practices and their approaches to learning.

1 Introduction

In preparing students for handling the complexity of modern societies, the educational system must focus on deeper learning, including metacognition and self-regulated learning (SRL). Deeper learning is a central goal of the Norwegian national curriculum (LK20), where metacognition and SRL are highlighted as important cross-curricular competencies. Self-assessment can have a positive impact on academic performance by promoting metacognition and SRL (Yan, 2022).

Limited research has been conducted on the topic of student self-assessment within the context of science education in upper secondary school. The present study will address this gap by investigating the following research questions:

- "*Which factors predict student's self-assessment intentions and practices?"*
- *"What is the correlation between students' self-assessment practices and their approach to learning?"*

2 Theoretical backgrounds

There exists a wide range of descriptions of the behaviours considered to be student self-assessment, ranging from simple to complex, as well as the underlying objectives these self-assessments aim to fulfil. Self-assessment can be defined "… as a process during which students collect information about their own performance, evaluate and reflect on the quality of their learning process and outcomes according to selected criteria to identify their own strengths and weaknesses" (Yan, 2022, p. 15).

Research spanning educational tiers indicates that appropriately implemented student self-assessment can significantly enhance academic performance, foster SRL skills – encompassing monitoring, evaluating, and reflecting on their own learning processes – and positively influence affective outcomes, including motivation, engagement, and self-efficacy (Yan, 2022). It is strongly suggested that the most advantageous outcomes of self-assessment, concerning both achievement and SRL, are attained when it is utilized formatively and complemented by adequate training (Andrade, 2019). However, the self-assessment process is complex and its effect on student performance varies within diverse contexts (Yan, 2022). As self-assessment is a student-driven process, it becomes imperative to acknowledge the variables that might influence students' motivation and involvement in this evaluative practice (Yan, 2022). The cognitive and affective mechanisms of student self-assessment are in the research literature referred to as "the next black box" (Andrade, 2019), hence more research is needed.

3 Research methods

In this quantitative study, 968 first-year students from 46 classes in 9 upper secondary schools, encompassing two rural and nine urban in western and eastern Norway, responded to a survey. All data were collected according to an ethical approval from the Norwegian Agency for Shared Services in Education and Research.

The survey is a translation of two previously validated questionnaires; the extended version of the Self-assessment Practice Scale (SaPS) (Yan et al., 2020) and the revised two-factor version of the Learning Process Questionnaire (R-LPQ-2F) (Kember et al., 2004). This includes 82 items spread across 15 subscales measuring students' self-assessment practices, predictors of self-assessment intention and practice, and students' approaches to learning (see Figure 1 and Table 1). The items are measured using a six-point Likert scale (1 = strongly disagree to 6 = strongly agree). In addition, the survey includes 6 items on students' background, such as science grade, gender identity, etc.

In initial analysis, the 15 scales were created in SPSS, followed by descriptive and correlation analyses. The forthcoming analysis will entail confirmatory factor analysis and path analyses utilizing SPSS Amos, supplemented by descriptive statistics in SPSS. This aids in assessing a measurement model of the latent variables, featuring varied item loadings, and examining complex networks of interrelated variables.

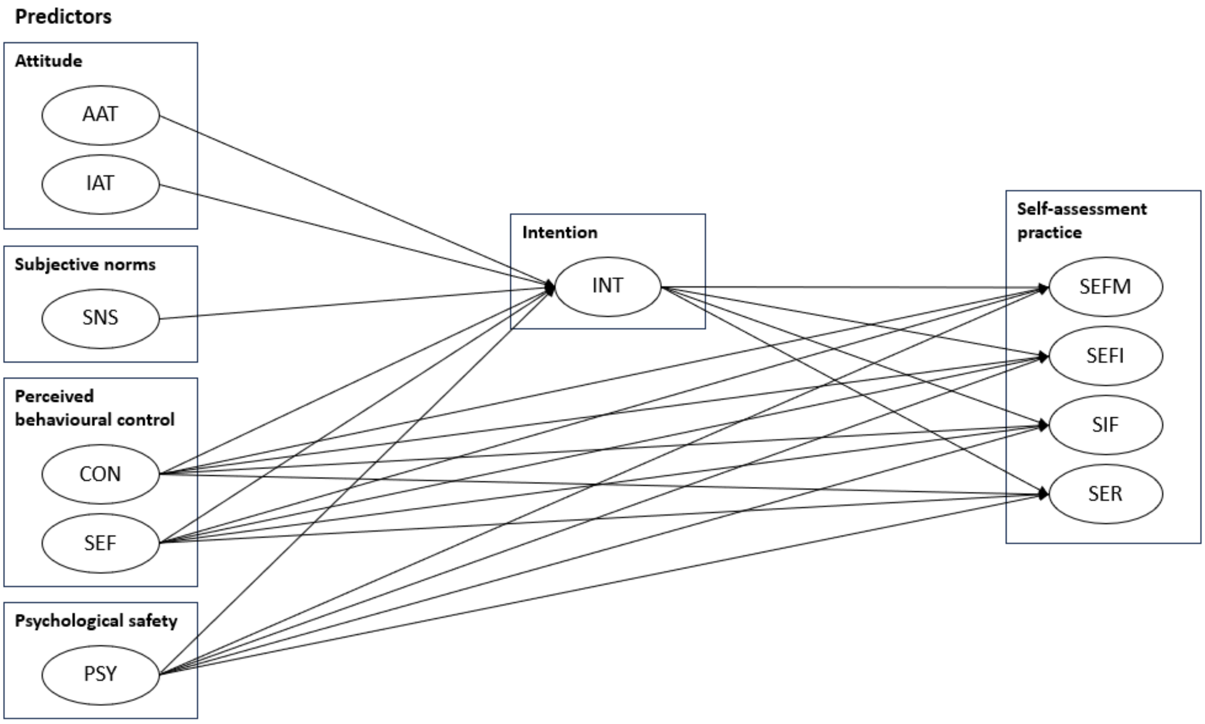

***Figure 1**: Hypothesized model for predictors of self-assessment intentions and practices as proposed by Yan (2022). The assumed interrelations between the predictors and between the self-assessment practices are not depicted in the figure to maintain clarity. AAT = affective attitude towards self-assessment, IAT = instrumental attitude towards self-assessment, SNS = sense of subjective norms, CON = controllability, SEF = self-efficacy, PSY = psychological safety, INT = intention to conduct self-assessment, SEFM = seeking external feedback through monitoring, SEFI = seeking external feedback through inquiry, SIF = seeking feedback from internal sources, SER = self-reflection.*

***Table 1:** Hierarchical factor structure of R-LPQ showing the four subscales DM, DS, SM and SS*

Deep approach				**Surface approach**			
Deep motive (DM)		**Deep strategy (DS)**		**Surface motive (SM)**		**Surface strategy (SS)**	
Intrinsic interest	Commitment to work	Relating ideas	Understanding	Fear of failure	Aim for qualification	Minimizing scope of study	Memorisation

4 Preliminary results

All scales demonstrate satisfactory Cronbach alpha values. However, the PSY scale stands out as it showed indications of misfit. A thorough analysis and discussion of all scales will be conducted in the subsequent analysis.

Histograms with a normal curve, as well as descriptive statistics from SPSS, were utilized to examine the kurtosis and skewness of all scales. The results indicate that the responses concerning all self-assessment predictors adhere to a normal distribution, with their central tendency aligning closely with the mean value of the Likert scale (see Table 2). The self-assessment practice scales also exhibit conformity to a normal distribution, but only SEFM and SEFI demonstrate mean values closely proximate to the Likert scale's mean value. Conversely, SIF and SER displayed the highest mean values of the self-assessment actions (M_{SIF} = 4.33 and M_{SER} = 4.27). This implies a predilection among students for seeking internal feedback on their performance rather than external feedback during the self-assessment process. Furthermore, students typically reported heightened expectations regarding their own self-reflection abilities.

Of all the scales SM has the highest mean value (M_{SM} = 4,83) and is also the only scale showing a significant skewness towards the right side of the Likert scale. This suggests that a considerable portion of students exhibit a surface motive to learning, characterizes by a fear of failure or an aim for qualification. This inclination remains consistent despite variations in their individual self-assessment practices or learning strategies. The students who responded above 4 on SM, on average also responded higher values on all the other scales. These results are interesting and will be explored in further analysis.

Table 2: *Mean value and standard deviation for the various scales*

Scale	AAT	IAT	SNS	CON	SEF	PSY	INT	SEFM	SEFI	SIF	SER	DM	DS	SM	SS
Mean	3,43	3,67	3,86	3,97	3,98	3,45	3,62	3,57	3,44	4,33	4,27	3,55	3,99	4,83	3,77
Std. Deviation	1,12	0,97	0,82	1,05	0,89	0,87	0,98	0,91	0,93	0,85	0,84	0,88	0,94	0,89	0,75

SPSS provided the Pearson's correlations between the scales. Apart from the PSY and SS scales, all the scales exhibited positive and statistically significant correlations. The most substantial correlation was observed between AAT and IAT (p = .837). This is not surprising given that both scales address students' attitudes towards self-assessment. AAT, IAT, SNS, CON, SEF all show significant correlation with INT, as predicted from the hypothesized model in Figure 1, with AAT and IAT showing the highest correlations (p = .759 and p = .819 respectively). Within the context of self-assessment practice, INT exhibits the highest correlation with SEFM and SER (p = .579 and p = .569 respectively). There is a negative correlation between INT and SS, suggesting that students who are willing to conduct self-assessment are less inclined to employ surface learning strategies. Furthermore, SEFM and SER show a moderate to high correlation with DM and DS, and a negative correlation with SS. The abovementioned results are coherent given that self-assessment does not align with a surface learning strategy, typified by minimizing the scope of study and reliance on memorization. The only scales with a significant and positive correlation with SS, are PSY and SM. Given the negative tone of the items within PSY, a positive correlation observed between PSY and SS implies that students with lower levels of security in their interpersonal and personal aspects of self-assessment tend to be more predisposed towards employing surface learning strategies.

All the findings will be explored and elaborated in subsequent analysis.

5 Preliminary discussion and conclusion

The preliminary findings imply a correlation between the distinct predictors and students' self-assessment intentions and practices, as well as a correlation between students' self-assessment practices and their approaches to learning. Subsequent analyses will delve into these relationships and explore the interrelation among the latent variables. Of particular interest is the investigation into the correlation between students' self-assessment practices and their approaches to learning, offering a novel contribution to the current utilization of the employed questionnaires. All results will be presented at NFSUN.

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SECONDARY HIGH SCHOOL TEACHERS SCAFFOLDING OF INQUIRY-BASED LEARNING IN THE CHEMISTRY CLASSROOM

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Abstract

In Norway, Inquiry-Based Learning (IBL) is an integral part of the science education curriculum, and empirical research has demonstrated that teachers' guidance plays a crucial role in students' achievements in IBL. The primary objective of this research is to examine the utilization of scaffolding strategies by secondary high school chemistry teachers in facilitating IBL in their instructional practices. Qualitative methodologies, such as observation and interviews, are employed to elucidate the scaffolding strategies employed by the teachers. The preliminary findings of this study indicate that teachers employ a diverse array of scaffolding strategies to support students' learning through IBL. Most of the strategies are given to facilitate students' conceptual and procedural understanding, with comparatively fewer scaffolds pertaining to their epistemic and social comprehension. To enhance students' learning outcomes, we recommend that teachers incorporate additional scaffolding strategies addressing the epistemic and social domains of knowledge.

1 Introduksjon og teoretisk bakgrunn

Utforskende arbeidsmåter (UA) karakteriseres som en elevaktiv undervisningsmetode, der elevene øver naturvitenskapelige praksiser som kritisk tenkning, formulering av spørsmål, planlegging og gjennomføring av undersøkelser, tolking av data og bruker disse som bevis, argumentasjon, utvikling av modeller og kommunikasjon av funn (Crawford, 2014). UA kan videre gi elever forståelse for sentrale kunnskapsområder (konseptuell, epistemisk, prosedural og sosial) innen naturvitenskapen (Furtak et al., 2012; Teig et al., 2021). Disse kunnskapsområdene er sammenvevde og dermed avhengige av hverandre for å få en helhetlig forståelse (Duschl, 2008).

Forskning viser at lærere spiller en viktig rolle for å støtte elevenes arbeid med UA. De kan gi elevene nødvendige støttestrukturer, verdsette og bygge videre på resonnementene deres, samt knytte teori til erfaringer og opplevelser (Engeln et al., 2013; Kjærnsli et al., 2021). Bjønnes & Kolstø (2015) argumenterer for at lærere kan fremme elevers læringsutbytte ved å gi klare rammer og støttestrukturer. Rammer kan sette betingelser som fokus og fremdrift for undervisningen, mens støttestrukturer inkluderer mer konkrete verktøy elevene kan få underveis, som hjelp for å navigere gjennom rammen (Knain et al., 2019). Støttestrukturer kan bidra til redusert kompleksitet i aktiviteten.

Til tross for at flere studier har understreket betydningen av lærerens rolle i UA (som f.eks. Aditomo & Klieme, 2020; Hmelo-Silver et al., 2007), gir disse studiene begrenset innsikt i *hvordan* lærere kan redusere kompleksiteten for elevene. Dette ønsker vi å undersøke nærmere i vår studie, med følgende forskningsspørsmål: *Hvordan benytter kjemilærere i videregående skole rammer og støttestrukturer for å støtte elevenes læring gjennom utforskende arbeidsmåter?*

2 Metode

Studien vår bygger på kvalitativ forskning, der vi observerer kjemilærere i klasserommet og intervjuer dem i etterkant. Hittil har vi samlet inn data fra fire lærere, men vi planlegger å utvide datainnsamlingen med flere lærere i løpet av våren 2024. Utvalgskriteriene for deltagerne er at de underviser elever i kjemi enten på VG2 eller VG3-nivå.

Observasjonene er gjennomført som ikke-deltagende observasjon (Cohen et al., 2018), der tredjeforfatter observerer ett utforskende undervisningsopplegg i klasserommet for hver intervjuet lærer. Observasjonene er gjort som forberedelser til semistrukturerte dybdeintervjuer (Cohen et al., 2018), som gir innsikt i hvordan lærere i praksis legger til rette for elevers læring gjennom UA. Intervjuene er også gjennomført av tredjeforfatter.

Intervjuene analyseres ved hjelp av deduktiv innholdsanalyse (Hsieh & Shannon, 2005), der de ulike rammene og støttestrukturene som fremkommer under intervjuene, kategoriseres i et todimensjonalt rammeverk. Den ene dimensjonen skiller mellom rammer og støttestrukturer, inspirert av Knain et al. (2019), mens den andre dimensjonen skiller mellom kjennetegn på de ulike fasene i UA (forberedelse, datainnsamling, konsolidering, sosiale perspektiver), basert Rönnebeck et al. (2016) sitt rammeverk. Da noen av rammene og støttestrukturene gjelder alle fasene, har vi opprettet en egen kolonne for «alle faser» (se tabell 1 i Resultat).

3 Resultat

Analyser basert på de fire første intervjuene avslører at lærere benytter seg av ulike rammer og støttestrukturer for å støtte elevenes læring gjennom de ulike fasene av UA (tabell 1). Noen av disse er gjennomgående for hele aktiviteten, mens andre brukes i spesifikke faser av UA, og grad og omfang varierer blant lærerne. Rammer som angir tema for økten, tydelige tidsfrister og antall frihetsgrader dominerer, sammen med aktivitetens formål. Enkelte lærere gir elevene klare mål i begynnelsen av timen, mens andre er mer forsiktig med å definere slike i utforskende økter. Når det gjelder støttestrukturer, ser vi også forskjeller blant lærerne, særlig de strukturene som er direkte knyttet til ulike faser av UA. De mer kontinuerlige strukturene som går gjennom hele undervisningsprosessen, slik som veiledning, benyttes av alle lærerne. Dette kommer til uttrykk ved at lærerne kommuniserer med elevene underveis, for å sikre at de går i riktig retning.

Tabell 1: *Rammer og støttestrukturer koblet til de ulike fasene i utforskende arbeidsmåter.*

	Alle faser	**Forberedelse**	**Datainnsamling**	**Konsolidering**	**Sosiale perspektiver**
Rammer	• Oppgaveformulering • Strukturering av prosessen • Frihetsgrader	• Tema	• Åpen eller gitt fremgangsmåte	• Mål • Krav til sluttprodukt	• Gruppearbeid
Støttestrukturer	• Veiledning	• Lekser • Utelukking av fagstoff • Eksempler på problemstillinger • Ressurser til fagstoff	• Mal for periodeplan • Demonstrasjon • Nødvendig utstyr satt fram og gruppert • Utstyrsliste og fremgangsmåte	• Mal for rapport • Reaksjonsligning • Felles gjennomgang	• Rollefordeling innad i gruppene

4 Diskusjon og konklusjon

I diskusjonsdelen ses bruken av lærernes rammer og støttestrukturer opp mot de fire kunnskapsområdene beskrevet av Duschl (2008) og Furtak et al. (2012).

Det konseptuelle kunnskapsområdet er knyttet til konstruksjon av nåværende forståelse innen naturvitenskap (Duschl, 2008; Furtak et al., 2012). Det omfatter fakta, teorier og vitenskapelige prinsipper (Teig et al., 2021). Rammer og støttestrukturer knyttet til dette området, kobles primært til forberedelses- og konsolideringsfasene. Eksempler kan være felles gjennomgang på slutten av økten, reaksjonslikninger, utdeling av lekser og tilgang til ressurser.

Rammer og støttestrukturer knyttet til det epistemiske kunnskapsområdet handler om hvordan kunnskap blir konstruert og evaluert. Eksempler på støttestrukturer i dette området inkluderer blant annet maler for rapportskriving, felles gjennomgang og veiledning.

Det prosedurale kunnskapsområdet er relatert til variasjonen av naturvitenskapelige metoder, prosedyrer og praksiser som er nødvendig for å tilegne seg naturvitenskapelig kunnskap (Furtak et al., 2012). Rammer og støttestrukturer knyttet til dette området er hovedsakelig relevante for datainnsamlingsfasen. Lærerne fremhevet veiledning, demonstrasjon, tilgjengeliggjøring av nødvendig utstyr og utdeling av detaljerte fremgangsmåter som eksempler. Disse støttestrukturene hjelper elevene med å gjennomføre nødvendige prosedyrer i et eksperiment, men selv om elever kan gjennomføre prosedyrer, betyr det ikke at de nødvendigvis forstår hvordan kunnskap faktisk konstrueres (Teig et al., 2021). Det er derfor viktig å gi elevene tid til refleksjon og diskusjon, noe som kan bidra til økt forståelse innenfor det epistemiske området.

Rollefordeling og bruk av mal for rapportskriving er støttestrukturer som kan knyttes til det sosiale kunnskapsområdet, bevisstheten om at naturvitenskapelig kunnskap er et resultat av sosiale prosesser. Lærerne er også opptatt av samarbeid i forbindelse med UA, men elevene ser ut til å ha få støttestrukturer knyttet til denne kompetansen.

Foreløpig konkluderer studien med at det er en skjev fordeling mellom rammer og støttestrukturer som lærere bruker i undervisning med UA. De fleste er knyttet til de konseptuelle og prosedurale kunnskapsområdene. Duschl (2008) påpeker at naturfag tradisjonelt har vært opptatt av konseptuell læring, men understreker at det er nødvendig å ta hensyn til alle områdene for å gi elevene en helhetlig forståelse av naturvitenskap. Studien indikerer at lærere bør øke sin bevissthet rundt bruk av rammer og støttestrukturer i arbeid med UA, for å fremme de ulike kunnskapsområdene innen naturvitenskapen.

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SCIENCE CENTRES AS ENVIRONMENTS FOR IN-SERVICE TEACHER EDUCATION: WHEN FORMAL AND INFORMAL SETTINGS MEET

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Abstract

This study concerns whether informal learning settings at science centres (SCs) can be used in formal in-service teacher education (TE). Using the field of programming education as an example, the study examines the opportunities and difficulties of using SCs as a resource for TE in STEM subjects (science, technology, engineering, and mathematics). The study shows that both strands are within the institutional norms of SCs. SC educators value engagement in learning processes and see programming as a learning tool within STEM. On the other hand, teachers ask how they should assess students' knowledge. This means there are good TE opportunities in practical programming at SCs. However, issues of formal assessment of students' knowledge lie outside the SC setting. The study is based on the evaluation of practical programming workshops at SCs. The workshops are part of a TE organised by the National Agency for Education in Sweden (NAE). The theoretical framework is "Designs for Learning", and concepts from the "Learning Design Sequence" model are used to analyse data consisting of interviews with two SC educators and questionnaire responses from teachers who participated in the TE.

Introduction

Over the years, the teaching of programming has, in some cases focused more on exciting equipment than on the learning process (Kjällander et al., 2018). When programming was introduced as a part of compulsory STEM education in Sweden, teachers asked for in-service teacher education (TE) in programming. There was a need for teachers to learn both programming itself and how to teach the content (Kjällander et al., 2018; Sparf, 2024). Also, not least, there was a need for teachers to be supported in assessing students' knowledge of programming (Björklund & Nordlöf, 2024). The Swedish National Agency for Education (NAE) took the initiative for both credit-bearing courses through universities and, from 2020 on, web-based TE with accompanying hands-on workshops. Science centres (SCs) were among others recruited to run these workshops.

In order to examine the outcome of the TE with workshops, the NAE's own evaluation questionnaire from the school year 2022 is used in this study. The evaluations are complemented by interviews with two of the SC educators who conducted TE workshops.

Aim

The aim of the study is to analyse the setting for TE at SCs and to see how the transformation in an informal learning environment to a formal TE takes place.

In response to the aim following research question is raised.

What challenges and advantages emerge when informal and formal educational settings meet in TE?

Methodology

The Learning Design Sequence (LDS) model within the Designs for Learning theoretical framework (Selander, 2021) is used for analysis in this study. LDS provides a structure for analysing how the setting, including institutional norms and framing, affects the conditions for learning. LDS differentiates between whether the setting is non-formal, informal or formal. In this study, SC is considered an informal learning environment. It is therefore interesting to analyse how this informal setting affects the outcome of the TE, where the participating teachers will then work in a formal environment (the school).

The study was conducted using a mixed method. The data consists of two interviews with SC educators combined with questionnaires answered by 167 participating teachers in the NAE TE with workshops during 2022. The interviews were conducted as part of a larger study of SC educators’ pedagogical content knowledge (PCK). The questionnaire was compiled by the NAE and is also supplemented by an excerpt from the 2022 annual report of the NAE and are public documents.

To analyse, I read the data several times and then sorted the teachers' responses and the educators' statements using the LDS model. That is, I analysed the teachers' positioning and interest in relation to the educators' positioning and statements about interventions. The analysis was also related to the current institutional norm at SCs and its setting and framing.

Overall, the data provides a picture of the challenges and possibilities in the settings for TE at SCs.

Result

The SC educators

Max has worked at a SC for over 20 years. Programming has been offered at SCs for basically the same amount of time. However, Max tells us that when programming became part of compulsory education, teachers in schools were in a state of near panic. Since then, Max and his colleagues have become more involved in TE in programming. Max's approach is to offer experiences that can be developed in other contexts, including TE. He also feels that SCs have an opportunity to continue to make teachers aware of the potential uses of programming. Max believes that programming is not a new subject in itself, but it gives teachers tools for teaching STEM subjects. Still, assessment of students' knowledge is something Max hands over to the teachers.

One of the reasons Linn applied to a SC was her approach to teaching; she likes to do creative things. She also wanted to avoid assessment, which she found limiting. She has been active in TE both in relation to NAE and TE under the SC's own auspices. She sees advantages in the NAE's course and the texts and films associated with it. Linn emphasises that although she is conscious that they do not work with assessment at SCs, all teaching and TE is adapted to the school's curriculum. Which in turn, she believes, ultimately benefits the students' abilities in various subjects. What makes the difference in the TE, she says, is how much teachers gain pedagogically from the practical experience at SCs.

The questionnaires

On the question, "provide examples of programming from the workshop series that you can use with your students", the teachers' answers focus mainly on physical artefacts and practical exercises that they can transfer directly to the classroom. Several different types of hands-on activities are mentioned, including different types of small teaching robots. Only a few teachers respond on a more general level about how to use concepts related to programming (e.g. sequence, alternatives, repetition, abstraction). When asked if they missed anything, some of the teachers emphasised that they lacked information on how to assess students' programming skills, specifically in mathematics.

Transforming in TE at SCs

The SC educators have experience in programming education under their own auspices. Traditionally, there are no formal requirements at SCs, and the centres are free to design for learning in different ways. In this case, however, they are obliged to use the material from NAE. Consequently, when the NAE asks SCs to provide TE in programming, it becomes a meeting of two worlds. The fact that the participating teachers mention several different types of hands-on exercises is in line with what is often offered at SCs and is a part of the settings. However, the SC educators' ambition is that it should not be a matter of doing things but that programming can lead to tools for learning, which some teachers emphasise that they got from the workshop. However, the fact that teachers ask for support in assessment becomes like a question straight out in the air, as SC educators express that it is something they do not work with.

Discussion

This study shows that teachers who participate in TE at SCs are essentially satisfied. They have learned more about programming and the basics of how to teach it. The NAE indicates that they are satisfied with the throughput. The use of SCs to TE can be considered valuable in terms of the number of teachers who have been through the course.

An advantage of using SCs in TE is the ability of SCs to adapt quickly to new conditions and thus meet needs that arise in certain specific subject areas. Thus, the teachers' interest in learning more about assessment is something that cannot be supported within the framing in the SC settings. This has to do with the institutional norms at SCs. One characteristic difference between informal and formal settings lies in whether they are designed for assessment or not (Selander, 2021). SC educators care about the learning process. However, assessment is not part of their professional role. At SCs, the purpose may be to adapt to the compulsory school curriculum, still, there are no regulations about this. This can have consequences that may not always be considered within TE. There is therefore a risk that what teachers need and want (e.g., Björklund & Nordlöf, 2024) cannot be fully met by TE at SCs but needs to be supplemented in other ways.

What the representation of transforming becomes is always dependent on institutional norms, settings, and specific framing but also on the participants' own interests and positionings. It is, therefore, important to continue to follow TE at SCs.

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REDESIGNING A STEM TEACHER EDUCATION FOR SUSTAINABILITY

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Abstract

Teacher education is recognized as pivotal in preparing prospective teachers for educating students with
Teacher education is recognized as pivotal in preparing prospective teachers for educating students with
necessary knowledge, skills, values, and agency to address the global environmental and social crises and act for a more sustainable future. This study provides insight into the process of redesigning the curriculum at a five-year STEM teacher education program for Education for Sustainable Development (ESD). Through educational action research we, teacher educators, collaborate with our teacher students and stakeholders at school to foster a more coherent and holistic integration of ESD. As a part of the larger research project, we investigate tensions between the curriculum levels: the curriculum as ideas and ideals and the curriculum document. Initial results indicate that we succeeded integrating ESD quite systematically throughout the program and that the collaboration with stakeholders was fruitful. However, the curriculum documents did not quite meet the ideal of strengthening student teachers in acting for a sustainable future in their own teaching, as the majority of learning objectives in the program deals with knowledge about (E)SD.

1 Introduction

There is an urgency to educate people with the necessary knowledge, skills, values, and agency to address global challenges including climate change, loss of biodiversity, unsustainable use of resources, injustice and inequality. Various research and policy documents have for several decades recognized the pivotal role of teacher education in preparing prospective teachers for educating students to act for a more sustainable future (e.g. Scott, 1996; UNESCO, 2005; 2014). Despite the acknowledgment of the importance of Education for Sustainable Development (ESD) in teacher education, it appears that ESD remains somewhat optional and peripheral to the main objectives of teacher education. It is often characterized by isolated initiatives rather than being integrated holistically (Stevenson et al., 2017; UNESCO, 2020).

A five-year STEM teacher education program at Norwegian University of Life Sciences has for two decades had ESD as an overarching vision. An internal review of the program conducted in 2021, as part of an external evaluation (NOKUT, 2021), shows that both students and teacher educators considered ESD important. While the student teachers appreciated the student active teaching methods, they also highlighted concerns about the implicit nature of ESD in the program, and the lack of a holistic approach. This provided an opportunity to redesign the program to emphasize coherent and holistic sustainability education throughout the five years. With this foundation, we pose the research question: *What opportunities and challenges emerge during the curriculum design process aimed at fostering student teachers as transformative intellectuals?*

2 Theoretical backgrounds

The concept transformative intellectuals captures that students and teachers are able to analyze, critically reflect on and pose question on a practical as well as a systemic level (Giroux, 2018). This view of teachers as intellectuals further entails that on basis of analyses and reflection teachers can propose smaller and larger changes in education. Hence, they need to engage with both practice and theory. The combination of practice and theory is seen important to succeed with ESD.

In a synthesis of literature on how teacher educations embedded sustainability in their teaching, Stevenson and colleagues (2017) found a taxonomy of four distinctive approaches: (1) embedding sustainability education widely across curriculum areas, courses, and institution; (2) through a dedicated core/compulsory subject; (3) through a component of a core/compulsory subject; and (4) through a dedicated elective subject (p. 410). The authors note that while participatory, inquiry-oriented teaching and learning methods are well-grounded in the literature, lack of reflexivity and critique limits the development of an in-depth understanding of ESD-practices in teacher education. For the successful implementation of ESD in teacher education, the curriculum is crucial (Weiss et al., 2021) as it provides direction and framework for teaching and practical training.

3 Research methodology

Context

The study is based on the five-year STEM teacher education program where the two authors work as science teacher educators. The Norwegian government regulates all teacher educations, and this program is characterized by high complexity regarding the integration of the three core elements of the curriculum: STEM subjects, educational subjects, and 100-days practical training in schools. The program aims at educating prospective teachers for grade 8-13. However, the regulating body concerning this program provide the universities with a possibility to decide organization and content within the core elements given above. The goal is to embed ESD across curriculum areas and courses to improve coherence and progression throughout the five-year program.

Educational action research and curriculum analyses

This presentation is part of a larger action research project (Carr & Kemmis, 2009), aimed at redesigning the teacher education curriculum in collaboration with students and teachers. In this presentation we zoom in on a curriculum analyses (Goodlad, 1979) and apply a combination of document analyses with self-reflections on our curriculum ideals.

4 Results

We have formulated our ideal in a new and more concrete vision for ESD: “We educate teachers who can view students, teaching, and schools in the light of nature, environment, and society. Education for sustainable development, democracy and citizenship, and health and wellbeing, are closely interconnected—and mutually dependent, as we understand it. The prospective teachers we educate should be able to handle different perspectives on complex issues, support students as individuals and as participants in collective citizenship, and to be a positive force in the development of their own school.”

To provide more coherent teacher education for ESD we have made a shared framework for all educational courses that express our ideal of a good ESD teacher education: They should express ESD in topics, teaching method, as well as ESD-competences. The emphasis on the various competences will vary within each subject course depending on context. Moreover, as part of ESD topics we have emphasized that students become acquainted with different perspectives and conceptual understandings of (E)SD, as well as whole school approach.

We have analyzed all the learning objectives in the curricula documents for the educational subjects, a total of 60 ECTS. The analyses shows that all courses have both explicit and implicit ESD objectives. There are many objectives concerning ESD as perspective and concept, and some on ESD competences and a very few on whole school approach.

The analyses also indicate that the majority of ESD-objectives are knowledge the students are to acquire, not something the students are to act on.

5 Discussion and conclusion

Through conversations and problem-solving with stakeholders at the university and schools, our understanding of key concepts of ESD and considerations that must be made to achieve a more comprehensive and integrated ESD have become more explicit and nuanced; thus, prompting a need to think more concretely about how we work with sustainable education, and the content and context we provide for it.

Especially, we need to think how we work to incorporate the ideal of teachers as transformative intellectuals into the ESD-approach. The curriculum documents with their specifications for learning objectives that is divided in knowledge, skills and general competences aimed at the individual student teacher may act as an hinderance to deal with complex issues such as ESD. Thus, in conducting teacher education we need to compensate this to strengthen the prospective teachers as transformative intellectuals.

We are partly successful in embedding sustainability education widely across curriculum areas and courses. However, what entails a holistic teacher education must be understood and acted upon in the local context with its boundaries, and actively involve teacher students as change agents.

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KØN, MOTIVATION, OG IDENTITET I NATURFAGSUNDERVISNINGEN.

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Abstract

The project consists of data from science classes in the Danish lower secondary school. The study used a mixed method design consisting of surveys, classroom observations and semi-structured interviews with students and teachers. Survey and interviews were designed with inspiration from the expectancy value motivation theory, in order to shed light on the driving factors behind the student's motivation and participation in the science classes. Our data indicates that male students tend to describe their motivation as being rooted in an internal interest and curiosity, whereas female students to a higher degree use utility value based arguments for their motivation, e.g. the need for science for a future education or career. Moreover, data showed that internal social dynamics between the student and their classmates' attitudes towards science-motivated students had a very large effect on the student's feelings and behavior in regard to science - and this effect seemed more pronounced for girls than for boys.

Introduktion og Teori

Udfordringen med pigers lavere motivation i naturfagene i udskolingen er beskrevet bredt (DamvadAnalytics, 2016; Jørgensen et al., 2019; Mark et al., 2020; Tænketanken DEA, 2019; Teknologipagten,2020; Villum Fonden, 2020). Denne problemstilling er kompleks. En række forskellige men interagerende faktorer menes at være med til at påvirke unges science interesse og aspiration, herunder 1) læreren, undervisningen og didaktikken, 2) den unges forældre og nærmeste families science kapital og indstilling til naturfag, 3) science fritidsaktiviteter, 4) fremtidsdrømme -og planer, 5) selvtillid og mestrings forventning (Villum Fonden, 2020).

Dette projekts fokus er samspillet mellem unges identitetsdannelse, og udvikling af interesse og motivation i naturfagene. Identitetsforskningen har bidraget med betydningsfulde perspektiver og viden i relation til at forstå, hvorfor nogle elever ser naturfag som frakoblet deres liv (Barton & Tan,2010), holdninger, interesser (Henriksen et al., 2015; E. W. Jenkins & Nelson, 2005) og aspirationertil fremtiden (Archer et al., 2013). Dertil har teorien om social identitet givet ophav til interessant indsigt i unges udvikling af en STEM-identitet (Kim et al., 2018). Social identitet forstås som i hvilken grad, et individ opfatter sig som medlem af en gruppe, og derfor er den sociale identitet forankret og formet i en social kontekst. Et individ udvikler sin sociale identitet (hvem er jeg som medlem af en gruppe) i samspil med sin personlige identitet (hvem er jeg som individ) (R. Jenkins, 2006). Ud fradette perspektiv er en STEM identitet en socialt baseret identitet, funderet i hvor meget et individ opfatter sig som en del af en STEM gruppe (Kim et al., 2018). Dette perspektiv kan bidrage til at forstå, hvordan sociale dynamikker blandt de unge - i samspil med lærerens forventninger, indholdog didaktik - er medbestemmende for, hvordan unge navigerer i forhold til STEM.

Metode

Vores projekt indeholder data fra en række udskolingsklasser i den danske grundskole. Projektdesignet er et mixed-method design og indeholder klasseobservationer af undervisningen, dybdegående semistrukturerede lærer -og elevinterviews, samt surveys med både lukkede og åbnesvarmuligheder. Spørgsmålene i surveyet og interviewguiden er blandt andet designet med inspiration fra expectancy-value motivations teorien, der kortlægger forskellige drivkræfter bag motivation såsom nysgerrighed og interesse, nytteværdi, socialt tilhør m.fl. (Eccles & Wigfield, 2020)samt forskning i unges motivationsorienteringer og lyst til læring (Katznelson et al., 2020). Derudover er det inspireret af erfaringer og testede items fra andre undersøgelser, specifikt SCOPE-projektet og følgeforskningen på LEAPS-skoler. Vi har tilstræbt at få så mættet et datasæt som muligt, blandt vha. fotoeliciterede interviews for at hjælpe informanterne til at udtrykke sig om tavse og implicitte kulturelle forståelser og narrativer, som indvirker på deres selvfortælling og måde at "gøre pige eller dreng" på (Leavy, 2020).

Resultater og Diskussion

Vi finder overordnet den samme tendens i vores datasæt som flere tidligere studier mht. motivationi naturfagene. Drengene var generelt mere motiverede og positivt stemte overfor naturfagene endpigerne i de undersøgte klasser. Men der var ganske markante forskelle mht. hvordan motiverede elever med hhv. pige -og drenge køn begrundede deres motivation, samt hvordan andre elevers synpå naturfagene påvirkede deres motivation. Dette fremgik tydeligt både i survey data og deuddybende interviews.

En række items i surveyet kredsede om det man kunne kalde "fagets status". Eleverne blev blandt andet bedt om at tage stilling til deres egen holdning til naturfagene, deres syn på naturfagsinteresserede klassekammerater, samt hvordan de troede deres klassekammerater tænker om naturfagsinteresserede elever. Dette gav en meget interessant indsigt i elevernes syn pånaturfagenes status i de pågældende klasser. Der var en klar overvægt af negative udsagn og det fremgik klart, at blandt en stor gruppe af vores respondenter blev det forbundet med at være nørdet og underlig, at være naturfagsinteresseret, og noget flertallet af eleverne tog afstand fra.

Vi fandt desuden at de elever, der havde angivet, at de godt kunne lide, og var meget motiverede for naturfagene, var fuldt bevidste om fagenes status. Med udgangspunkt i expectancy-value teorien som beskriver, hvordan enhver handling et individ foretager sig, afvejes i forhold til værdi og omkostninger (Eccles & Wigfield, 2020), kan overvægten af naturfagsmotiverede drenge blandt vores respondenter tyde på, at det tilsyneladende er mindre omkostningsfuldt at stå ved sin science-identitet som dreng end som pige, i de klasser vi har undersøgt. De naturfagsmotiverede drenge vidste altså godt, at naturfagene havde lav status i deres gruppe, men vurderede tilsyneladende disse omkostninger acceptable, og det påvirkede ikke i samme grad som pigerne deres motivation negativt.

Dette fænomen blev yderlig belyst i de uddybende interviews - her eksemplificeret med uddrag fraelevinterview med hhv. en naturfagsmotiveret dreng og pige. Den naturfagsmotiverede dreng kommed flere udtalelser, der understregede hans interessedrevne motivation såsom: *"det er en fedfølelse ligesom at forstå tingene".* Selvom han var bevidst om naturfagenes lave status blandt hansklassekammerater, påvirkede det ikke hans egen interesse eller motivation. Blandt andet udtaltehan med stolthed *"Jeg er meget nørdet".* Han bar desuden en T-shirt med et Albert Einstein citat. Den naturfagsmotiverede pige begrundede derimod hendesmotivation med hendesfremtidsplaner, hvor naturfag var en nødvendighed. Hun sagde fx indledende *"Mine yndlingsfag ernok sådan biologi og fysik-kemi, men det er også fordi, den uddannelse jeg gerne vil på, der skal manogså have en interesse for de fag"*. Flere steder i interviewet påpeger hun dette "alibi" for hendesmotivation i fagene, og på et tidspunkt understreger hun også: *"jeg er ikke sådan en nørd"*.

Konklusion

Vores foreløbige data fra både surveys og uddybende interviews indikerer altså, at motiverede elever fra de to køn begrunder deres motivation for deltagelse og engagement i naturfagsundervisningen forskelligt. Hvor de motiverede drenge primært var nysgerrighedsdrevne,brugte pigerne primært nytteværdiargumenter – og fremførte dem som et slags "alibi" for deres motivation. Det fremgår også fra vores data, at elever fra begge køn oplever sociale "omkostninger" ved at påtage sig en naturfagsidentitet, men at der tilsyneladende er en forskel mellem de to køn,på hvordan dette påvirker deres motivation og ageren i naturfagsundervisningen.

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DO INQUIRY PRACTICES FOSTER HIGH-QUALITY INSTRUCTION? – RESULTS FROM A CLASSROOM VIDEO STUDY IN SCIENCE

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Abstract

Science education research has a long tradition of exploring the relationship between instructional methods and student outcomes. This paper discusses the results of a video study of science lessons in primary and lower secondary schools. The study aimed to develop a knowledge base for understanding classroom practices and how different forms of inquiry instruction were connected to students' achievement in science. Hence, the study offers an evidence-based framework for exploring relations between students' learning and teachers' instruction in science with a special focus on inquiry activities. The research design built on previous national video studies and consisted of two whole-class and two head cameras. Twenty classes participated, with four science lessons each. The video analyses revealed positive associations between high-quality inquiry activities, student engagement and conceptual understanding. The results are discussed according to the quality of instruction.

Introduction – theoretical background

Science is one of the central subjects in school, well suited for educating creative, critical thinking and future-oriented students. At its best, science can engage students in practical problems in the classroom that can be solved in the here and now. This requires a combination of engagement, practical skills, common sense and conceptual knowledge. Different students can therefore contribute in different ways. Thus, science has the potential to be an inclusive subject with many possibilities to engage most students, not only future scientists. Inquiry-based science offers excellent means to engage and empower students (Crawford, 2014). Numerous research studies have focused on the potential of inquiry as a basis for quality teaching in science education (e.g. Cairns, & Areepattamannil, 2019; Furtak etal., 2012; Teig, 2021). Nevertheless, no agreement on what we mean by either inquiry or quality in science education has been reached (Crawford, 2014; Teig, 2021; Wittek & Kvernbekk, 2011). This study explores the quality of inquiry practices and science teaching quality in general. Therefore, a framework focusing on both these areas was developed to investigate mutual associations.

The framework is based on a sociocultural view of learning (Vygotsky, 1998) and subscribes to the overarching goal of education to empower students in their lives and enhance their knowledge base (Wittek & Kvernbekk, 2011). A key perspective in the current study is that inquiry is a central dimension for empowerment in science education, together with facilitating student participation (Grossman etal., 2013; Crawford, 2014; Ødegaard etal, 2021). In addition, the framework includes content knowledge and cognitive activation as two knowledge dimensions (Grossman et al., 2010; Ødegaard etal., 2021). All embedded in a sound learning environment and values and quality criteria from the national curriculum. (See Figure 1.)

Quality teaching in science – dimensions of instruction, including specific categories		
Empowerment:	**Knowledge:**	**Learning environment:**
Inquiry - *Preparation* ⎫ - *Data collection* ⎬ *Inquiry phases* - *Consolidation* ⎭ - *Degrees of freedom* - *Nature of Science*	Content depth - *Representation of content* - *Content depth (teacher + student)* - *Use of academic language* - *Feedback*	Classroom management - *Behaviour management* - *Time management*
Facilitating student participation - ***Use of learning materials*** - *Teacher role* - *Student participation* - *Classroom discourse (uptake + possibility)* - *Practical work*	Cognitive activation - *Connection to prior knowledge* - *Intellectual challenge* - *Student reflection*	
Values and quality criteria democracy, critical thinking, ethical consciousness, independence, anchored content, curiosity, motivation, sustainability, social justice, human dignity		

Figure 2. *A conceptual framework for quality teaching in science used in this video study (Ødegaard etal, 2021).*

The research question of this study is:
What characterizes high quality inquiry instruction in science, and how does it relate to students' classroom discourse and conceptual understanding?

Research design

Video observations are valuable in classroom studies because of the possibility of systematic investigations of complex situations, and they provide opportunities for scrutinizing the quality of instruction (Klette, 2015; Snell, 2011). The video design in this study employed two camera perspectives: one camera focusing on the whole class and one on the teacher. In addition, there were two head-mounted cameras on students to capture student dialogue and practical activities and to be more flexible when observing. Teachers and students from ten primary schools (4th grade) and ten secondary schools (8th grade) participated. At least four succeeding lessons were observed and videotaped at each school.

The study's video observation protocol was re-created and further developed from already existing analysis protocols that were tested and validated (Grossman, etal. 2013; Klette, Roe & Blikstad-Balas, 2017; Marshall, Horton, &White, 2009; Ødegaard etal, 2021). The protocol involves five dimensions of categories: inquiry; facilitating student participation; content knowledge, cognitive activation and classroom management (see Figure 1). Each category is described in terms of four levels of quality with evidence-based observations. The video observations were divided in 15-minute segments, and all segments were given a quality code for the 19 categories. Lessons were defined as four segments (60 min) and were coded with the highest code for each category. For a lesson to be characterized as an inquiry lesson, it needed to have high codes in the three inquiry phases (preparation, data collection, consolidation). Non-inquiry lessons had low codes in all phases.

Results – analyses and findings

Science lessons that included inquiry elements in the participating primary schools were characterized by having practical activities in ordinary classrooms focused on seeking information and exploring topics. At the secondary level, the science lessons' inquiry activities occurred in ordinary classrooms and science laboratories. The video analyses showed that the degree of freedom and what counts as inquiry, varied amongst the participating schools. Students rarely got to ask and inquire about their own research questions, and there was scarcely a focus on nature of science or scientific practices. However, when exploring our data further, we found connections between inquiry lessons and the quality of classroom discourse and conceptual understanding. The results indicated that instruction in inquiry lessons more often had higher quality scores for classroom discourse and content depth than lessons without inquiry. Indicating higher quality teaching in inquiry lessons. Additional findings will be presented during the conference presentation.

Discussion and conclusion

Although inquiry-based science education has been widespread (e.g. EC, 2008; KD, 2019), it has been subject to debate (e.g. Kirschner etal., 2006; Zhang, 2016). Indeed, the results of this study show us that not all teaching with inquiry elements has a great impact on students' achievement. However, the results also suggest that elements of inquiry with high quality more often coincide with high-quality classroom discourse. This can be understood as that inquiry based on students' own research questions (which indicates high quality in the presented framework (Ødegaard etal, 2021) might have scaffolded classroom discourses by engaging the students to participate in discussions about the results of their investigations. Further, this may empower the students by raising their belief in their own agency in science (Jiang & McComas, 2015; Rivera Maulucci, Brown, Grey & Sullivan, 2014). Likewise, classroom discussions engendered by high-quality inquiry activities might have raised the students' requirement for conceptual understanding and the teachers' conceptual and content instruction (Hmelo-Silver etal., 2007). Studies have shown the significance of the students' own inquiry questions and questioning as a scientific practice (Chin & Osborne, 2008). The role of the teacher's instructional practice also has a central position supporting students' being active inquirers (Harris etal. 2012; Ødegaard etal, 2021). It is recognized that the coherence of high-quality inquiry and high-quality classroom discourse and content may merely be due to good teachers. It does not seem to be the case, however, this must be further scrutinized. The findings in this study may hopefully nuance and enrich the discourse about the role of inquiry-based science in school.

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EXPERIENTAL AESTHETIC SCIENCE EDUCATION: FIELDTRIS IN DANISH SECONDARY SCHOOL

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Abstract

In this paper we propose an experiential, aesthetic, sensorial and place-based approach to science education – to educate the next generation of responsible humans to inhabit Earth. Experiential aesthetic science education employs John Dewey's concept of experiential learning and its contributions to fieldwork in science education. We argue that science education should foster active learning using aesthetic methods and all senses in natural environments, while dealing with the complex and systemic problems the world is facing. The study is based on two projects on place-based science education in Danish secondary school. These projects conduct science field excursions with the aim of increasing students' interest in science. The empirical material consists of surveys, participatory observation, logbook-notes, video-recordings, and interviews with both students and teachers. The results show that the pedagogical situations fail to engage the physical environment and hence offer the students a very limited experiential aesthetic science learning environment.

1. Introduction

There is an urgency to rethink and redefine science education to address the challenges and crises of today. We ask the same type of questions as Persson *et al.* (2022): *How might the ongoing and human-made crises be dealt with in science education – and how might we rethink and redefine science education in an era of ecological breakdown?* One approach is place-responsive pedagogy, a specific type of place-based education, where the aim of teaching is to understand and improve human-environment relations (Mannion *et al.*, 2013) and engage the full potential of the human sensorium in building understanding (Kjørup, 1999).

Science fieldwork as place-responsive, experiential and aesthetic pedagogy is difficult to attain in the Danish upper secondary school system, as practical circumstances make it difficult for teachers to use excursions as a daily pedagogical approach. This study reports findings from two Danish projects that facilitate place-based natural science education for secondary school in Denmark. We analyse empirical data with inspiration from Dewey's framework for experiential education and aesthetics. A preliminary conclusion is that when fieldwork is used in secondary education, there tends to be a focus on subject specific knowledge, rather than on the experiential aesthetic affordances of the fieldtrip environment.

2. Theory

Field trips and other place-based education can contribute with real investigations where students develop questions, experimental designs and conduct empirical data gathering that they further analyse (Coker, 2017). This provides a way of interacting with natural surroundings that can support the human-environment relations amongst the students. This pedagogical approach correlates with the experiential approach to education that Dewey presented in 1916 where he argued that 1) experience consists of the active relations that exist between a human being and the natural and social environment, 2) the learning environment should involve a variety of professions, from agriculture to production, as these environments are characterized by applied science, and 3) humans must manipulate objects if they want to make discoveries - and laboratories are just environments where humans can do controlled experiments and make discoveries (Dewey, 1916/1997). Dewey advocates for involving nature and laboratories, as well as other authentic learning environments in education – and for the students to manipulate objects and make experiments to acquire new knowledge and skills.

Dewey's arguments for experiential education are still very relevant. Recently there has been an increasing research interest in how aesthetics and affect play a role in natural science education (Wickman *et al.,* 2022, Elliott, 2022). With the term *aesthetic,* we apply the definition from Wickman *et al.* (2022) that propose two views of aesthetics: 1) aesthetics as a set of design and art practices and 2) aesthetics as responses of affect, emotion, beauty and a taste to experiences and objects. Natural science education should offer the opportunity for the students to sense as they are observers of the natural surroundings and expect them to be affected by the experience (Dewey, 1934/2005).

In this paper we argue that experiential aesthetic place-based education, like fieldtrips, must also be organized as sensorial aesthetic experiences. There is a critical demand for students to prepare to engage and act responsibly in the economic, environmental, and socially 'wicked' problem sphere of contemporary life (Rittel and Webber, 1973) by acquiring critical and communicative 21st century competencies (Achiam *et al*. 2021; Berg *et al.*, 2021).

3. Method

3.1 Case 1: Belt in Balance (Bælt i Balance – reffering to the sea area ‚Lillebælt')

Belt in Balance develops teaching materials and problem-oriented learning activities for secondary school at the coastal line of Lillebælt. The project aims to increase students' interest in the ocean and the natural sciences. The courses are interdisciplinary. The courses involve field excursions to the coastal line, as well as formal school activities and laboratory work.

We have followed the educational program from 2020-2023 in a mixed-methods study with both surveys, observation, and interviews. The participants answered a survey before, right after and three months after participating in the course. 81 students answered both survey 1 and 2, only seven students answered all surveys. The surveys evaluated the student's interest in the ocean and natural sciences and were designed using Hidi & Renningers research in interest, motivation and engagement (Hidi & Renninger, 2006). We furthermore used arts-based methods in the interviews in the form of photo-elicitation (Rose, 2016). The fieldwork has been completed and reported to the institutional agencies. This is the first research dissemination of the results.

3.2 Case 2: Geo and Bio Science Center South

Geo and Bio Science Center South is a project that offers free place-based educational natural science courses for secondary school in specific nature areas located in Southern Funen. One of the aims of the project is to increase the students' interest in the natural sciences. The courses are interdisciplinary and relate to the sustainability crises of today. The students investigate different problem-oriented topics with the scientific method in the local nature. Some activities take place in formal school environments or as laboratory work.

We follow the educational program in an ethnographic approach inspired by Ingold (2021) using video recordings, photos, and conversation with participants as well as interviews. We also use arts-based research methods, inspired by Heinrichs (2018) for a more holistic insight into human experience. The empirical work started fall 2023 and will mainly be conducted in spring 2024.

4. Analysis

From the empirical data we find that the field excursions provide a highly sensorial learning environment where the students interact with the surrounding local natural environment. using different equipment, for example waders and fishing gear. A lot of positive emotions are involved, as well as fear and surprise. The learning environments offer rich aesthetic experiences, but the teaching situation does not make the most of this, but gives priority to modes of interacting with the students that are modelled on classroom interactions. The focus and goals from the educational team are on ensuring subject knowledge and skills, not on the sensorial aesthetic experience. The pedagogical situations fail to engage the physical environment and hence offer the students a very limited experiential learning environment. The aesthetic dimensions of the human-environment relations could be supported by applying organized sensorial-experiential situations where the students are encouraged to interact with the surroundings by touching, smelling, tasting etc. according to Dewey's experiential approach (1916/1997).

5. Discussion and conclusion

To support aesthetic learning situations, the sensorial dimensions of experience need to be ascribed value in themselves and not only be seen to be valuable as 'hooks' for scientific knowledge (Persson, 2022; Coker, 2017). Haraway (2016) addresses science facts as vigorous and vivacious actants that shape the human-environment relations and thus scientific knowledge is an important part of the learning experiences but must be intertwined with sensing and interacting with the surrounding environment. We must rethink the learning objectives for the place-based natural science education with experiential and sensorial aesthetic encounters with the natural environment in focus.

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HÖGSTADIELÄRARES TANKAR OM ATT ARBETA MED SKÖNLITTERATUR I ÄMNENA BIOLOGI, FYSIK OCH KEMI

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Abstract

This presentation reports from a sub study that is part of a PhD-project with the overall aim to study how literary texts can be incorporated in science teaching in ways that enhance student interest and engagement in science. In the sub study Swedish secondary biology, chemistry and physics teachers (n=100) answered a questionnaire about their experiences connected to the incorporation of literary texts in secondary science teaching. The questionnaire was followed up by interviews (n=10). The preliminary results presented here show that teachers have an interest in using literary texts in science education especially in the subjects biology and physics. According to the teachers there are specific parts of the curriculum in biology, physics and chemistry that is better suited for literary texts (eg. content related to health and environment) and there are also specific types of texts and literary genres that are more relevant for science education than others (e.g. short stories and science fiction). Even if the teachers show interest in using literary texts in their teaching, they have limited experience of it, according to the survey. The PhD-project is expected to contribute with didactic models that can aid teachers in their planning and implementation of incorporating literary texts in science teaching.

1. Introduktion och bakgrund

Under lång tid har forskning visat på skolelevers bristande engagemang och intresse för naturorienterande ämnen (no-ämnen) (Harlen, 2015; Keller et al., 2017; Potvin & Hasni, 2014). Bristande engagemang och intresse för naturvetenskap är ett problem inte bara relaterat till en svensk eller nordisk skolkontext utan till naturvetenskaplig utbildning över hela världen (Stuckey et al., 2013). Forskning har visat att intresse och engagemang kan skapas om no-undervisningen i större utsträckning utgår från frågor som intresserar och engagerar eleverna (Feinstein et al., 2013). Det finns indikationer på att användning av skönlitterära texter (exempelvis noveller och romaner) i naturvetenskaplig utbildning kan öka elevernas intresse och engagemang för naturvetenskap (Klassen & Froese-Klassen, 2014). Skönlitteratur i den naturvetenskapliga undervisningen antas kunna utveckla elevernas språk, både det allmänna och det ämnesspecifika språket (Boswell & Seegmiller, 2016), elevernas ämneskunskaper (Hadzigeorgiou et al., 2012) eller övergripande förmågor såsom kritiskt tänkande (de Oliveira Moraes et al., 2021). Emellertid är empiriska studier som stödjer dessa indikationer sällsynta, något som visas i Edvardssons et al. (kommande) forskningsöversikt.

Projektet som den här presentationen bygger på är ett avhandlingsprojekt där skönlitteraturens didaktiska potential i högstadiets no-undervisning (biologi, fysik, kemi) undersöks. Syftet med avhandlingsarbetet är att bidra med kunskap om och hur skönlitteratur kan integreras i no-undervisning och på vilka sätt sådan undervisning kan leda till att elevers lärande, intresse och engagemang utvecklas och då i relation både till specifika delar av no-ämnena och till naturvetenskap i stort. I andra skolämnen har skönlitteraturens didaktiska potential undersökts och forskare har visat att skönlitterära texter och samtal om dessa kan väcka både engagemang och intresse och bidra till lärande (Alkestrand, 2016; Bryntorp et al., 2022; Franck & Lilja, 2023; Ingemansson, 2016; Sporre et. al., 2022). Därför är en hypotes att den skönlitterära texten kan bidra till att elevers lärande, intresse och engagemang för naturvetenskap utvecklas och att vägen dit går genom gemensam läsning och samtal om det lästa, där eleverna får sätta ord på sina tankar och läsupplevelser.

I avhandlingens första delstudie görs en systematisk forskningsöversikt med fokus på empiriska studier, där skönlitteratur använts i no-undervisning. Syftet är att få en överblick över tidigare metoder, resultat och kunskapsluckor (Edvardsson et al, kommande). Utifrån denna översikt har delstudie två växt fram. Den är en enkät- och intervjustudie, där verksamma no-lärare ger sina tankar och beskriver sina erfarenheter av att arbeta med skönlitteratur i no-undervisningen. I denna presentation kommer preliminära resultat, från avhandlingens andra delstudie, att läggas fram. Delstudien utgår från forskningsfrågan:

- Vilka tankar och erfarenheter har verksamma no-lärare av att använda skönlitteratur i sin undervisning?

2. Metod

Delstudie två, som presentationen bygger på, utgår från en enkätundersökning (n = 100) genomförd i svenska skolor under 2023. Enkätstudien följs under våren 2024 upp av semistrukturerade intervjuer med 10 verksamma högstadielärare som undervisar i ämnena biologi, fysik och kemi i Sverige. Ett obundet slumpmässigt urval av lärare gjordes för deltagande i enkätundersökningen (Ejlertsson, 2014). De lärare som besvarade enkäten och kunde tänka sig medverka i en uppföljande intervju fick ange sin mejladress sist i enkäten. Då fler än tio lärare lämnade sin mejladress kommer ett urval att behöva göras.

Utgångspunkt för urvalet blir att få med så många olika perspektiv som möjligt för att på så sätt få fördjupade kunskaper om verksamma no-lärares tankar kring och erfarenheter av att använda skönlitteratur i undervisningen.

Enkätresultatet har sammanställts och analyserats med både kvantitativa (statistiska beräkningsmetoder) och kvalitativa analysredskap (kvalitativ innehållsanalys). Intervjuerna kommer att analyseras genom en kvalitativ innehållsanalys (Schreier, 2014).

3. Resultat

Preliminära resultat bygger på svar från enkätundersökningen. Den visar att det är få lärare som använder skönlitterära texter i sin undervisning (ca 13 %) men att det finns ett förhållandevis stort intresse för att använda skönlitteratur (2,7 på en fyrgradig skala) i biologi, fysik och kemi. Störst intresse finns i ämnena biologi och fysik. Vid en genomgång av skolämnenas innehåll är det tydligt att intresset att använda skönlitteratur är kopplat till specifika delar av det centrala innehållet. I biologi är det främst till området ”Kropp och hälsa” (Skolverket, 2022) och mer specifikt till de delar av det centrala innehållet som behandlar sexualitet och relationer samt psykisk hälsa. Även området ”Natur och miljö” i biologiämnet betonas av flera lärare som relevant om skönlitteratur ska användas. I fysik handlar det om området ”Fysiken i naturen och samhället” (Skolverket, 2022) med särskilt fokus på universum och, i likhet med biologiämnet, frågor som kan relateras till miljö såsom växthuseffekt och klimatförändringar. Även i de fall där lärarna föreslår att skönlitteratur ska användas i kemiundervisningen betonas frågor om miljö och hälsa.

Över 60 % av lärarna vill lära sig mer om hur skönlitteratur kan användas i den egna no-undervisningen. När det gäller lärarnas tankar om vilken typ av skönlitteratur som kan användas är det framför allt kortare textutdrag och noveller som lyfts fram. Den textgenre som flera lärare återkommer till är science fiction.

4. Diskussion och slutsats

Det preliminära resultatet från enkätundersökningen visar att det inte är så vanligt att arbeta med skönlitterära texter i no-ämnena på svenska högstadier. Däremot finns ett intresse och en nyfikenhet bland lärarna. De vill lära sig mer för att också kunna väva in litterära texter i den egna undervisningen. Det finns ett behov av kunskap om hur skönlitteratur kan användas som ett pedagogiskt redskap i no-ämnena och detta behov av kunskap gäller även lärarutbildningen. Ska framtida lärare använda skönlitteratur som ett didaktiskt redskap i sin undervisning behöver det ingå som en del i lärarutbildningen.

Resultatet behöver följas upp med vidare forskning och mer specifikt med praktiknära forskning. Den typen av forskning kan bidra med konkreta förslag på hur en no-undervisning med skönlitteratur skulle kunna se ut, vad skönlitteratur i no-undervisning kan bidra med och vilket stöd lärare kan behöva för att skönlitteratur ska integreras på ett meningsfullt sätt no-undervisningen.

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VI TRÄFFAS I NÄTVERK – VILKEN TYP AV KUNSKAPER I NATURVETENSKAP OCH HÅLLBAR UTVECKLING BESKRIVER LÄRARSTUDENTER ATT DE FÅTT MED SIG FRÅN EN NORDISK NÄTVERKSKURS

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Abstract

This study focuses on the reflection papers submitted by students after completing a course centered on sustainable development, grounded theoretically in place-based learning. The course comprises a blend of distance learning and a one-week intensive session held at one of the Nordic universities within the network. The analysis encompasses reflection texts from 12 students at the same university but spanning three different years. The findings reveal that students describe their observations and experiences regarding the varying conditions in the northern regions, contingent upon available resources. However, most descriptions are rooted in everyday situations, with few delving into deeper analyses. For instance, there is a lack of exploration into how diverse phenomena can yield multiple consequences for sustainability. Surprisingly, despite having completed a minimum of 15 credits in natural science—typically through regular university courses—few students explicitly connect their reflections to scientific contexts or concepts during this course.

What becomes evident is the significant influence of the environment and its conditions on students' reflections. While they acknowledge that conditions appear different in some aspects yet similar in others, they also contemplate the realization that a singular solution cannot universally apply to all.

1 Introduktion och teoretiska antaganden

Studentinteraktioner och utbyten mellan olika universitet så kallad internationalisering är nästan alltid ett uttalat mål inte minst i de nordiska länderna. Denna artikel fokuserar på en interaktion som sker mellan flera olika lärosäten i Norden under en universitetskurs där studenterna dels läser på distans, men är även tillsammans under en vecka där den besökta platsen är i fokus utifrån ett hållbarhetsperspektiv. De som undersöks i denna studie är vilket kunskapsbidrag som studenterna tar med sig utifrån ett naturvetenskapligt- och hållbarsperspektiv.

Att bygga nätverk mellan olika universitet för att ge en gemensam kurs är utmanande. För att nätverket skall hålla över tid och bli meningsfullt för studenterna behövs det förståelse både bland lärosätena, men inte mist bland studenterna att det finns förkunskaper och ett engagemang att lära dvs få mer kunskaper (Simone 2004; Tsegay 2016). Kaufman (2015) liksom Janasz (2008) lyfter fram fördelarna och utmaningarna som studenter upplever när de bygger kontakter utanför klassrummet genom att detta stärker studenternas kunskaper och dess implementeringar i andra sammanhang.

När nätverksaktiviteten dessutom sker utifrån en specifik plats sker ett så kallat platsbaserat lärande. Platsbaserat lärande innebär undervisning och lärande som är förankrat i specifika lokala platser och som påverkas av de naturliga, kulturella och socioekonomiska egenskaperna hos dessa platser. Syftet är att engagera studenter genom tvärvetenskapliga och autentiska upplevelser i lokala samhällen, främja hållbarhet och en djupare förståelse för miljön och kulturen (Semken 2012; McComas 2014; Surface 2016; Monet and Greene 2012). Detta förhållningssätt betonar vikten av att förstå den unika historien, miljön, problemen och ekonomin i det lokala samhället och främja en känsla av nyfikenhet och koppling till platsen (Surface 2016). Platsbaserat lärande kan implementeras i olika utbildningskontexter och har potential att öka studentengagemang, göra läroplanen mer relevant och bidra till positiva förändringar i samhällen. Vad gäller universitetsstudenter är de generellt duktiga på att återberätta exempel från läroböcker, men genom att systematiskt använda platsbaserat lärande har de lättare att koppla teoretiska resonemang och se dess bärighet i vardagssammanhang (Monet & Greene 2012).

Platsbaserad undervisning är tvärvetenskaplig och inriktad på att engagera studenter med omgivning, främja hållbarhet samt integrera olika inlärningsmetoder (Semken 2012). En genomtänkt pedagogik som kopplar samman konceptuellt material med geografisk plats kan främja djupare koppling mellan studenterna och deras lokala miljö samtidigt som det främjar meningsfulla inlärningserfarenheter (Langran 2020). Att använda platsen som utgångspunkt i interkulturella samtal ger dessutom studenterna en möjlighet att se varandras kulturer och förutsättningar. I förlängningen finns också möjligheten att det sker en utökad förståelse som i detta fall mellan ursprungs- och majoritetsbefolkningen (Reid 2019).

Det är även viktigt för lärarstudenter att kunskaperna de får med sig både från att delta i ett nätverk och hur platsen kan var en utgångspunkt för undervisning och lärande i deras kommande profession dvs hur de kan transferera kunskapen från ett sammanhang till ett annat. Transfer kan ske på flera olika nivåer tex specifik och ospecifik överföring. Specifik överföring innebär överföring av speciell faktakunskap, medan ospecifik överföring avser överföring av allmänna principer eller strategier till nya sammanhang (Hasselhorn & Mähler 2000). Överföringen ske på olika nivåer, akademisk överföring (high transfer) då abstraktionen kräver en medveten förståelse (Salomon & Perkins 1989).

Forskningsfråga

- Över vilket ämnesinnehåll och på vilket sätt reflekterar studenterna i kursen?
- Vad har platsen för betydelse för studenternas reflektioner?

3 Metod

Urval

Alla studenter i studien läser gundlärarprogrammet med inriktning F-3, 4-6 eller 7-9 på Malmöuniversitet och alla har läst minst 15hp naturvetenskap (i vissa fall även teknik) innan SPICA-kursen genomfördes. Intresserade studenter ansökte och motiverade sitt deltagande i nätverkskursen. Därefter gjordes att aktivt val där fyra studenter per kurs och år fick delta. Studenterna i denna studie är från tre olika SPICA-kurser, tre år i rad (2023, 2022, 2021). Totalt deltog 12 studenter, fördelat på fyra studenter/SPICA-kurs.

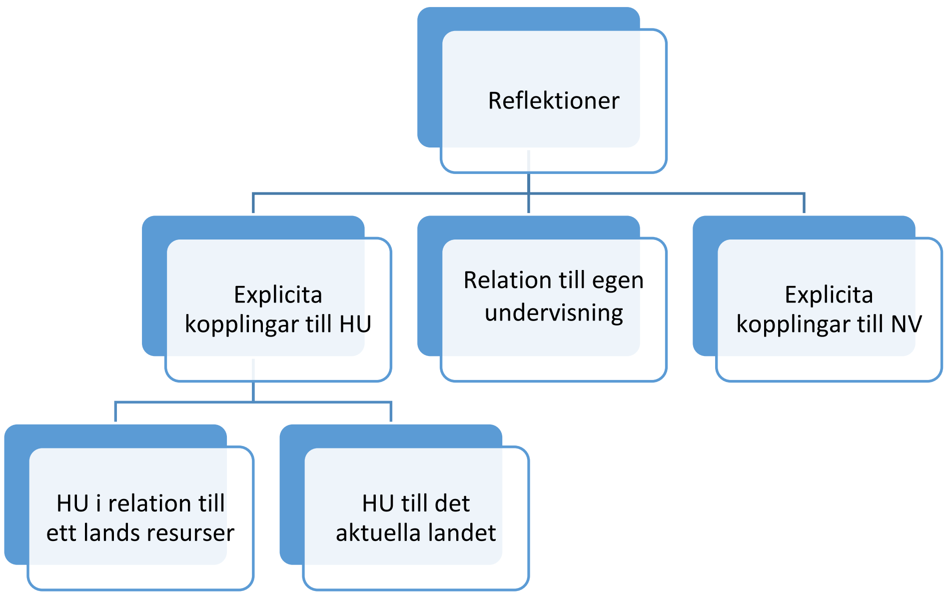
SPICA (2023) är ett nätverk bekostat av Nordplus och består av sju olika universitet från de nordiska länderna. Sedan 2007 ges en kurs om 5hp, med en digital och en intensiv kursdel för studenter med målområden inom hållbarutveckling (Agenda 2030), demokrati, medborgarskap och mångfald, såväl lokalt som globalt. Kursen alternerar årligen mellan de olika ländernas universitet, vars utmaning primärt utgår lokalt ifrån landet och platsen där intensivkursdelen på en vecka genomförs. När kursen är slut skriver studenterna ett reflektionspaper om den egna lärandeprocessen och vad de anser ha lärt sig av kursen.

Analys

Studenternas reflektioner analyserades först utifrån Roberts emfaser (1982). Sedan analyserades i vilket sammanhang som dessa emfaser uppkommer. Sammanhangen kategoriserades därefter utifrån dess innehåll (Zhang & Wildemuth 2017) med ett diskursivt anslag. Texterna analyserades också utifrån hur studenterna applicerade sina kunskaper från kursen i ett undervisningssammanhang, så kallad transfer av kunskaper (Hasselhorn & Mähler 2000).

4 Resultat

Det mest dominerande emfasen som framkom i studenternas texter är vardagsemfasen. Endast en av studenterna visade fram ett mer akademiskt resonemang. Analyserna utgår därför främst från hur dessa reflektioner tar sin utgångpunkt i den vardagliga kunskapsemfasen.



Figur 1. *Innehållskategorisering av studentreflektioner (NV- naturvetenskap; HU- Hållbar utveckling)*

Explicita kopplingar till NV

Några få studenter gjorde dessa explicita kopplingar till naturvenskapliga sammanhang och bara en student (Je) med ett fokus som höjde sig över en vardagsemfas.

Jo: Renmuseet vi besökte…allt om renarna som man förstår betyder mycket för landet… det kommer jag att implementera i min undervisning framöver att besöka museum. …hur vattenfallen skapade el som i sin tur ledde till möjligheten att tillverka papper och gödningsmedel.

Je: Jag har fått en djupare förståelse för bryggan mellan ekologi och undervisning, även begreppen ”eco traps” och ”biophilia hypothesis” var nytt för mig.

Relation till egen undervisning

I princip samtliga studenter skrev fram vikten av att använda sina kunskaper från kursen i sin kommande undervisning. Det intressanta var att flera studenter inte kopplade samman exkursioner och studiebesök de gjort under den ordinarie utbildningen på universitet som är ett platsbaserat lärande utan skrev fram detta som något nytt.

Sa: Platsbaserat lärande innebär att läraren använder fysiska platser som läranderesurser, där platsen i sig utgör den enskilt viktigaste resursen för lärandet. …. som en renodlad metod kände jag inte till innan kursen… metod som tilltalar mig, tror att elevernas lärande gynnas… något jag kommer att ta med mig i mitt framtida yrkesutövande.

Explicita kopplingar till Hållbar utveckling

Hållbar utveckling var ett begrepp som de flesta studenterna återkom till. Studenternas reflektioner kan delas in i två spår, dels i förhållande till det land vi befann oss i (platsbaserat), dels genom diskussioner studenterna haft om olika förutsättningar i de olika länderna.

<u>I förhållande till värdlandet</u>

Id: Efter besöket på både laxodlingen och i parlamentet förstår jag att fisket är mycket i fokus här, viktigt för ekonomin och hur det formar samhället och hela landet.

<u>Olika förutsättningar</u>

Sa: På flera av de länder som var med i SPICA såsom Island, Grönland och Färöarna är det inte möjligt att odla många grödor. Det lokala utbudet är väldigt begränsat och ur en hållbarhetsaspekt är det då bättre att äta till exempel fisk eller får. Diskussionen i Sverige är väldigt centrerad kring ett visst perspektiv och mötet med studenter från andra delar av Norden har fått mig att se andra perspektiv.

4 Diskussion

Det är tydligt att studenternas reflektioner påverkats av den plats de befinner sig på och att de gör kopplingar till sin egen kommande undervisning. Samtidigt är det som Tan (2021) beskriver att reflektioner tenderar till att bli enkelskiktad (icke-iterativ) och monologisk, snarare än iterativ och dialogisk, där de flesta utav texterna inte djupare reflekterar om det egna lärandet, utan konstaterar faktum och är av beskrivande art. Det som förvånar är att studenterna fastnar i vardagsemfasen och inte intellektualiserar sina reflektioner mer/djupare.

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BÆREKRAFTIG UTVIKLING I NORD: KLASSEROMSVIRKELIGHET UTFORDRER GODE INTENSJONER

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Abstract

Recently, "sustainability" has become more visible in various contexts in society. The use of natural resources in an ethical and responsible manner is a central aspect of sustainable development (SD), as such use safeguards the environment in the long run. It is therefore important that pupils in primary school develop the necessary competences and skills in order to be able to participate actively in SD. This study focuses on 8th grade students' and their teachers involvement with SD. The aim of the study is to understand what characterizes the students' critical thinking where mathematics and science are presented in contexts with reference to the students' real world. It is widely agreed that critical thinking is an important skill for developing the concept of sustainability. Development of critical thinking can start at young age. The research method is qualitative, and data are video recordings of learning activities, the pupils' written work and audio recordings of interviews with teachers. Participants are three classes of secondary school pupils (N= 90) from a secondary school in Northern Norway, as well as 6 teachers who teach at the 8th grade. Preliminary results suggests that critical thinking is challenging for 8th grade pupils.

Innledning

Det er et uttrykt mål fra FN at det bør gis en helhetlig undervisning for bærekraftig utvikling (BU), som viser det globale samspillet mellom sosiale, økonomiske og miljømessige forhold og hvordan verdens utfordringer henger sammen. Dette er et satsingsområde som får oppmerksomhet i Norge (Scheie & Korsager, 2014).

Flere land implementerer nå BU i sin utdanning, både i skole og høyere utdanning (Fredriksson & Kusngai, 2020). I Norge er det fokus på BU i læreplan for grunnskolen (LK20) (Kunnskapsdepartementet, 2017), der den nevnes i overordnet del under tverrfaglige tema. Beskrivelse av «bærekraftig utvikling» i LK20 indikerer en kompleksitet som krever forståelse for hvordan sammensatte faktorer påvirker menneskers levesett, og således utvikle forståelse for sammenhengene mellom livsmestring, samfunnsmessige prosesser (demokrati og medborgerskap) og hensynet til natur og miljø. Tverrfaglighet er sentralt i utvikling av elevenes forståelse av bærekraftig utvikling. Gjennom tverrfaglige aktiviteter skal elevene skape en forståelse av sammenhengene mellom ulike tema, altså sammenheng mellom handlingene og konsekvenser av disse.

Flere organisasjoner som EU, OECD og FN uttrykker viktigheten av at elever gjennom sin utdanning utvikler kompetanser som er sentrale for deres aktive deltakelse i komplekse og sammensatte endringer i verden, initiert av behovet for en bærekraftig utvikling. For å få til dette så er tilegning av kunnskap, samt det å utvikle ferdigheter og holdninger essensielt. Kompetansebegrepet handler her om å bruke både kunnskap, holdning og ferdigheter for å møte utfordringer og problemer knyttet til BU (Scheie & Korsager, 2014).

Dette prosjektet er et samarbeid mellom en ungdomsskole i Nord-Norge og UiT Norges arktiske universitet, campus Alta. Prosjektet er 1-årig, men både UiT og ungdomskolen ønsker å utvide samarbeidet til tre års periode. Hovedfokus i dette studie er på elevenes kritiske tenkning i arbeid med tverrfaglige tema med referanse til reelle kontekster i en bærekraft sammenheng.

Vår intensjon med prosjektet er å utvikle kunnskap om bærekraftig utvikling i en læringskontekst, parallelt ved at rike tverrfaglige prosjekter/undervisningsopplegg utvikles i samarbeid med skolen.

Vi ønsker å få kunnskap om ungdomsskoleelevers kritiske tenkning om BU i matematikk- og naturfagfaget, der det benyttes reelle kontekster som elevene kan kjenne seg i. Kritisk tenkning er betraktet som en nøkkelkompetanse for dette århundre av flere (Voogt & Robin, 2012; Jang, 2016), og er en av de sentrale ferdighetene i arbeid med BU (Pache & Rouiller, 2022). For å forstå bedre hvordan elever utvikler kritisk tenking, ønsker vi å studere hvordan de utrykker sine tanker i arbeid med tverrfaglige aktiviteter. Deres ytringer er derfor en sentral analyseenhet i studiet.

Forskningsspørsmål: Hva kjennetegner elevenes kritiske tenkning?, og hva kjennetegner læreres tanker om bærekraftig utvikling og kritisk tenkning i deres undervisning?

Teoretisk bakgrunn

Studiet bygger på sosiokulturell læringsteori, der en argumenterer for at individet er en aktiv deltaker i sin egen læringsprosess (Cobb & Bowers, 1999; Wertsch, 1991). Kritisk tenkning er ikke et nytt begrep, men komplekst og utfordrende å definere. I litteraturen kan vi finne ulike definisjoner for kritisk tenkning (Siegel, 1988; Facione, 1990; Ennis, 1987). Uavhengig av dette, så er det er bred enighet om at kritisk tenkning betraktes som en ferdighet knyttet til individets evne til å involvere seg i målrettet og selvregulert dømmekraft (Abrami et al., 2008). I vår studie bruker vi blant annet modellen til Watson og Glaser (2009) der de redegjør for ulike faser i utvikling av sentrale ferdigheter, for utvikling av kritisk tenkning.

Metode

Dette er en kvalitativ casestudie der vi studerer et fenomen i en kontekst med referanse til realitet hvor grensene mellom fenomenet (kritisktenkning) og konteksten (BU) ikke er klar og tydelig (Yin, 2014). Deltakere er forskere fra UiT og en ungdomsskole (av totalt 2 ungdomskoler i byen) fra Nord i Norge, med fire lærere som underviser matematikk, naturfag, samfunnsfag og/eller norsk. Hele 8. trinnet (tre klasser) er involvert i skoleåret 2023-24. Valg av deltakere bygger på skolens engasjement i bærekraftig utvikling og viktigheten av det. Valg av klassetrinn er påvirket av ønske/ mulighet til en kontinuitet der elevene kan delta i hele sin treårige skolegang på ungdomstrinnet.

Analyseenheter bygger på elevenes ytringer (muntlig og skriftlig) og intervjuer av lærere. I samarbeid med skolen utarbeidet vi en modell for organisering av aktiviteter i en tidslinje som strekker seg gjennom ett skoleår. Aktivitetene er designet med hensyn til tverrfaglighet, har lokal forankring og har alle referanse til reelle-kontekster med bærekraftige dimensjoner. Elevaktiviteter er gjennomført og vi har video-opptak fra aktivitetene, samt skriftlige refleksjoner fra elevene.

Intervju av lærerne er gjennomført og transkribert. Tematisk analyse basert på de ulike stegene foreslått av Braun og Clark (2006) brukes til å analysere transkripsjonene: 1) å bli kjent med innhentet data, 2) lage foreløpige koder, 3) lete etter temaer 4) undersøke om temaene passer med generte koder 5) definere og navngi temaer. I siste steg vil endelig analyse formes, og funnene sees i lys av relevant litteratur.

Prosjektet er godkjent av nasjonalt organ for forskningsdata (www.sikt.no).

Resultat / diskusjon

Både i matematikk og naturfag har læringsperspektivet til undervisning i de senere år beveget seg fra en tradisjonell til en undersøkende tilnærming. Eksempelvis, vil en tradisjonell tilnærming til læring i matematikk bidra til en statisk oppfatning av faget hvor matematikken fremstår som en samling av regler og formler (Kaiser & Vollstedt, 2007). Kommunikasjonen i en tradisjonell undervisning er ofte preget av en autoritativ samtaleform (Mortimer & Scott, 2003) hvor det er lite rom for deltakerne til å diskutere egne tanker og meninger. I kontrast til tradisjonell undervisning vil undersøkende undervisning støtte elever i utvikling av HOCS (High Order Cognitiv Skills) (Zoller & Nahum, 2012), som innbefatter kritisk tenkning. Aktivitetene som var designet i samarbeid med lærere hadde et undersøkende preg.

Analysen viser at elevene brukte i liten grad de faglige begrepene i vurderingsprosesser og beslutning taking. Men gjennom diskusjon og samarbeid utrykker noen elever deres disposisjon for kritisk tenkning. Analyse av klassediskusjon viser indikasjoner til meningsdanningsprosess hvor ulike prosesser som å argumentere, presenter ulike perspektiver, støtte og/ eller utfordre andres meninger. Men analysen viser også at det var et mindretall av elevene som utrykker tegn på kritisk tenkning i aktivitetene.

Analysen lærerintervjuene viser at implementering av undersøkende tilnærming er utfordrende, noe som i stor grad sammenfaller med de utfordringer som utrykkes i sammenheng med utviklingen av elevenes kritiske tenkning. Eksempelvis elevens modenhet, motivasjon og deres faglige forutsetninger. Vider analyse viser at matematikkundervisning i stor grad er tradisjonell (lite undersøkende). Vi mener at en utforskende matematikkundervisning er en viktig faktor for utvikling av BU i skolen.

Implementeringen av BU i underving må inkludere alle tre dimensjoner. Analysen indikerer at lærene oftest fokuserer på BU i naturfaget, og at hovedfokus er på miljødimensjonen.

For å kunne implementere BU i skolen bør kritisk tenkning og undersøkende tilnærming til læring forankres i skolens praksis, og alle dimensjonene må inkluderes. Dette er en krevende og viktig prosess som krever stort engasjement fra alle deltakende parter.

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PRESCHOOL TEACHERS'S DISCUSSIONS ABOUT USING DIGITAL TOOLS IN PLAY-RESPONSIVE SCIENCE TEACHING

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Abstract

The aim of this study is to contribute knowledge of how preschool teachers can use digital tools when initiating play-responsive science teaching. Play-responsive teaching (Pramling et al., 2019) is a relatively new way of approaching teaching in preschool, where play and teaching are seen as a mutual activity between preschool teachers and children. The Play-Responsive Early Childhood Education and Care (PRECEC) framework (Pramling et al., 2019) is used to analyse preschool teacher discussions in focus groups thematically. The study is conducted as a CPD project where eleven preschool teachers take part in and discuss interventions about play-responsive teaching and science. Attempts to initiate play-responsive science teaching are video-documented by the preschool teachers and viewed for stimulated recall in focus group. All participants have been informed and agreed to voluntary and anonymous participation with the right to cancel their participation at any time (Swedish Research Council, 2017). Preliminary results from the ongoing analysis show how the preschool teachers in different ways use projected pictures or video as a background in play, to trigger a play, or as part of the play. The attempts involve a threefold challenge for the preschool teachers when encompassing knowledge about play, science, and digital tools.

1 Introduction

Play-responsive teaching (Pramling et al., 2019) is a relatively new way of approaching teaching in preschool, where play and teaching are developed as a mutual activity between preschool teachers and children. Preschool environments and materials can create opportunities for children to explore science in different ways, although it is not enough for children to explore science content by themselves (Fleer, 2009; Tu, 2006). The importance of adult mediation is highlighted if the children are to pay attention to and explore science content provided in the environment (Fleer, 2009). In previous research, different possibilities for using digital tools in science teaching are described (Otterborn et al., 2023; Walan & Enochsson, 2022). The tablet could, for example, be used for filming, taking pictures, searching for facts or using apps, but also in combination with other digital tools like action cameras and microscopes. Connecting digital tools to a projector is described as creating opportunities for more children to participate and re-experience the activity (Otterborn et al., 2023). When there are opportunities for children in the preschool practice to explore, play, and learn with digital tools, Undheim (2022) describes the preschool teachers' role as important in supporting and guiding the children. Based on this, there is a need to create opportunities for preschool teachers to discuss and reflect on what, how and why digital technology could be used in their practice.

In this study, the focus is on possible ways of including digital tools in play-responsive science teaching. This is done by, for example, projecting digital pictures or videos to create representations of science content and, at the same time, opening up for a mutual play (Lund et al., 2024a; 2024b). This means that the digital tools are used in interaction between preschool teachers and children in a mutual activity that is open for play and analysed based on the preschool teachers' discussions. The aim of this study is to contribute with knowledge of how preschool teachers can use digital tools when initiating play-responsive science teaching. The research question guiding the analysis is: *How do preschool teachers in a CPD project describe the use of digital tools in attempts at play-responsive science teaching?*

2 Theoretical background

The Play-Responsive Early Childhood Education and Care (PRECEC) framework (Pramling et al., 2019) is used to analyse the preschool teachers' discussions. The concepts as is and as if, triggering, and agency have been selected to analyse the preschool teachers' statements in the focus-group discussions. The preschool teachers use digital tools in different ways to make representations (Ainsworth, 1999) of science content in their attempted play-responsive science teaching. The role of different representations is considered in addition to PRECEC.

3 Research method

This study is based on a Continuous Professional Development (CPD) project where eleven preschool teachers took part in different interventions about play-responsive teaching and science. Each semester in a two-year-long project started with a lecture or reading of an article (Pramling & Wallerstedt, 2019), followed by a focus-group discussion about the intervention. During the semester the preschool teachers attempted to initiate play-responsive teaching with science content where digital tools in different ways are used as support. These attempts were video documented by the preschool teachers. A selection of the documentation was brought to a subsequent focus-group session by the preschool teachers and used as a basis for stimulated recall (Reitano & Sim, 2010; Geiger et al., 2016). Both participants and the children's caretakers have been informed and agreed to voluntary and anonymous participation with the right to cancel their participation at any time (Swedish Research Council, 2017). The data consists of 14 audio-recorded focus-group discussions, each lasting approximately one hour, and is thematically analysed (Braun & Clarke, 2022).

4 Preliminary results

In the preschool teachers' discussions, a variety of possible ways of using digital tools in attempted play-responsive science teaching is discussed. One way the preschool teachers describe using digital tools is by projecting digital pictures or videos when initiating a mutual activity that is open for play. This could, in some examples, be projections of places that they do not have the opportunity to visit in real life, for example, being below the surface in the ocean, or in a rainforest. In other examples, it is places that the children have shown interest in, but where the real environment creates limitations for play, for example in an anthill. Three themes of using projected pictures or videos emerge from the preschool teachers' discussions: as a background, as an introduction, or as part of the play. When the projection is used as a background in the attempted play-responsive science teaching, limited attention is drawn to the picture. In the second theme, the digital picture or video is used as an introduction to the activity, for example, drawing the children's attention to the projection as a way to start playing. This can be seen as a way to trigger a mutual play focusing on the science content. In the third theme the digital picture or video is used in interaction between the preschool teacher and children, as a part of the play. One example of this is when a preschool teacher describes how a picture taken on a mutual exploration focusing on woodlice in the woods were used as they together pretended to be woodlice in a play.

4 Discussion and conclusion

The preliminary results indicate that creating representations of science content by projecting digital pictures or video can be used to trigger a play with focus on the chosen content. Detailed results will be presented at the conference, especially concerning the preschool teachers' discussions about what, how, and why digital tools can contribute to the attempted play-responsive science teaching. These attempts involve a threefold challenge in encompassing knowledge about play, science, and digital tools.

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INDUCTION ACTIVITIES SUPPORTING NEW SCIENCE TEACHERS' PROFESSIONAL IDENTITY AS SCIENCE TEACHERS

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Abstract

In the paper the first results are presented from a Design Based Research project developing induction activities for new science teachers. Based on a scoping literature review and focus group interviews with new science teachers the preferable subject specificity of mentoring and the need for support concerning the practical experimental approaches in science are among the issues highlighted. The need for supporting professional identity as a science teacher is emphasised in recent research, and the new science teachers who are interviewed mention that they struggle both with classroom management and with the transition of the science teaching they have worked with in teacher education to a concrete everyday school context. Induction activities at two sites have been designed as respectively on-site and online facilitated dialogues. The participating teachers discussed among other things the large difference in the degree of and framing of the mentoring they have been offered. The scaffolding of the dialogues with cases/utterances from other new science teachers developed from the interview material are experienced to be supportive to balance the dialogues and include both positive experiences and challenges, some of the latter in a quite emotional way. Therefore, ´trust´ is an important issue in the groups.

1 Introduction

In Denmark as well as internationally there is a lack of well-educated science teachers and concerns are raised when the new teachers leave the profession. Hence, the development of an induction program is part of the large scale Danish NAFA initiative aimed to improve science teaching. The induction program will be enrolled at a national scale from autumn 2024, and the research presented here is aimed both to inform the design of this national program and to contribute to the knowledge base on specific issues concerning induction for science teachers.

2 Theoretical backgrounds

The need for supporting new teachers in the transition from teacher education to the often challenging first practice as a teacher is emphasized in the literature highlighting e.g. the need for mentoring (Frederiksen, 2020; Luft et al., 2015). Based on the literature there is no simple connection between induction and retention as a teacher, but a recent research review however emphasises that common collaboration time in professional dialogues with other teachers decreased the odds of leaving the profession (Ronfeldt & McQueen, 2017). Referring to a call for more knowledge about how to support new *science* teachers specifically (Luft et al., 2015), we have formulated the following research questions for the exploratory first cycles of the larger Design Based Research project:

RQ1: What issues are raised in the research literature about induction for new *science* teachers?

RQ2: What do new science teachers emphasize concerning their experiences and needs in the first year of practice?

RQ3: What issues are raised by new science teachers in pilot studies with facilitated dialogues?

3 Research methods

The Design Based Research project (Barab & Squire, 2004) operates with an iterative approach to design, testing, re-design, and adaptation in developing the induction activities, utilising mixed methods (see Figure 1). This enables the design of the first pilot activities, where results are presented at the conference, to be informed by a scoping literature review and focus group interviews with new science teachers (4 groups, N=15), preceding their implementation, first at VIA University College (on-site induction activity, N=13) and later in January at University College South Denmark (online induction activity). Data from these piloting activities is systematically collected through facilitated dialogues among research participants. Data have been analysed by thematic analysis.

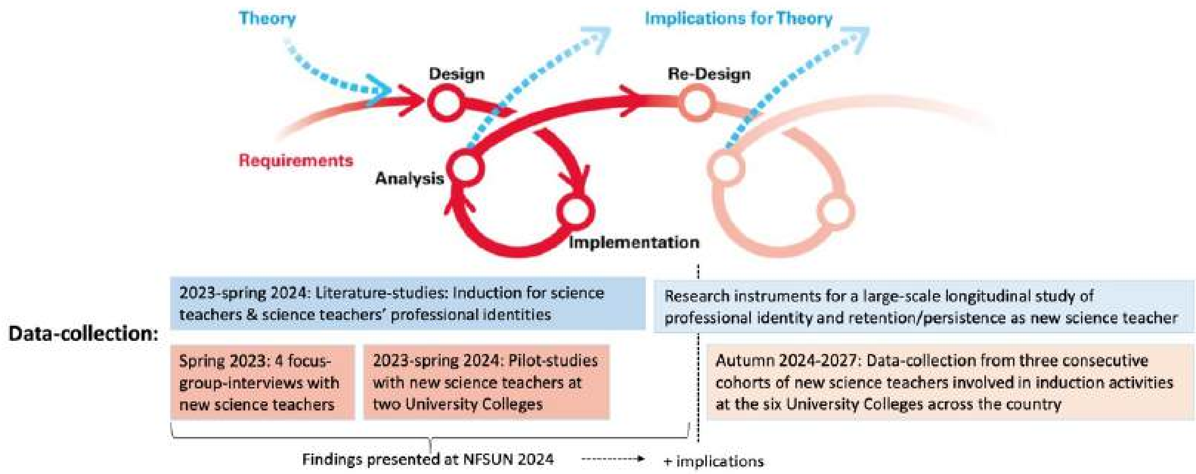

***Figure 1**. An overview of the full research project and the data presented at the conference.*

4 Results

Based on the systematic analysis of research literature (RQ1) a range of themes were identified concerning induction for science teachers. The importance of mentoring and prolonged cooperative activities over at least a year for example organised as learning cycles, are issues emphasized in the generic literature about induction (Frederiksen, 2020). Based on the analysis, 1) the preferable subject specificity of mentoring can be added. Other issues are, 2) the need for support in particular concerning the practical experimental approaches in science, 3) the potential in including science resource centres, supporting communities of learning, both in- and out-of-school (e.g. Heredia & You, 2017; Luft et al., 2015), and 4) the need for working specifically with the professional identity as science teacher as part of induction (Webb, 2015; Saka et al., 2013).

In relation to RQ2 thematic analysis of the group interviews with the new science teachers has revealed a need for both more knowledge and concrete initiatives in the Danish context. The teachers emphasise generic challenges related to classroom management and relational work, but they also emphasise science specific challenges, e.g. in the transition of the science teaching they have worked with in teacher education to a concrete everyday school context. They among other things experience tensions between the ideal of problem based and inquiry-based science teaching and the demands in the complex reality as a new teacher, where pragmatic solutions can be necessary without feeling you challenge your own ideal as science teacher. Issues related to organising induction was also raised in the interviews. There were huge differences among schools concerning if and how induction was organised. Some of the teachers also raised the issue, that they were teaching in an out of field setting. The new science teachers hoped for opportunities for meeting other new science teachers with a possibility for dialogue and for sharing concrete experiences.

In the pilot studies referring to RQ3 dialogue formats respectively on-site and online are tried out. Findings referring to both formats will be included in the presentation at the conference, but only analysis of the on-site data is included in the proposal. The pilot study reveals the extended need for action. The large difference in the degree to which the new science teachers meet induction is confirmed. Not all of them have a mentor and if they have a mentor this is not always a science teacher. The latter is emphasised as crucial e.g. when learning to know the local laboratories and outdoor facilities. Likewise, there is a large variation in the organisation of the new teachers' teaching schedule. During the scaffolded dialogues they - beside these issues - discussed challenges concerning classroom management with a certain science specificity due to some of them being ´the guest of the week´ in many classes. They also highlighted specific security issues concerning classroom management when working in the laboratories. The mediation with cases/utterances from other new science teachers (developed e.g. from the interview material) supported the dialogues both in groups where the first round with experiences was merely positive and groups where extended challenges were raised, sometimes in a very emotionally affected way. This balance appears to be important to support the novice teachers' agency. Furthermore, ´trust´ is an important issue. In the pilot study two of the facilitators were well-known UC-educators and the group knew each other from teacher education. Activities in this on-site induction group continue spring 2024, along with also the work in the online group at the other University College.

5 Discussion and conclusion

The first findings confirm the need for induction, and furthermore the need for working specifically with issues related to teaching science. The new science teachers discussed among other things the ideals they have about inquiry-based science teaching and the challenge when they meet the everyday reality in schools. Hence, discussion of the professional identity as science teacher can preferable, as highlighted by Webb (2015) and Saka et al. (2013), be an explicit part of induction dialogues. Persistence and retention as science teacher are complex issues (Ronfeldt & McQueen, 2017), and based on these first data their appears to be a large variance in both the context the new teachers meet and in how they find their ways as a new science teacher. There are however some generic issues to address in induction activities and induction dialogues in a trusting atmosphere is experienced to be highly supportive. Findings from these first phases will inform the design of the national induction program starting autumn 2024. The next phases of the research will include quantitative data where the development of professional identity as science teacher, which based on the data appear to be crucial, can be followed over time (Figure 1).

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STUDENT TEACHERS IN A CO-INQUIRING POSITION IN PROFESSIONAL INQUIRY PROJECTS INITIATED BY SCIENCE TEACHER EDUCATORS

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Abstract

In NAFA - a large-scale nationwide initiative to improve science teaching in Denmark - teacher educators are organized in professional learning communities (PLC). The paper presents research from the second of four consecutive themes ‘assessment in a double didactic perspective’. In a mixed method design it is examined how the science student teachers are positioned in the professional inquiry projects and what kind of outcomes they emphasize. Data is case-specific data (interviews and reflective writings) from three PLCs, a group interview across cases, and a repeated questionnaire from all student teachers in NAFA (n=200). Findings show a development over the first two themes where more student teachers report about having own small inquiries at schools, and about a role as co-developers. Overall, there is a correlation between being positioned as co-developer and positive perceived outcomes. Data from the cases illustrate how the student teachers in various ways have been involved in developing the projects, so these are cases of whole class co-creation, where student teachers among other things have examined assessment through using pupil drawings and interviews. Furthermore, some student teachers have volunteered as representatives in national workshops. Themes across cases illustrate both positive outcomes and some challenges.

1 Introduction

The paper is presenting research from the context of a large-scale initiative (2021-2028) run by NAFA, an association of the major actors in Danish science education https://nafa.nu/about-nafa/ . The aim is among other things to improve science teacher education at the six national University Colleges. A main lever for this is to support professional learning communities (PLC), where all science teacher educators are working with professional inquiry (Boyd & White, 2017). Each PLC formulates their own focus and to a large degree steers their activities within a common theme. The data is from the second of four consecutive themes, namely ‘assessment in a double didactic perspective’, where representatives from three PLC have initiated an action research process (Burns et al., 2021). The common focus across sites is beside the theme of assessment to develop ways to support student teachers’ active position in the co-creation process (Bovill, 2020). This focus is informed by international research as well as by findings from research in the first phase of NAFA (Nielsen et al., 2024).

The research is guided by the following research question:

- How are the science student teachers positioned in the professional inquiry projects and what kind of outcomes do they emphasize?

2 Theoretical backgrounds

With the headline of ‘a double didactic perspective’ the key-point is, that the ones being taught in teacher education themselves are going to be teachers. Internationally this is discussed using the term ‘second order teaching’ actualizing the possibility for modelling of practices in teacher education also practices of professional inquiry (Vanderlinde et al., 2021). Boyd & White (2017) highlight that teacher educators can use modelling by explicitly working inquiry-based iterative developing their teaching, here related to science education. Doing so they can provide the student teachers with experiences of values and strategies that they might consider reconstructing in their own classrooms. Theoretically the PLC-organization in NAFA is informed by international research, where a main part however focuses on elementary teachers, and with only a few studies of PLCs for teacher educators (Hadar & Brody, 2012). Co-creation with students in higher education is in the literature discussed under various headlines, 1) students as partners (Mathews et al.,2018), 2) co-creation with students to move from ´curriculum as delivery ´to ´curriculum as joint meaning-making´ (Bovill, 2020), and 3) ´a student as researcher pedagogy´.

3 Research methods

The research at the three local sites is designed in an action research process (Burns et al., 2021). The research group have been cooperating across the three cases, and with two external researchers, to analyse experiences from the processes, and generating and analysing data across sites. Data from student teachers is both case-specific data (interviews, survey, and reflective writings) from the three cases, a group interview with student teacher representatives across cases, and a repeated questionnaire from all the student teachers involved in the PLC-work in NAFA (n=200). The survey data has been compared with findings from the same survey after the first theme in NAFA (Nielsen et al., 2024). The multiple qualitative data has been condensed and thematized in a cooperative analytical process.

4 Results

Findings from analysing the survey-data is presented under three headlines:
1) There is a development where far more student teachers have been involved in trying things out at a school connected to the PLC-work in Theme 2 than we saw in Theme 1 (a development from 29% in Theme 1 to 77% in Theme 2)
2) There is also a development from Theme 1 to Theme 2, where more student teachers report about being co-developers, participating with ideas, having influence and contributing with ideas for the next steps.
3) There is in both datasets after Theme 1 and Theme 2 a correlation between being positioned as co-developer as a student teacher and the perceived outcomes.
The findings from the cases show that student teachers in various ways have been involved in developing the projects, for example in a role as representatives from a class of student teachers. Some of them have volunteered to take this position, also representing the project in national workshops. Furthermore, student teachers have as part of the teaching been involved in their own small inquiries with pupils from schools (whole class co-creation)..

In the first case teacher educators and student teachers have cooperated with researchers in science ´frontier research´ at the University and with teachers and pupils from local schools referring to educational reconstruction (MER: Duit et al., 2012). The student teachers have been applying the MER-model in learning activities and assessment inspired by the frontier research in the scientific field of future energy. They have at the campus analysed models and other material from pupils' posters, interviews and questionnaires. Hence these materials have, like the materials mentioned in the next cases, worked as what Grossmann (2018) calls *practice-representations*.

In the second case, a group of student teachers in biology used a co-creation process to investigate ways of teaching biology in 7.-8. grade. They brainstormed on "good teaching in biology", developed templates for planning and interviewing pupils and completed focus group interviews in two school classes before and after testing their own hypotheses on motivating learning activities.

In the third case, teacher educators and student teachers in a co-creation process have investigated pupil drawings as a part of a formative assessment. The project has followed an action research cycle in which the student teachers after presentations on assessment in a Zoo and trying out their own drawings in science have planned an inquiry with pupil drawings during their internship.

Three themes across cases illustrate positive outcomes:

- Being recognised and included in the collaboration with fellow student teachers, teachers, lecturers and researchers has contributed to the student teachers' motivation and commitment
- Cooperation and co-determination in the planning and implementation of teaching and empirical data collection have helped student teachers to acquire a deeper and more nuanced understanding of teaching methods
- Several student teachers state that their participation in the project has created "added value" and transfer value in relation to using academic content and approaches in e.g. their internships, exam assignments, bachelor projects, other courses and as future teachers

And three themes illustrate some challenges:

- Frameworks and organisation are important for the student teachers' sense of ownership and meaning. Significant variations exist among the students, which highlights the importance of teacher educators being aware of varying levels of scaffolding
- The student teachers have different understandings of what it means to be a co-investigator in relation to roles, ownership and scope, e.g. understanding that you can develop within certain frameworks
- Some students see the project as an "add on", diverting time away from what they consider to be "the real" teaching. This places demand on teacher educators to provide explicit modelling to clarify the meaning and relevance.

4 Discussion and conclusion

Student teacher representatives from the three cases have presented and discussed the data at a seminar with researchers and teacher educators across the country. They highlight the professional outcomes from these processes, both the inspiration from peers from other sites also working with professional inquiry examining assessment processes in schools, and the cooperation co-inquiring with researchers and teacher educators. They fell positioned as co-developers (equal relations: Bovill, 2020) and the process in an inspiration for how to work with pupils in more open inquiring processes as (future) science teachers. This is supported by the national data showing a correlation between being positioned as co-developer and positive perceived outcomes. The rich case-specific data illustrate the motivating effect of being recognised and included in the collaboration with fellow student teachers, teachers, lecturers and researchers. But there are also challenges and "knots" to work on looking forward.

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NORWEGIAN PRE-SERVICE TEACHERS' KNOWLEDGE ABOUT HOW TO USE PROGRAMMING IN SCIENCE EDUCATION

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Abstract

Programming became part of the Norwegian national science curriculum in 2020. This requires teacher education programmes to figure out how pre-service teachers should be prepared to use programming appropriately in science education. We have gathered survey data from 147 pre-service teachers in 5 different Norwegian primary and lower secondary teacher education programmes and examined their self-reported knowledge of programming in science education from a TPACK perspective. TPACK theorizes the relation between teachers technological, pedagogical, and content knowledge. The data were analysed using hierarchical multiple regression and show the importance of programming knowledge (TK) as well as knowledge about teaching science (PCK). The analysis also shows there are differences in pre-service teachers' (PSTs) knowledge at different teacher education programmes about using programming in science education. We suggest that looking at what is being done at different institutions to increase PSTs' TK, as well as how they connect it to their PCK, could provide Norwegian teacher education programmes with ideas for how PSTs could be prepared to use programming in science education.

1 Introduction

Programming has entered the curricula of many nordic countries (Vinnervik & Bungum, 2022). Finland and Sweden include programming as a cross-curricular theme and within other subjects (e.g., Maths, Technology), while Norway incorporates it within other subjects (e.g., Maths, Science). In this proposal we are interested in programming in the context of science education in primary and lower secondary education.

We would like to know how we can prepare pre-service teachers (PSTs) to incorporate programming into their science teaching. We have therefore done a survey of PSTs in Norwegian teacher educator programmes that offer science as a master subject, using a TPACK questionnaire by Karlsen et al. (in review). TPACK (Mishra & Koehler, 2006) is a theory that technological knowledge works in concert with pedagogical and content knowledge when teachers use different technologies in their teaching. To teach efficiently, PSTs need to combine their knowledge of technology (TK), pedagogy (PK) and content (CK).

The purpose of this research proposal is to examine what variables may explain PSTs self-reported TPACK. We will examine TK and PCK (which is the combination of PK and CK), as well as other background variables. The research question is: What variables explain PSTs TPACK?

2 Theoretical backgrounds

Programming is now included in the national science curricula of Norway. We therefore assume that different approaches are being tried in the Norwegian teacher education programmes to figure out how to teach the use of programming in science education. PSTs at the same institution in different study years may therefore have been taught programming differently. In addition, research indicates that there are differences between genders when it comes to knowledge about programming (e.g., Çoban et al., 2020), and it is known that a larger proportion of females teach in primary school than in lower secondary school. In our analysis we have used *institution, year of study, gender,* and *target grade level* as background variables (cf. Table 1).

Mishra & Koehler (2006) developed a theoretical framework called TPACK about the knowledge PSTs need to teach efficiently using educational technology. In the framework, PSTs' knowledge about technology, pedagogy and content is central. The idea is that there is a reciprocity between these three knowledge domains. Karlsen et al. (in review) have suggested that TPACK can be an appropriate theory when working to develop and assess PSTs' knowledge about the use of programming in science education.

3 Research methods

We use a cross-sectional research design (i.e., survey) with a purposive sample. The sample is from Norwegian teacher institutions who offer master's degree courses in science education. We contacted several institutions and five agreed to participate in the survey. The survey was administered online (nettskjema.no) in autumn 2022 and spring 2023, and we received answers from 154 of 200 PSTs. After cleaning the data, 147 respondents were used for analysis. See table 1 for details of the sample.

Table 1: The table shows the background variables describing our sample.

Variable	**Type / values**	**Sum (percent)**
Gender	Male = 0 Female = 1	n = 45 (31 %) n = 102 (69 %)
Year of study	Year 2/3 = 0 Year 5 = 1	n = 81 (55 %) n = 66 (45 %)
Target grade level	Primary = 0 Lower secondary = 1	n = 37 (25 %) n = 110 (75 %)
Institute	Institute 1 Institute 2 Institute 3 Institute 4 Institute 5	n = 40 (27%) n = 9 (6%) n = 15 (10%) n = 45 (31%) n = 38 (26%)

In the survey we used the TPACK-questionnaire by (hidden) et al. (in review). The questionnaire contains questions related to the three knowledge areas of TK, PCK and TPACK. The questionnaire is therefore not a full measure of the TPACK-framework, but measure the most significant elements related to programming in science education. The measure consists of 19 Likert-type items on a 5-point scale from "strongly disagree" (1) to "strongly agree" (5). TK is operationalized as general skills in using programming (e.g., "I can develop algorithms when programming"), and PCK as teaching science to students (e.g., "I know how to support students in developing critical thinking and argumentation skills in science."). TPACK is operationalized as the merging of these two constructs (e.g., "I know how to use programming in science to help students understand scientific concepts and phenomena.").

The TPACK constructs are described in Table 2. The mean and standard deviations are calculated using the R package psych 2.3.9 (Revelle, 2023). Reliability is calculated using ω_t in the R package semTools (Jorgensen et al., 2022).

Table 2: The table shows the mean and standard deviations of the TPACK-variables used in our analysis, as well as the reliability of the constructs.

Construct	**Type / values**	**Mean (sd)**	**Reliability (ω_t)**
TK (3 items)	5 pt Likert scale Strongly disagree = 1 Strongly agree = 5	3.01 (1.18)	0.93
PCK (4 items)	5 pt Likert scale Strongly disagree = 1 Strongly agree = 5	4.04 (0.56)	0.75
TPACK (6 items)	5 pt Likert scale Strongly disagree = 1 Strongly agree = 5	2.72 (1.12)	0.92

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The data were analysed in R 4.3.2 using hierarchical multiple regression, which allows us to estimate the contribution of each variable to the variance of TPACK. The regression was done blockwise, adding *gender*, *year of study* and *target grade level*, *PCK* and *TK* successively as independent variables. The interaction between *year of study* and *institute* was also examined since it could vary when and how institutions had taught programming to the students.

26 (1 %) Likert values and 3 (0.5 %) background values were missing and substituted with the median value. Assumptions for regression analysis were checked, such as linearity. A minor concern with collinearity was detected as TK correlated strongly with TPACK (r = 0.85). This was due to technology- and programming-items being conceptually related.

4 Results

The results are presented in Table 4. The table shows that *gender*, *target grade level* and *year of study* contribute little ($\Delta R_{adj}^2 = 0.01$) to the variance in *TPACK*. *Institution* explains 29 % of the variance in *TPACK*. This suggests differences between the institutions in how they teach programming related to science education. An additionally 5 % of the variance in *TPACK* is explained when examining the interaction between *institution* and *year of study*, suggesting that there are some differences in how PSTs at the same institute are being taught about programming in different study years, perhaps due to developmental work or testing of interventions. Adding *PCK* explains about 12 % of the variance in *TPACK*. This suggests that PCK contributes to developing TPACK. *TK* adds 32 % to explaining the variance in *TPACK*. TK could therefore be considered a crucial component of TPACK.

Table 4: *The table shows how much of the variance in TPACK was explained when adding predictor variables in five steps. R_{adj}^2 is the amount of explained variance adjusting for the number of predictors. ΔR_{adj}^2 indicates the change in R_{adj}^2 when adding predictor variables.*

Step, Predictor Variable	R_{adj}^2	ΔR_{adj}^2
1. Gender, Target grade level, Year of study	0.01	0.01
2. Institution	0.30	0.29***
3. Institution x Year of study	0.35	0.05
4. PCK	0.48	0.12*
5. TK	0.76	0.32**

** p < .05. ** p < .01. *** p < .001. (F-statistic)*

4 Discussion

What variables explain PSTs' knowledge about how to use programming in science education? From a TPACK-perspective we have seen that both *TK* and *PCK* contribute to PSTs' *TPACK*, as *PCK* explains about 12 % of the variance of *TPACK*, while *TK* explains about a third of the variance at the individual PST level. The results also showed that a third of the variance in *TPACK* was explained at the *institutional* level. This suggests that working with how TPACK (and TK) are implemented in the institutes is important for developing PSTs' knowledge about using programming in science education.

This is a cross-sectional research design, so we do not know the change in time. The results are based on a purposive sample and is not necessarily representative of the PST population at large. The data is however from a relatively large sample of PSTs from institutes offering masters in science education, suggesting that the results represent a considerable proportion of our target population. When doing regression analysis, the error terms are assumed to be zero (i.e., perfect measurement).

Programming is a relatively new topic in the science teacher education programmes. The results presented in this study suggest that developing PSTs' TK and TPACK could be important to prepare PSTs to integrate programming efficiently in science education. We therefore suggest monitoring the development of PSTs' TPACK as programming becomes integrated into teacher education programmes to see how different implementations play out.

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WORDS MATTER: A COMPREHENSIVE ANALYSIS OF ADDRESSEE ORIENTATION IN SECONDARY STUDENTS' SCIENCE WRITING

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Abstract

In our study we examine secondary chemistry students' ability to write scientific texts tailored to a specific addressee as a key element of science communication competence and hence a central contribution to Scientific Literacy. We therefore analyzed 336 texts on the dissolving of salt in water which the participants addressed either to their chemistry teacher or a peer, with a particular focus on the language being used to present the subject matter. We also took the students' academic language competences into consideration. After coding the texts applying qualitative content analysis and a category system which we deduced from a literature review, we counted the student utterances in each category. Subsequently we performed descriptive statistics and calculated t-tests as well as regression models. The analyses reveal that students establish addressee orientation through several language features and that their language competences to a certain degree predict how they succeed in this endeavor. This baseline study provides a solid starting point to plan measures which help students in their scientific writing and communication skills.

1 Introduction

Scientific Literacy is regarded the main objective of schooling in STEM subjects. Despite an abundance of conceptualizations of Scientific Literacy in the field of STEM education (e.g. Gräber & Bolte, 1997), the main focus of the term revolves around helping students understand scientific concepts and relating these concepts to phenomena outside the classroom, i.e. in the students' natural world (OECD, 2019).

Many pressing issues in our modern world[1] should hence be examined from the perspective of STEM education to equip students with a robust knowledge base as well as competences to draw conclusions, make informed decisions and work towards solutions. Therefore, students should develop three core competences, namely

- "Explaining phenomena scientifically;
- Evaluating and designing scientific enquiry; and
- Interpreting data and evidence scientifically" (OECD, 2019, p. 99).

To explain science phenomena based on scientific enquiry and data, students have to extract information from scientific texts, present scientific information in an appropriate way and argue on the basis of scientific knowledge, or in other words: they need scientific communication competences (Kulgemeyer & Schecker, 2013; Ziepprecht et al., 2017).

[1] for instance, the climate crisis, the increasing loss of biodiversity or the outbreak of pandemics

2 Theoretical backgrounds and research question

Scientific communication poses a major challenge to students in secondary schools as the process of communicating scientific concepts requires sound subject-matter knowledge as well as appropriate communicative competences (Kulgemeyer & Schecker, 2013). At the same time, large-scale assessment has continuously identified students' competences in the language of schooling as a major predictor for competence development and learning outcomes in STEM (e.g. for Germany: Reiss et al., 2016, pp. 338–339).

Scientific communication competence is composed of two aspects which Norris and Phillips (2003) refer to as the fundamental sense (literate practices like reading and writing) and the derived sense (knowing about science). From their point of view, scientific communication and consequently the teaching of it need to include communication in both senses (Norris & Phillips, 2003).

One area of communication illustrates the interplay between fundamental and derived sense impressively: aligning communication with the prerequisites of the person being addressed. On the one hand, it is essential to have knowledge of the subject matter at one's disposal while at the same time estimating the other person's knowledge (see. Figure 3). On the other hand, the message being communicated has to be structured and articulated in a way which is understandable for the other person regarding the language (= *code*, see Figure 3) being used.

We refer to this area of science communication competence as *addressee orientation* which Becker-Mrotzek et al. (2014, p. 22) define from the perspective of writing didactics as anticipating the recipient's knowledge, expectations and in general the subject matter as well as linguistic prerequisites regarding the topic being communicated. Addressee orientation has been included in STEM curricula, for instance, in Sweden where students are required to "create developed texts and other communications with relatively good adaptation to purpose and target group" (Skolverket [Swedish National Agency for Education], 2018, p. 196).

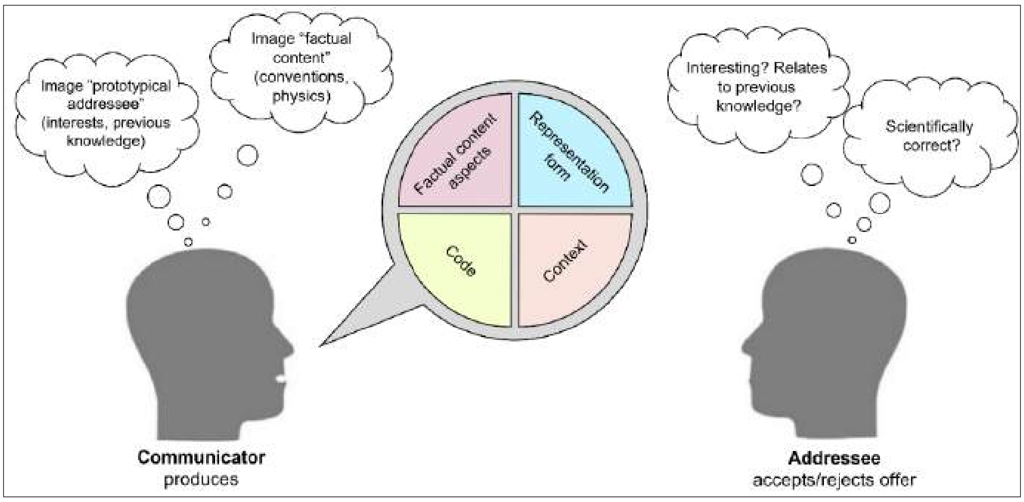


Figure 3*. Constructivist communication model for science communication, slightly adapted from Kulgemeyer & Schecker, 2013, p. 2238.*

Kulgemeyer and Schecker (2013) developed a constructivist science communication model from the perspective of physics education which differentiates a subject-oriented from an addressee-oriented view. Regarding the addressee-oriented view they distinguish four aspects which influence the attractiveness of the content for the recipient (Kulgemeyer & Schecker, 2013, p. 2239; see Figure 3):

- *Factual content* – Which aspects do I communicate and which ones can I neglect?
- *Context* – How do I make the content relevant to the addressee?
- *Code* – Which (scientific) terms and other language means do I use to present the content?
- *Representation form* – In which way (e.g., graphs, images) do I present the content?

As Norris and Phillips (2003) highlight the interplay between language- and subject-orientation, science teaching should promote students' ability to use appropriate language (= *code*) and relevant knowledge (= *factual content*) in the process of science communication. To analyze students' ability to establish addressee orientation in science communication, we investigate the following research questions in our study:

To what extent are secondary chemistry students able to establish addressee orientation (for instance addressing a teacher vs. a peer) in written scientific texts regarding the language/code they are using to present the subject matter?

To what degree do students' academic language competences predict the way in which they manage to use language for establishing addressee orientation?

3 Research methods

The 8th grade students participating in our study attended a language- and subject-integrated teaching sequence of 8×45 minutes on dissolving processes of salts (Gieske et al., 2022). The students took a subject-matter knowledge test prior to and after the teaching sequence as well as a c-test only before the sequence. The c-test provides information on the students' academic language competences. After the teaching sequence the students were also prompted to write two texts on the same scientific concept which only differ with respect to the person being addressed (see **Error! Reference source not found.**).

> Task 1:
> Explain to **your friend, who has not dealt with the topic salts in chemistry,** how salt dissolves in water.
> Use the following example for your explanation: You cook pasta and add salt to the water.
> Consider the model of matter being composed of particles for your explanation.
>
> Task 2:
> Explain to **your chemistry teacher** how salt dissolves in water.
> Use the following example for your explanation: You cook pasta and add salt to the water.
> Consider the model of matter being composed of particles for your explanation.

***Figure 2**. Two tasks on dissolving salts in water addressing two different recipients.*

To analyze the texts comparatively we first extracted relevant features from scientific literature, e.g. on writing competence (Becker-Mrotzek et al., 2014), language use in science education/scientific terminology (Childs et al., 2015; Kulgemeyer & Schecker, 2013) and pedagogical psychology/audience design. The extracted features of addressee orientation in written texts for the dimension *language/code* were structured along the word, sentence and text levels (see tab. 1) and thus formed the category system for the qualitative content analysis (Gieske et al., 2024; Mayring, 2022).

Student utterances could consequently be matched with categories during the process of coding using the program MAXQDA. Subsequently we counted the utterances allocated to the categories and performed descriptive statistics as well as basic statistical testing (linear regression and t-tests) to compare students' abilities regarding addressee orientation within the *language/code* dimension.

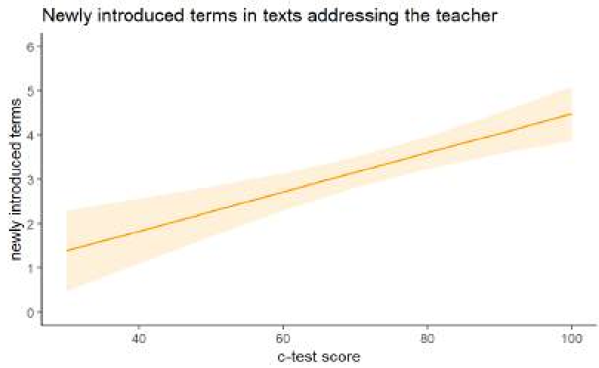
4 Results

We examined 320 written texts from 160 secondary school students from grades 8 and 9. First, we adjusted this primary data source and excluded 54 texts which either did not consider the dissolving process on the particle level or which did not pass the benchmark of 30 words. 25 per cent of the texts were coded by two independent coders which resulted in an excellent intercoder reliability of $\kappa_n = .91$. The results regarding *code* are displayed in table 1.

Table 1. *Selection of descriptive statistics and t-test outcomes (p-values) for the distribution of coded student utterances in the language/code dimension regarding the person being addressed in the text (teacher or peer).*

Level	Category	**Addressing teacher**	**Addressing friend**	*p*
		M	M	
word	newly introduced science terms per text e.g., *ions, ionic substance, crystal lattice, ionic bonding*	3.51	1.64	< 0.001
	familiar science terms per text e.g., *charged particles, salt, lattice, attraction*	1.94	3.02	< 0.001
	compounds	4.59	3.45	< 0.001
clause/ sentence	personal expressions in relation to number of clauses	0.27	0.71	< 0.001
text	text length [words]	60.13	61.85	0.521
	number of clauses	8.17	8.42	0.522

In the second step of our analysis, we tested for correlations between the number of newly introduced and familiar science terms, the addressee of the text and the students' c-test scores. Figures 3a and 3b illustrate the number of newly introduced and familiar science terms as a function of the c-test score.



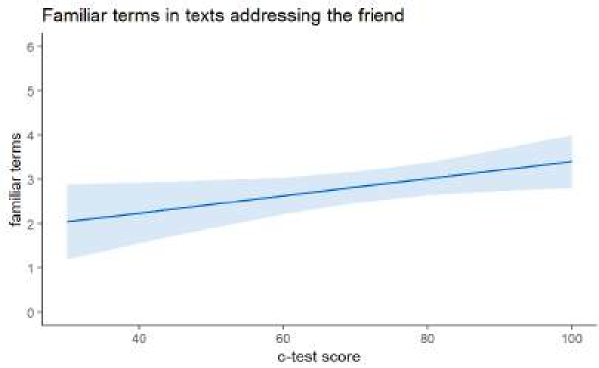


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***Figure 4a**. Number of newly introduced science terms per text addressing the teacher in relation to c-test score.*

***Figure 3b.** Number of familiar science terms per text addressing the friend in relation to c-test score.*

The students use a higher number of science terms which they acquired during the teaching sequence in the texts addressing the teacher when they reached a high score in the c-test (see fig. 3a). Moreover, they use a higher number of science terms which they had already been familiar with in texts addressing their peers when they scored high in the c-test (see fig. 3b).

5. Discussion and conclusion

The results of our study demonstrate that students to a substantial degree manage to tailor their writing to the addressee in terms of the *language/code* used in the text (see tab. 1). They primarily vary the use of familiar and newly introduced science terms on the word level as well as the structure of the sentences to appeal to the recipient of the explanation. The students' academic language competences measured through a c-test apparently facilitate the purposeful selection of terminology appropriate for the respective addressee (more familiar terms for the peer, more newly acquired terms for the teacher).

Our findings suggest that students are all in all able to formulate texts which match the language competences of the specific person being addressed. Nevertheless, we assume that addressee-oriented communication plays a subordinated role compared to communicating in a scientifically correct way, even though research has highlighted that both modes need to be established in conjunction (Kulgemeyer & Schecker, 2013).

In future studies, we intend to embellish our understanding of students' ability of addressee-oriented communication by investigating the interplay of *language/code* with the other dimensions *(factual content, context* and *representation form)* more in depth. We are also planning treatment-control studies to examine possible effects of language- and subject-integrated instruction on promoting scientific communication.

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YNGRE ELEVERS POTENSIALE TIL Å UTVIKLE FORSTÅELSE GJENNOM DYBDELÆRING

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Abstract

Deep learning, central to policy documents, means that students must work with a topic over time, see connections and be able to apply their knowledge in new contexts. Heritage is explicitly introduced in the Norwegian curriculum after first year in upper secondary school. This case study examines the potential of the younger students to develop understanding of such a complicated topic as genes and inheritance through teaching module that goes over time. The students showed that they were able to apply their knowledge, by giving examples of inherited and acquired characteristics based on a picture, they showed knowledge both at macro and micro level and they answered as well, or better, than students from upper secondary school. The study concludes that the youngest students have a great potential for developing an understanding of complicated topics as long as they are allowed to go into depth on the topic over time.

1 Introduksjon

Dybdelæring anbefales både internasjonalt og nasjonalt som viktig for at elevene over tid skal utvikle forståelse på et høyt kognitivt nivå. Men hvor tidlig skal vi egentlig introdusere elevene for f.eks. begrepene gener og arv? For å forstå. tilpasning og evolusjon trenger man å vite noe om arv, og hva som gjør arv mulig. I USA innføres arv i læreplanene for barnehagen, og de har i tillegg eksplisitte kompetansemål på trinn 3-12 (Research Council, 2013). I Norge er situasjonen annerledes. Ordet arv nevnes ikke i kompetansemål før etter Vg1, der det står at elevene skal «beskrive DNA og hvordan egenskaper arves, og gjøre rede for hvordan arv er en forutsetning for evolusjon» (KD, 2019). Arv og gener kan omtales tidligere, men dette avhenger av læreren da det ikke nevnes eksplisitt. I denne studien undersøker vi hvilket potensial som ligger hos de yngste elevene til å utvikle forståelse for et komplisert tema gjennom et undervisningsopplegg om gener og arv, som vektlegger dybdelæring.

2 Teoretisk bakgrunn

Kunnskapssamfunnet stiller større krav til kompetanse enn noen gang før. Hver enkelt må i større grad enn tidligere evne å tilegne seg nye kompetanser i løpet av livet og å bruke det man lærer i nye sammenhenger. En norsk utredning (NOU 2015:8) viser at innholdet i skolen er for omfattende og fragmentert. Fullan og kolleger (2018) mener dybdelæring er løsningen for å tilpasse undervisningspraksisen til vår samtid. Dybdelæring betyr at elevene gradvis og over tid utvikler sin forståelse av begreper og sammenhenger innenfor et fag, at de ser sammenhengen mellom fag, samt greier å anvende det de har lært til å løse problemer og oppgaver i nye sammenhenger (Meld. St 28, 2015-2016).

Progresjon løftes fram som et sentralt grep som muliggjør dybdelæring. Duschl og kolleger (2007) beskriver læringsprogresjon som en avansert måte å tenke på et tema hvor læring utvikles over tid i et læringsforløp gjennom elevenes utforskning.

En norsk studie viste at andelen tid som gikk med til dybdestrategier var ca. 1% for grunnskolen og 8% for videregående (Hodgson et al., 2012). Det var stor grad av muntlig samhandling mellom lærer og elever, men en knapphet på dybde i samhandlingene. Dette indikerer at det er potensial for forbedring i norsk skole for bruk av flere dybdelæringsstrategier. Elevene kan tilnærme seg naturfaglige tema i tre dimensjoner, gjennom naturfaglige praksiser, kjerneideer og overordnede begreper, noe som har potensial for å gi både progresjon og dybde til elevenes læring. Dette var fokus i Wyner og Doherty (2017) sin studie hvor de i løpet av et år undersøkte elevers (grade 6-8) forståelse av felles aner hos levende organismer. De fant en sterk kobling mellom vitenskapelig praksis og begrepsforståelse, hvor det vitenskapelige fokuset var nødvendig for kvaliteten på elevenes observasjoner. Når elevene ble bedt om å observere vitenskapelig, gikk de over til å legge merke til vitenskapelige nyttige funksjoner.

3 Kontekst

Det gjennomførte undervisningsopplegget er hentet fra det amerikanske prosjektet Seeds of Science, Roots of Reading[2]. Denne studien har fokus på undervisningsopplegget Variasjon og adapsjon, beregnet til å gå over 4 uker. Klassen brukte ca. 24 timer. Først var det fokus på variasjon hos dyr og ideen om at beslektede grupper deler visse egenskaper. Elevene observerte forskjeller, de lette etter evidens på slektskap og de sammenlignet ulv og rev. Deretter var fokuset på gener som kode for egenskaper. De leste et hefte om gener (Koden), de forutså avkom etter bananflueforeldre, de leste om ervervede egenskaper, de undersøkte likheter og forskjeller mellom et tvillingpar. De observerte foto av en gutt og laget liste over hans arvede og ervervede egenskaper.

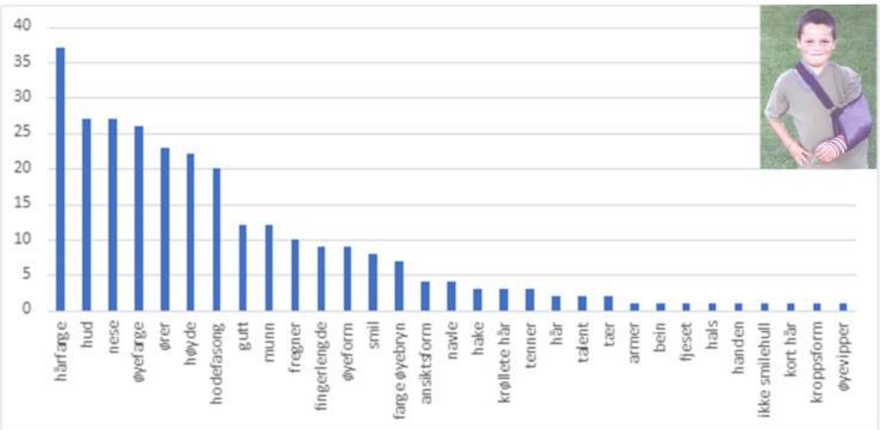
4 Metode

Studien er en kasusstudie av en gruppe elever på 3. og 4. trinn. Elevene ble undervist av 3-4 lærere pr. trinn. Studiens datamateriale består av elevenes arbeidshefter (totalt 44, fra 3. og 4. trinn), samt 16 besvarte spørreskjema av elever på 3. trinn. Spørreundersøkelsen besto av 7 både åpne og lukkede oppgaver. Spørreskjemaets flervalgsoppgaver ble kvantifiserte. Elevenes uttrykk for ervervede og arvede egenskaper ble gruppert der de ble tolket til å være uttrykk for like (hodefasong og hodeform) eller beslektede egenskaper (skrive, lese, svømme = ferdigheter). De kvalitative dataene fra spørreskjemaets åpne spørsmål ble induktivt analysert ved bruk av refleksiv tematisk analyse (Braun & Clarke, 2021). De kvalitative dataene ble også analysert med mikro-makro-overganger som analytisk rammeverk, hvor det som er synlig (blå øyne) for elevene er på makronivå, og det som ikke er synlig (gener) er på mikronivå (Ringnes & Hannisdal, 2006).

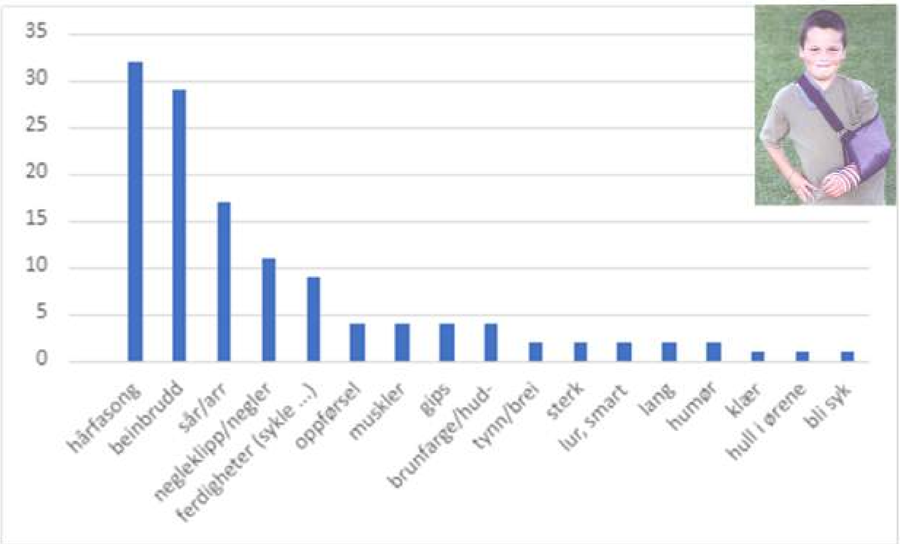
[2] https://store.lawrencehallofscience.org/Category/seeds-of-science-roots-of-reading

5 Resultater

Analysene vitner om at elevene opparbeidet seg kunnskap om enkeltbegreper, slik som gener, særtrekk og arv. Elevene på 3.trinn assosierte gener med kroppen (n=16), slektskap (n=8), kode (n=6), særtrekk (n=5), forskjellig (n=2) og annet (n=4). Alle svarte at en gutt arver særtrekk fra både mor og far (ikke bare far, bare mor, eller en av dem), 11 av 16 (69%) avviste at ervervede særtrekk kan arves, 13 av 16 (81%) mente vi kunne avgjøre slektskap ved å sammenligne gener (heller enn blodtype, håndskrift, fingeravtrykk), og 10 av 16 (63%) mente at genene for øyefarge befinner seg i alle celler i kroppen. 3. og 4.klassingene klarte også å identifisere arvede og ervervede særtrekk ut ifra et bilde av en gutt (Figur 1 og 2). Hovedsakelig hadde elevene forståelse på makronivå, men vi ser også spor av forståelse på mikronivå (eks. «den ligger i alle cellene i kroppen») når det gis forklaring på at gener for øyefarge finnes i alle celler i kroppen. Elevene mente at de personlig trenger kunnskap om gener og arv for å ha kunnskap om kroppen (n=5/16) (eks. «det er viktig at vi vet hva vi har inni oss»), for å få mer kunnskap generelt (n=4/16) (eks. «for at vi skal få mer kunnskap i livet»), og for å vite hvordan gener uttrykkes (n=3/16) (eks. «for å vite hvem du ligner på»).



***Figur 1**. Arvede egenskaper elevene observerte fra bildet.*



Figur 2. Ervervede egenskaper elevene observerte fra bildet.

6 Diskusjon og konklusjon

Elevene arbeidet med temaet over lang tid (6t/uke, 4 uker) sammenlignet med hva naturfaget har til rådighet i norsk skole (1,5t/uke). De gjorde flere utforskende aktiviteter, de leste, skrev og hadde faglige, utforskende samtaler. Fra beskrivelsen av hva elevene gjorde og hvordan de jobbet drister vi oss til å kalle dette for dybdelæring. Spørsmålet som veiledet studien, var om de yngre elevene hadde potensiale for å utvikle forståelse for et komplisert tema som gener og arv. Spørsmålet "Hvor i kroppen er genene for øyefarge?" er et kognitivt utfordrende spørsmål for de yngre elevene, da de må sette kunnskapen de har inn i nye sammenhenger (jamfør definisjonen av dybdelæring). På dette spørsmålet svarte 63% av 3.klassingene at genene sitter i alle celler i kroppen. Sammenlikner vi med en masteroppgave fra videregående skole (Vg1), ser vi at elevene i 3.trinn svarte bedre enn elevene på videregående, der 47% svarte rett (Kvam, 2012). Elevene viste forståelse på mikronivå, og vanlige misoppfatninger som at gener bare finnes i enkelte celler, og at ulike celler inneholder forskjellig genetisk informasjon (Lewis & Wood-Robinson, 2000) var til stede i liten grad. Elevene har tilnærmet seg temaet gjennom bl.a. observasjoner, å lete etter evidens, å stille hypoteser, undersøke likheter og forskjeller, som kan sees på som naturfaglige praksiser. Elevene har også jobbet grunnleggende med begrepene over tid gjennom skriving, lesing og dialog, som skaper progresjon (Duschl et al., 2007) og dybde. Dette er i tråd med Wyner og Doherty (2017) sin studie hvor de fant at et vitenskapelig fokus var med å forsterke dybdelæringen, noe som kan forklare elevenes gode resultater. Studien viser at det er et potensiale for å utvikle forståelse for kompliserte temaer hos de yngste elevene. Dette kan være verdifullt i vår tids krav til andre kompetanser, som vektlagt av Fullan og kolleger (2018).

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REVISIONING SCIENCE EDUCATION: FOSTERING CONTENT KNOWLEDGE-LINKING WITHIN THE ENERGY CONCEPT USING THE INTEGRATED SCIENCE TEACHING APPROACH

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Abstract

According to learning theories, on the one hand the linking of content knowledge is a feature of successful learning, on the other hand integrated science instruction should foster content knowledge-linking more effectively compared to differentiated science instruction – although empirical evidence is still scarce. In this study, we investigated the effects of both science teaching approaches on students' content knowledge-linking performance within the energy concept. We focused on the energy concept, since energy is a cross-cutting concept which is important in all science subjects. To investigate long-time effects, we examined essays written by students at the beginning of grade 9 who received either subject-differentiated (N(cg) = 132) or integrated science instruction (N(tg1) = 141 and N(tg2) = 137) in grades 7 and 8. By developing our own theory-based model, we analyzed students' content knowledge-linking performance in essays regarding three dimensions: vertical linkage level, horizontal linkage and scientific correctness. Our analyses show that students who received the integrated science approach more frequently formulated correct statements that can be assigned to a higher vertical linkage level than students who received the differentiated science approach. In addition, these correct statements more often contained horizontal links between terms that formally belong to different naturals subjects

1. Starting point

The integrated science approach is the dominant approach in many English-speaking countries. In contrast, there is a long tradition to teach science differentiated in biology, chemistry, and physics during the secondary level of education (grades 7-10) in Germany. Since German schools principally have the opportunity to change their curriculum to an integrated science education, the question raises: Which science teaching approach should schools select to ensure that students acquire scientific concepts most successfully?

2. Theoretical Framework

Successful learning means building up knowledge structures that the learner can actively access (Renkl, 1996). According to constructivist learning theories, the active use of content knowledge is possible if it has as many links as possible (e.g., Renkl, 1996). Therefore, content knowledge-linking is a useful criterion to compare different science teaching approaches with regard to successful students' learning (de Jong & Ferguson-Hessler, 1996). From the perspective of learning theories, integrated science teaching should foster content knowledge-linking more effectively compared to differentiated science teaching (Labudde, 2014). To check this theory-based hypothesis, it is necessary to investigate content knowledge-linking within a concept that is equally relevant in all science subjects. This is the case for the interdisciplinary energy concept (e.g., Duit, 2014).

At NFSUN conference 2020, we presented a self-developed model – MAVerBE – that allows for an investigation of students' content knowledge-linking within the energy concept (Dietz & Bolte, 2022). We used MAVerBE to investigate the content knowledge-linking within the energy concept of students at a cooperating school who received subject-differentiated science education in grades 7 and 8 (Dietz & Bolte, 2022). Since this cooperating school meanwhile has changed its curriculum in grades 7 and 8 to integrated science education, we could examine the following research question:

In what way and to what extent does the integrated science teaching approach in grades 7 and 8 affect the content knowledge-linking performance of students within the energy concept compared to the differentiated science teaching approach?

3. Design and Procedure

To answer this research question, we conducted a treatment-control case study. Control group (cg) students received the differentiated science teaching approach in the 2017/18 and 2018/19 school years. Students of the first (tg1) and the second treatment group (tg2) received integrated science lessons in grades 7 and 8 in the school years 2018/19 and 2019/20 or in 2019/20 and 2020/21 respectively. By studying three cohorts from the same school who receive either differentiated or integrated science teaching, we could mitigate confounding effects from different teachers or different student populations as much as possible.

To investigate students' knowledge-linking performance, we asked the students of all three cohorts at the beginning of grade 9 to write an essay explaining the energy concept. To support the students in writing the essays they received a list with 26 terms. We selected these terms from German science curricula before 107 science teachers assessed them as highly relevant to their own science teaching (Dietz & Bolte, 2022). All surveys were conducted during a German lesson to avoid subject-related (chains of) association(s).

For the investigation of the content knowledge-linking performance, we conducted qualitative content analysis (e.g., Mayring, 2014) with MAVerBE that considers three dimensions: (1) The vertical linkage level which describes the complexity with which terms are linked with each other (Dietz & Bolte, 2022). (2) Horizontal linkage which refers to the cross-curricular linkage of terms that can be formally assigned to different subjects via their presence in the different science curricula (Dietz & Bolte, 2022). (3) Scientific correctness which focuses on the correctness of the linking of terms (Dietz & Bolte, 2022).

For the statistical comparison of the group performances, we carried out t-test calculations for independent samples.

4. Analyses and Findings

We conducted all surveys as planned. Descriptive statistics are presented in table 1.

Table 1. *Descriptive statistics (cg: control group, tg1: treatment group 1, tg2: treatment group 2; cg-tg1 and cg-tg2: ***p < 0,001, *p < 0,05)*

	cg	**tg 1**	**tg 2**
science teaching in grades 7 and 8	differentiated	integrated	integrated
survey at the beginning of the school year 9	2019/20	2020/21	2021/22
9th grade students (essays for examination)	134 (132)	141 (141)	141 (137)
age of the students	13,9 ± 0,4	13,8 ± 0,4	13,8 ± 0,5
words per essay	126 ± 75	173 ± 73***	144 ± 69*
analysis units per essay	14.3 ± 7.4	19.3 ± 6.3***	16.8 ± 6.8*

Students of both treatment groups on average wrote longer essays, and we on average identified more analysis units in the treatment groups' essays than in the control groups' essays (tab. 1).

Due to space limitations in these proceedings, we only present results regarding the correct linking performances of the students differentiated by all three groups. Excluding incomprehensible or repetitive statements we assessed 1.315 of 1.797 analysis units in 132 essays of the control group (cg in fig. 1 and 2), 2.220 of 2.632 analysis units in 141 essays of the treatment group 1 (tg1 in fig. 1 and 2) and 1.862 of 2.217 analysis units in 137 essays of the treatment group 2 (tg2 in fig. 1 and 2) as being explicitly or at least implicitly correct.

The distribution of these analysis units within the different vertical linkage levels is shown in fig. 1. Because of the different sizes of the three groups, we normalized the results in terms of the number of essays in each group.

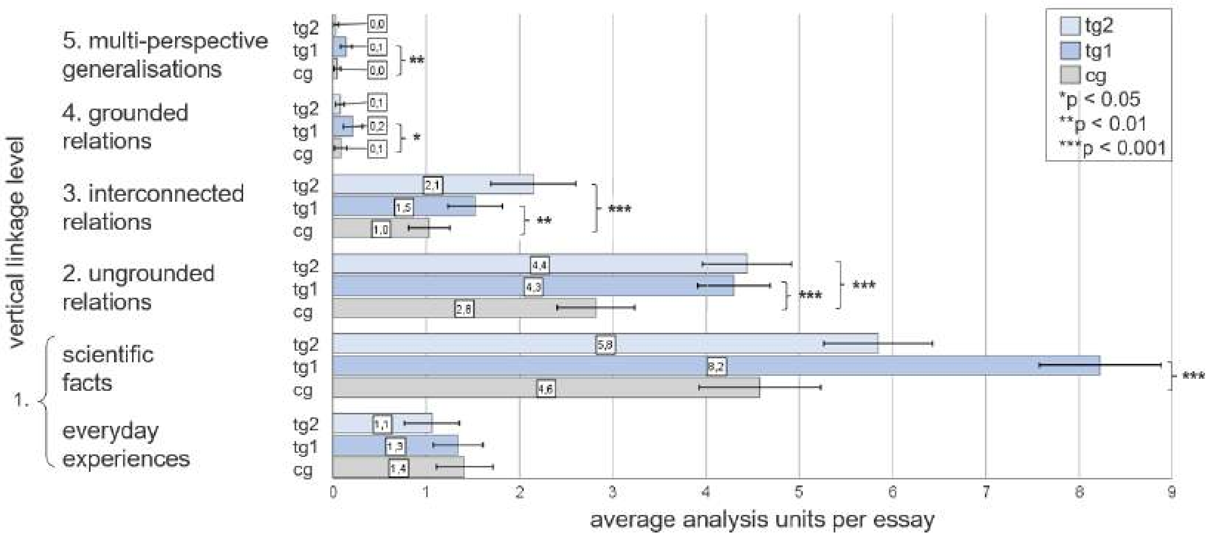

Figure 1. *Distribution of the mean scores "analysis units per essay" only focussing on correct student statements among the different vertical linkage levels (cg: control group, tg1: treatment group 1, tg2: treatment group 2; cg-tg1 and cg-tg2: ***p < 0.001, **p < 0.01, *p < 0.05)*

Compared to the control group, the students of both treatment groups on average wrote more statements in their essays that are assigned to a higher vertical linkage level (fig. 1). For treatment group 1 we found statistically significant differences at all five vertical linkage levels compared to the control group (fig. 1).

Results from the analyses of the *horizontal linkage dimension* in correct student statements are shown in figure 2.

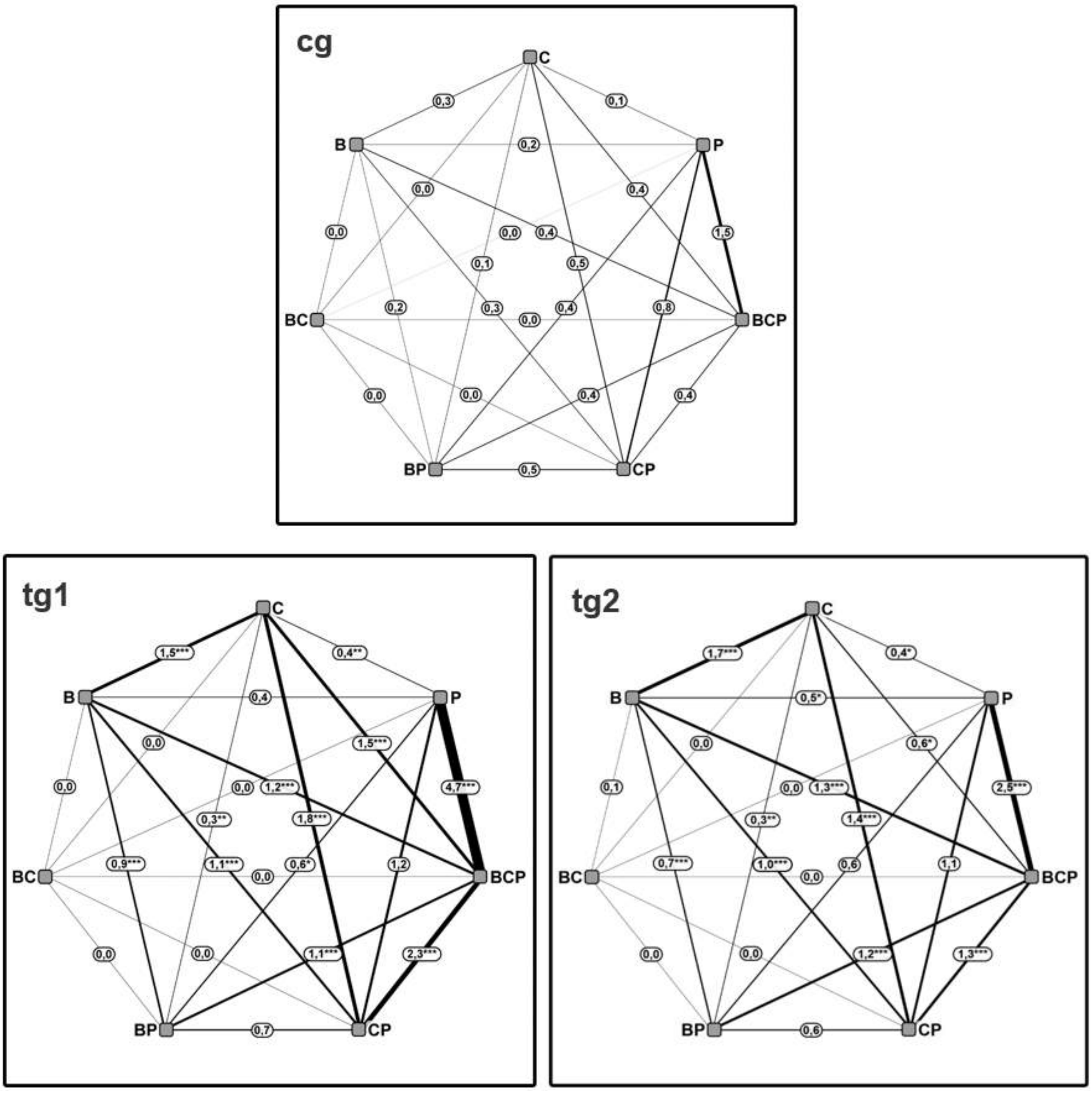

Figure 2. *Average values of horizontal term linkages per essay focussing only on correct student statements (cg-tg1 and cg-tg2: ***p < 0,001, **p < 0,01, *p < 0,05; B = biology, C = chemistry, P = physics, BC = biology/chemistry, etc.)*

In the essays of both treatment groups, we found significantly more links between subject-specific terms and terms that can be assigned to one (e.g., B C) or two different other subjects (e.g., B CP) as well as to all three subjects (e.g., P BCP) than in the essays of the control group (fig. 2).

5. Discussion

Due to the large number of statements which the students provided in their essays, we can state that the students we examined have already built up notable knowledge structures on the energy concept at the beginning of 9th grade regardless of the chosen approach of science teaching. However, in this study we identified several positive effects of an integrated science teaching approach in grades 7 and 8: The students in both treatment groups not only linked more terms of the energy concept in their essays, but also more often in a correct way than the students in the control group. In addition, students of both treatment groups formulated more statements at a higher vertical linkage level and more frequently linked terms from different subjects in a cross-curricular way. These positive effects were first observed in treatment group 1 (at the beginning of school year 2020/21) and could be confirmed in the treatment group 2 (at the beginning of school year 2021/22). These findings – especially those for treatment group 2 – are even more impressive when we consider the unusual conditions under which many science lessons took place during the pandemic period.

Of course, there are limitations concerning our investigation. First, as a pre-post-test design was not possible for school organisation reasons, we did not compare learning gains and thus we cannot completely exclude (unlikely) differences in the cohorts' abilities (prior to our study). Secondly, the assignment of terms to a subject or a combination of subjects via their presence in specific curricula might be criticised. Although this form of assignment may not be the best choice, but as these curricula are negotiated by science education experts and highly experienced curriculum developers, they finally represent social and professional consensus. Third, we conducted a case study, which is why there needs to be further research into the effects of integrated science teaching on the development of content knowledge-linking at other schools.

In summary, to the best of our knowledge, we have provided empirical evidence that integrated science education fosters content knowledge-linking within the energy concept more than differentiated science teaching – which is essential for successful learning – for the first time.

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A FORMATIVE INTERVENTION TO SUPPORT SCIENCE TEACHERS’ PROFESSIONAL LEARNING

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Abstract

The purpose of this study was to develop teachers´ professional learning (PL) and teaching agency and thereby enable improvements of students' transition from primary to lower secondary school in the science subjects. The research was designed as a formative intervention which was conducted for one year and involved five teachers and two researchers in five collaborative sessions. The teachers’ group talk and reflective thoughts from individual interviews are reported. The intervention design provided a permissive atmosphere and enabled open-minded talks about the teachers’ own views on possibilities for scientific inquiry in class and also about science content in relation to students’ transitions. The participants' willingness to share their experiences and thoughts about their own teaching enabled PL and a developed personal PCK. Results show that the teachers highly value science education talks and collaboration and that meetings which allow the teachers to discuss science content and teaching appear to be missing since the implementation of a new curriculum in 2012.

1 Introduction

This study involved science teachers in collaboration with researchers to develop professional learning (PL) in science teaching. Kaur et al. (2022) recommends professional collaboration among primary and secondary teachers in both science and mathematics education. In Swedish compulsory school, student transitions from 6th to 7th grade are significantly hampered by a lack of communication between primary and secondary school teachers. Most students are disappointed with secondary school science (Kaur et al.). These findings indicate the importance of teachers from both sides of the transition collaborating to learn about and understand what is taught to, and expected of, students at different grade levels. Such collaboration can enable further discussions about possible improvements of the pedagogical continuity across the transition, and teachers can create a supporting environment and motivate students both socially and in developing key skills (ibid.). According to Biesta et al.’s (2017) ecological approach on agency, teachers’ talk is important, and resources are needed for letting teachers articulate both individual and collective thoughts of teaching. An important aspect of PL efforts is the long-term impact on teaching, and in relation to this, the need for teachers to be active participants and co-constructors rather than passive receivers (Nilsson, 2014).

We let the teachers own the process and our task as researchers was to maintain the focus by presenting current and relevant research and introducing various methods building on previous meetings. We used Sannino et al.’s (2016) design of formative interventions where teachers:

1. formulate what they would like to process (the *object*),
2. get to talk and work hands-on together (the *process*),
3. formulate how they can change their teaching and their collaboration (the *result*).

The learning process is called expansive learning, and the intervention of the researcher should be viewed as guiding and not controlling (Sannino et al., 2016). Our research questions are:

1. How do teachers' talk reveal their knowledge and experiences of the *object*?
2. How do the *process* and *result* of the intervention improve teachers' professional learning and teaching agency?

2 Theoretical backgrounds

Our theory is grounded in both sociocultural and individual learning, since teachers' agency develops on both an individual and social level (Biesta et al., 2017). In our analysis teachers' individual reflections from teaching i.e. enactment PCK help them to develop the personal PCK (cf. Alonzo et al. 2018) during the intervention. The sociocultural professional learning context, which is characteristic for formative interventions, can be achieved and observed during both group discussions and in individual interviews (Sannino et al., 2016).

3 Research methods

The formative intervention was conducted for one year and five teachers and two researchers participated (Table 1) in five collaborative sessions (Table 2).

Table 1 *The participating teachers (all names are pseudonyms)*

Teacher	Grades	Subjects taught
Alice	4-6 and 7-9	Biology, physics, and chemistry
Ben	7-9	Biology and physics
Carl	7-9	Technology
Dina	4-6	Biology, physics, and chemistry
Ted	1-9 (science centre teacher)	Biology, physics, technology, and chemistry

Both talks and interviews were semi-structured (Kvale, 1997) using questions and/or prompts to initiate the talk. Each session was audio recorded and transcribed verbatim by the researchers. To explore the participants' own narratives and experiences we conducted a thematic analysis. We read and re-coded the transcripts several times to identify and agree on possible codes connected to the themes *process* and *results* of the formative intervention (c.f. Sannino et al. 2016).

Table 2 *The formative intervention plan (those that were used for this article are shaded)*

Session	Date	Theme	Participating teachers
1	Aug. 2021	Introduction to formative interventions *Group talk*	Core group (5 teachers)
2	Nov. 2021	Workshop with lab material related to photosynthesis. *Group talk* at each station	Core group (5 teachers) 16 other teachers from grades 4-9
3	Jan. 2022	Group talk and trial use of the tool Content Representation (CoRe), (Loughran et al., 2004)	Core group (5 teachers)
4	Feb. 2022	Continued talk using CoRe together with teachers from other schools, topic: dialogic teaching and the carbon cycle	Core group (5 teachers) 18 teachers from grades 4-9
5	May 2022	Group talk and *final individual interviews*	Core group (5 teachers)

4 Results and discussion

The object – session 1

During the teachers' talks, the object of photosynthesis was identified as something challenging to the teachers, in terms of abstract content and perceived difficulties knowing what was expected from students at different grade levels.

Processing the object - session 2

At a workshop held at a local Science Centre the teachers were prompted to talk by their interaction with plants, seeds, and materials set up in six stations e.g. a closed ecosystem and cress sprouted in dark and light conditions. The practical tasks enabled permissive talks about science content in relation to students' transitions as well as the teachers' questions and suggested possibilities for in-class scientific inquiry. As researchers we expected possible difficulties for primary and secondary teachers to meet and bring up questions, but their talk showed no such tendencies. There was an apparent willingness to share their own enactment PCK (ePCK), which allowed both professional learning and a developed personal PCK (pPCK) (c.f. Alonzo et al., 2018). The excerpt below shows part of a talk between Ben and Carl (secondary teachers), Dina (primary teacher), and Alice (primary and secondary teacher) (cf. Table 1).

Ben: Do you grow cress in primary school?

Dina: No, we haven't.

Ben: No, I have a cress bag, but I've never used it.

Dina: No, but this is rewarding.

Carl: It's so quick and obvious.

Dina: However, I have grown peas and sort of done this…

Ben: That's a typical thing we should talk to each other between stages because we've also grown peas and had it in both darkness and light….
[…]

Dina: Yes but open this lid [crass grown in the dark] and we'll see. I'm getting curious.

Alice: Yes, I am also very curious.

Carl: Well… we must make a prediction.

Dina: I don't think it's as green as...

Alice: Well, exactly, I also think it will be...

Carl: Why then?

Ben: We know that something has happened, but I think they are thinner, if anything has happened.

Dina: Yes.

Carl: I don't think they have become as long, perhaps.

[They open the lid]

Dina: Oh!

Alice: Yes, they're not green. Although these [dark sprouts] are a bit longer. Maybe they are looking for the light.

[…]

Alice: Ehh, is it, is it the chlorophyll that must be developed by the light or? Or why does it happen?

Dina: Yes exactly?

Ben: Why does it turn green there?

Dina: Doesn't a plant already have chlorophyll, or can it form chlorophyll by itself?

Ben: Mmm…

Dina: It can?

Ben: Well, I didn't answer **that** question.

Dina: Ok…

Carl: But you mean…, where does the colour come from?

Alice: Yes, exactly. So that one [dark sprouts] has, it must be the chlorophyll that is missing here?

Dina: This is really an inquiry task, where you can work with the scientific method, study and draw conclusions and compare.

Ben: Mm, and create interest, because something happens every day

Both primary and secondary teachers expose a knowledge gap related to chlorophyll, and this is an example of possibilities for professional learning (c.f. Alonzo et al.,2018) and increased teaching agency among the teachers in a sociocultural context (c.f. Biesta, 2017).

Reflections of the result - session 5

What do the teachers view as professional learning (PL) and increased teaching agency according to this intervention? In the individual interview, Ted (science centre educator) emphasizes the importance of practical work in science. Alice's and Ben's excerpt below show how they stress the importance of group talk, which has disappeared and is missing in their present work. This is unfortunate since there is strong evidence of the need for this in PL (Alonzo et al., 2018; Sannino, 2016).

Researcher: Has your approach to your own teaching been influenced by the work we have done during this project?

Alice: Erm, I think more about what is said and done in the classroom… PLUS: it's useful to be able to discuss and it's great to have science education meetings like this, … So, it's very rare that you have the chance to sit down and just talk and get immersed in teaching. I think that's fun. To get to think.

[…]

Researcher: Don't you talk about science teaching at school?

Ben: No, since we teach our separate disciplines now, it isn't as natural. A few years ago, when everyone taught all the science disciplines, we helped each other… then it was natural, and we talked all the time in a different way...

Ben misses the collaboration from earlier years, but as he thinks a little more, he realizes that he and Alice still talk sometimes between lessons. According to Desimone (2012), talk between lessons is an important part of PL which teachers do not count as PL. This may need to be acknowledged among teachers, school developers and school leaders so that science teachers from primary and secondary school are encouraged and allowed to meet and collaborate. This would offer continual PL with the purpose of improving science education across the transition from 6th to 7th grade.

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HVILKE BÆREKRAFTKOMPETANSER ANVENDER ELEVER I ARBEID MED ET BÆREKRAFTPROBLEM

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Abstract

Sustainability education is crucial for future generations to promote a sustainable society. A shift from a content focus towards a more competence-driven education, has also had an impact on sustainability education, where key competences for sustainability have been promoted as learning goals. Analysis of the Norwegian curriculum found that the curriculum does not particularly emphasize the importance of students developing their own strategies and being aware of how they can implement these strategies individually or collectively. This lack of emphasis can lead to teaching that is normative and does not empower students to take action. To address this issue, this study investigates which sustainability competences students actually apply after completing teaching related to sustainability issues in upper secondary school, and to what extent. Deductive analysis of 18 upper secondary school students' texts showed that implementation competence and interpersonal competence were almost absent in the students' texts. If students are to become active participants in, or leaders of, change processes related to sustainability, it is crucial for teaching to focus more on developing implementation competence. In addition, teachers should also explicitly address interpersonal competence, as this is necessary to elevate individual action competence to a societal level.

1 Introduksjon

Bærekraftundervisning anses som viktig både fra politisk hold og i et utdanningsperspektiv, for at nye generasjoner skal kunne bidra til et bærekraftig samfunn (UNESCO, 2017). Innen utdanning har et kompetansedrevet læringssyn fått en større plass, noe som indikerer et skifte fra det som undervises til det som læres. Prosessen har blitt kalt «The competence turn» i utdanningen (Vare, 2022), og antyder et skifte fra innhold fokus mot en mer kompetansedrevet utdanning. Dette skiftet har også hatt en innvirkning på bærekraftundervisning, der nøkkelkompetanser for bærekraft har blitt fremmet som læringsmål av politikere og forskere (Brundiers et al., 2021; UNESCO, 2017; Wiek et al., 2011).

En analyse av norsk læreplan utført av Scheie og kolleger (2022) viste at både overordnet del og fagspesifikke læreplaner hadde få koder knytta til bærekraftkompetansene framtidstenkning, strategisk tenking og implementering. Dette kan tolkes til at læreplanen ikke vektlegger i særlig grad at elevene selv skal utvikle strategier og være bevisste på hvordan de kan implementere disse strategiene enten individuelt eller sammen med andre. Å bare analysere konkrete bærekraftutfordringer gjennom å utforske systemene og verdiene knyttet til disse er ikke tilstrekkelig til at elevene får utviklet handlingskompetanse. Hvis de ikke skal utvikle strategier, hvor skal de da hente strategiene fra? En manglende vektlegging av strategitenkingskompetanse kan i verste fall føre til at undervisningen blir normativ ved at lærerne forteller elevene hva de skal gjøre. Scheie og kolleger (2022) konkluderer blant annet med at læreren selv må være bevisst på å inkludere disse kompetansene i sin bærekraftundervisning.

Som en følge av resultatene fra Scheie og kolleger (2022) vil denne studien undersøke hvilke bærekraftkompetanser elevene faktisk anvender etter gjennomført undervisning knytta til bærekraftproblematikk i videregående skole.

Forskningsspørsmålene er: 1. *Hvilke bærekraftkompetanser anvender elevene?* 2. *Hvor frekvent anvender elevene de ulike bærekraftkompetansene?*

2 Teoretisk bakgrunn

Kompetanser omfatter kognitive, affektive, viljestyrte og motiverende elementer (UNESCO, 2017; Brundiers et al. 2021), og kan ikke undervises, men bare utvikles av elevene selv (UNESCO, 2017). Det er flere kompetanser som pekes på som spesifikke for bærekraftundervisning og disse er i hovedsak diskutert i forhold til høyere utdanning (Brundiers et al., 2021; UNESCO, 2017; Wiek et al., 2011). Det hersker lite enighet om hvilke kompetanser som er nødvendige, hvordan de defineres og om noen er viktigere enn andre (Mochizuki & Fadeeva, 2010). Det gis stort sett bare korte beskrivelser av kompetansene, men Brundiers et al. (2021) sin Delphi-studie går mer i dybden. I denne studien støtter vi oss på Brundiers et al. (2021) beskrivelse av kompetansene (Tabell 1). Vi velger imidlertid å skille ut kritisk tenking som egen kompetanse og erstatte problemløsningskompetanse med problemutforskningskompetanse, dette på linje med Scheie og kolleger (2022).

Tabell 1: *Korte beskrivelser av bærekraftkompetanser.*

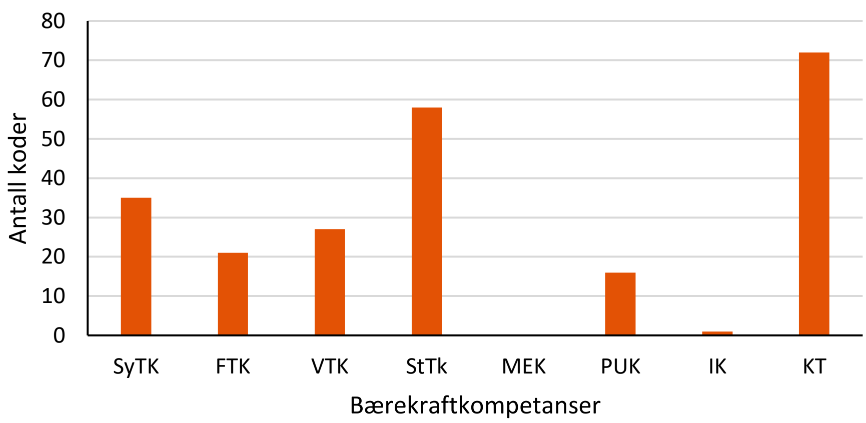
Bærekraftkompetanser
Systemtenkingskompetanse (SyTK) er å kunne analysere sammensatte komplekse system på tvers av domener i tid og rom, og avdekke effekter og responser (Wiek et al., 2011).
Framtidstenkingskompetanse (FTK) er å kunne analysere, evaluere, redefinere og kontinuerlig foredle ens egen framtidstenking, samt anerkjenne at hvordan samfunnet fungerer i dag er med på å påvirke framtidstenkingen (Brundiers et al., 2021; Wiek et al., 2011).
Verditenkingskompetanse (VTK) er å kunne kartlegge, anvende og forhandle bærekraftverdier, prinsipper og mål (Wiek et al., 2011), dette med søkelys på egne og samfunnets verdier (Brundiers et al., 2021).
Strategitenkingskompetanse (StTK) er å kunne utvikle strategier for bærekraftige handlinger (Wiek et al., 2011), men også å kunne gjenkjenne bakgrunn for manglende bærekraft og motstand mot og barrierer for endring (Brundiers et al., 2021).
Problemutforskningskompetanse (PUK) innebærer å integrere og kombinere trinn i problemutforskningsprosessen ved å bygge på fag og tverrfaglighet (Scheie et al., 2022).
Implementeringskompetanse (IK) er å kunne være deltakende i eller lede endringsprosesser som bryter med eller forstyrrer bestående handlingsmønster.
Mellommenneskelig kompetanse (MEK) vektlegger blant annet motivasjon for samarbeid med andre og innsikt i egen rolle, samt en bevissthet om egne følelser (Scheie et al., 2022).
Kritisk teningskompetanse (KTK) er evnen til å stille spørsmål ved normer, praksis og meninger; å reflektere over egne verdier, oppfatninger og handlinger; og ta posisjon i bærekraftdiskursen (UNESCO, 2017).

3 Metode

Studien er en kvalitativ studie av elevtekster fra 18 elever (11 gutter og 7 jenter) på videregående skole i en norsk kommune med omtrent 5000 innbyggere. Utvalget er et bekvemmelighetsutvalg da elevtekstene er tekster gjort tilgjengelig for forskerne (Cohen et al., 2018). Det er gitt informert samtykke fra elevene. Elevtekstene ble skrevet på slutten av et undervisningsopplegg om mikroplast hvor bærekraftig utvikling var et sentralt tema. Dette er datagrunnlaget for deduktiv innholdsanalyse (Braun & Clarke, 2021) med analyseverktøyene: 1) Kjennetegn på måloppnåelse for bærekraftkompetanser og 2) Disposisjoner og ferdigheter i kritisk tenking (Scheie et al., 2022).

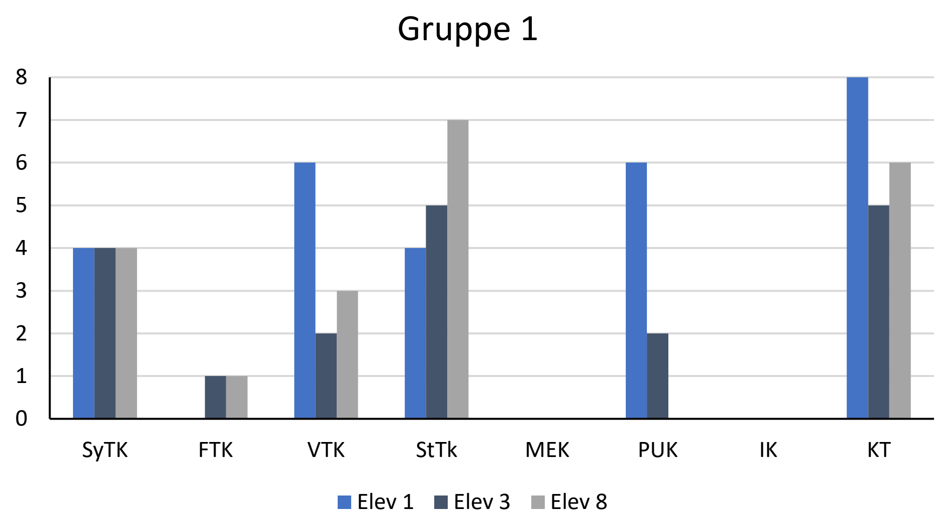
4 Resultater

Foreløpige analyser viser at elevene anvender bærekraftkompetansene i ulik grad som vist i Figur 1.



Figur 1. *Antall ganger elevene har anvendt de ulike bærekraftkompetansene systemtenking/SyTK, fremtidstenking/FTK, verditenking/VTK, strategitenking/StTk, samarbeid/SAM, problemutforskning/PUK, implementering/IK og kritisk tenking/KTK.*

Elevene er gruppert i tre grupper etter hvor mange bærekraftkompetanser de har anvendt og frekvensen av disse. Elevene i gruppe 1 og 2 har anvendt de samme kompetansene (figur 2), men det som skiller gruppene er den totale mengden koder oppnådd (hhv. snitt på 22,3 og 13,3). Av de 18 tekstene som er analysert er det 11 som plasserer seg i gruppe 2.



Figur 2. *Den totale mengden koder funnet hos elevene i gruppe 1, fordelt på de ulike bærekraftkompetansene.*

De tre elevene i gruppe 1 anvendte systemtenkningskompetanse ved fire anledninger. Elev 1 viste systemtenkingskompetanse på følgende måte:

"Plast er et veldig bra materiale på mange måter. Det er lett å produsere, lett å forme, har mange bruksområder og er billig. Helt siden 1950-tallet har plast vært det mest brukte industrimaterialet i verden. Siden plasten er billig å produsere blir ting billigere. Dette gjorde det mulig for at store deler av befolkningen å få råd til ting som nå er helt «vanlige» ting." (Elev 1)

Eleven ser på bruk av plast i et tidsperspektiv, og på sammenhengen mellom anvendelse av plast og økonomi og samfunn. Eleven peker også på hvorfor plastforbruket har økt drastisk med industrialiseringen og identifiserer dynamiske sammenhenger mellom forbruk og tilgjengelighet/pris.

Alle de 4 elevene i gruppe 3 har vist kompetanse innen kritisk tenking, og alle har anvendt minst 2 bærekraftkompetanser. Sammenlignet med elevene i gruppe 1 og 2 viser elevene i denne gruppa en mindre bredde i anvendelsene av bærekraftkompetanser, og også en mindre total anvendelse av disse.

4 Diskusjon og konklusjon

Implementeringskompetanse er nærmest fraværende i datamaterialet. Skal elevene kunne delta i, eller lede endringsprosesser som bryter med, eller forstyrrer fastsatte handlingsmønster i vårt samfunn (Scheie et al., 2022), vil det kreve et økt fokus på implementeringskompetanse. Fravær av implementeringskompetanse kan imidlertid skyldes at elevene tolket oppgaven til at de skulle beskrive strategier, uten tanke for implementering.

Studien kan i tillegg tyde på at lærere må jobbe mer eksplisitt med mellommenneskelig kompetanse for å løfte handlingskompetansen fra et individ- til et samfunnsnivå.

Å la elevene få prøve ut ulike prosjekter i praksis ved å inkludere alle bærekraftkompetansene, hvor de får erfaringer med implementering og vurdering av hvilke strategier som fungerer og hva som skal til for å få iverksatt ulike tiltak på en mest mulig effektiv måte, kan derfor være hensiktsmessig for at de skal kunne være med å ta kloke beslutninger på komplekse bærekraftproblem.

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HISTORY OF SCIENCE AND ARGUMENTATIVE TEXTS FOR LEARNING ABOUT THE NATURE OF SCIENCE: AN INTERVENTION STUDY IN SECONDARY PHYSICS

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Abstract

Historical approaches may be constructive for students to learn about the Nature of Science(NOS). However, teachers often lack teaching strategies that engage students actively. This paper reports a study where the discovery of photoelectric effect and its influence on the understanding of the nature of light is used as a historical case in upper secondary physics teaching. Students are asked to write a chronicle where they argue for one of the historical views. We investigate how the students' texts and their reflections about the teaching approach reflect aspects of NOS. Data consist of six chronicles from students and group interviews with four student groups. Results show that students cover key aspects of NOS intheir writing and reflections about the historical case. In contrast to the traditional laboratory reports, the untraditional genre for writing in physics also showed to be constructive for including argumentation in teaching about NOS with a historical case.

1. Introduction

Teaching about the history of science is one way of familiarizing students with the Nature of Science (NOS), alongside contemporary socio-scientific cases and student inquiry activities (Allchin et al., 2014). However, teaching about the history of science can easily turn out to be merely anecdotes, and teachers often lack insights and strategies for teaching historical topics in ways that engage students (Henke & Höttecke, 2015). On the other hand, it hasbeen shown that students' experimental work and report writings often lack the argumentative aspects of establishing new knowledge in science (Knain et al., 2019).

This paper reports an intervention study where the discovery of photoelectric effect is usedas a case to combine teaching about the Nature of Science with argumentation and creative writing in upper secondary physics. After an introduction by the teacher, the students writea chronicle, imagined to be dated 1922, where they argue for one view of what photoelectric effect means for the interpretation of the nature of light. Students get a text describing the historical case as a resource, adapted to the students' level of knowledge.

The research question is: *What aspects of NOS do the students cover in their chronicles andin their reflections on the case?*

2. The historical case and analytical framework

The photoelectric effect has been important for understanding the nature of light. A metal plate radiated by UV light will release electrons, and the physicist Philipp von Lenard studied this experimentally around 1900. He found that the light's intensity influenced the number of electrons released, but not on their speed as one would expect with the dominating view of light as waves. Lenard explained this by proposing that electrons have an internal movement inside the atom and that they were released due to a resonance effect between the UV light and the electron. Albert Einstein showed that this could instead be explained byviewing light as particles (photons), and that each photon interacted with only one electron.This was massively rejected by the physics community since the wave model could explain so many other phenomena.

The work on the photoelectric effect illustrates many aspects of the Nature of Science. For analysis, an analytical framework of characteristics of NOS based on Stadermann og Goedhart (2022) is used. The characteristics are:

- Use of models
- Scientific knowledge as tentative
- Science as a human activity, collective and including creativity
- Controversies as part of scientific development
- Interaction between theory and experiment

These characteristics were *not* presented to the students ahead of their work.

3. Research methods

The teaching activity was tested in one class of 13 upper secondary physics students. Data were collected in terms of six chronicles written by these students in groups, and four group interviews with four of the six student groups. Both types of data were analysed by means of the analytical framework of characteristics of NOS.

4. Results

Analysis of the students' chronicles showed that all student groups included many of the characteristics of NOS in the framework, and that each characteristic was covered by several groups. Example 1 below shows a fraction of a chronicle that shows student argumentation for why light cannot be particles, due to how light then would be subject to gravitational forces. Example 2 shows how students point to empirical evidence that does not fit with the explanation suggested by Lenard.

Example 1, Student 1 and Student 2.

The problem is: Imagine you are a particle travelling from the sun with a given initial speed. Is it then right that the speed will remain the same when you are miles away? Due to the sun's gravitational force, you will have an acceleration against the direction of your speed, which will slow you down. Det same applies to any object with mass. If light consists of particles, it is therefore impossible that the speed is constant since the light will be accelerated due to the gravitational force. from objects such as the Sun and the Earth.

Results shown in Example 1 and 2, as well as from interviews, indicate that students have benefited from the work with the historical case in how they think about NOS. However, they tend to associate a model more with a hypothesis than with models in a scientific sense. One student suggests that the anticipations models, in terms of formulas, build on should be given more emphasis in physics teaching, and that s/he has become more awareof the anticipations that physics formulas build on through the working with the case, in ways that traditional physics problem solving does not.

Example 2, Student 10 and Student 11

Lenard proposes that the electron's speed and kinetic energy already exist as vibrations inside the atoms. He further claims that this is because light and the electron resonate, so that the electron is released at certain wavelengths and frequencies. Therefore, he says, the light is just as a catalyst, it releases something that is already there.

Lenard's claims do not take heat energy in the metal plate into account. Heat will increase the electrons' internal kinetic energy, so that they vibrate faster, which should mean that a released electron has higher initial speed. Several researchers in the period 1905-1911 have found that this isnot the case.

Several students describe in the interviews how the historical approach has elicited scientific knowledge as tentative and the value of debate, for example:

> *Student 8: «In this topic the historic approach shows that it was a lot back and forth, and much was not clear (...). It shows perhaps that science does not give a clear-cut answer. There is no fixed solution. It is more like a process where, after many arguements back and forth, some sort of conclusion is reached, but which is still not afinal answer.*

The interaction between theory and experiment in the case of the photoelectric effect isalso described, for example:

> *Student 5: «And the reason why Einstein came up with a new theory was because the changed wave theory had weaknesses. For photoelectric effect, that heating*

the metalplate didn't make the electrons go faster, as Lenard's theory proposed. So there wereall the time weaknesses with the theory about photoelectric effect that caused new theories to be developed.»

Students also describe science as a human activity, for example by pointing to that the process of establishing knowledge is collective when asked about what they have learntfrom working with the task, for example:

> *Student 3: «That it wasn't only one person who came up with everything. That it is actually many people who built on each other's theories and tested them, while at thesame time arguing about what was the correct interpretation.»*

5. Discussion and conclusion

Using history of science in science teaching may be seen as irrelevant, old-fashioned and too time consuming, in addition to not being engaging for students (see Allchin et al., 2014). In the intervention presented here, however, students were highly engaged in working on their chronicle. This may be due to that the task was student-active and invited students' to be creative as well as requiring insights in not only the history but also the physics involved in the case.

The results show that students are able to describe key characteristics of NOS in the concrete case, although what a 'model' means seems not so clear. Although the teachingapproach is time consuming, we will argue that going into depth in one specific case is valuable for understanding the more general characteristics of NOS. Generalization may bepresented to students afterwards, to enable them to see the same characteristics in other cases, historical or contemporary, as suggested by Allchin et al. (2014). The approach also appears to be constructive in familiarizing students with the role of argumentation in science. While it has been shown that argumentation hardly forms part of students' experimental reports (Knain et al., 2019), the chronicle as genre is already familiar tostudents as argumentative.

Working in detail with the history of science is of course challenging for teachers, and morein-depth cases should be presented on suitable level for students and made available as resources to teachers.

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UDVIKLING AF FAGSPROG I FORBINDELSE MED PRAKTISK ARBEJDE

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Abstract

The project is based on our own experiences, which indicate a need for increased focus on the use of the language of science in connection with laboratory work in the natural sciences.

Student teachers have recorded audio dialogue during laboratory experiments and analyzed the dialogue using an analytical tool. After reflecting on the analysis, various tools were developed to facilitate 'the talking of science' during laboratory work. The tools were tested, adjusted, and a master list of science-language-tools was compiled together with the student teachers. Different elements of the tool were tested with pupils from elementary school.

Through the investigation, the student teachers have created a project logbook and reflected on both the method and their own learning outcomes. These are analyzed using thematic analysis, with key points from Pedagogical Content Knowledge (PCK) used as the analytical framework. The logbooks show a good attention to the student teachers own development of science language, and there seems to be a significant benefit in incorporating the double didactical perspective, both in terms of motivation and ownership. It suggests that the combination of self-evaluation through a logbook and testing with students from elementary school overall provides a good learning outcome for teacher students.

1 Introduction

Undersøgelsen tager udgangspunkt i erfaringer om lærerstuderendes anvendelse af fagsprog ved laboratoriearbejde. Erfaringerne viser manglende transfer mellem fagsprogbrug i den teoretiske- og praktiske del af undervisningen.

Dette har inspireret os til at undersøge spørgsmålet *"Kan lærerstuderende vha. selvevaluering i projektlogbøger understøtte og forbedre deres brug af fagsprog i forbindelse med det praktiske arbejde i naturfagene, og hvilke erfaringer gør studerende sig med at omsætte dette til grundskolepraksis?"*.

2 Theoretical backgrounds

Overgangen mellem læreruddannelsens skole- og campusarenaer repræsenterer vigtige læreprocesser (Nielsen & Jelsbak, 2018; Raaen & Thorsen, 2020). I LU23 er der en forventning om, at skolearenaen inddrages mere i uddannelsen. Dette skal understøtte lærerstuderende i at danne synteser mellem fagfaglig og fagdidaktisk viden. Lærerfaglighed kan bl.a. anskues med begrebet Pedagogical Content Knowledge (PCK) (Carlson & Daehler, 2019; Ellebæk & Nielsen 2016). Udvikling af en professionel tilgang til lærerjobbet fordrer, at studerende er i stand til at reflektere over egen undervisning (Levy, 2018). De studerende bør derfor beskæftige sig med observation og vurdering på en systematisk og bevidst måde gennem uddannelsen.

Lærerstuderendes faglighed udvikles bl.a. ved, at de opnår et tilstrækkeligt fagsprog og samtidig opnår kompetencer til at kunne facilitere kommende elevers fagsprogsudvikling. Eleverne skal kunne udtrykke sig præcist og nuanceret ved brug af fagsprog og begreber, og de skal kunne vurdere kvaliteten af kommunikation om naturfaglige forhold (Undervisningsministeriet, 2019).

I et undersøgende fag som biologi møder både lærerstuderende og grundskolens elever usikkerhed og uforudsigelighed, når de bevæger sig fra teorilokalet til laboratoriet. Det kræver en bevidsthed hos en underviser at skabe sammenhæng i fagsprogsudviklingen i bevægelsen mellem de to fysiske rum. Tænkningen omkring at bruge fagsprog i forbindelse med laboratoriearbejde er inspireret af Lemkes (1990) forståelse af ”doing science” og ”talking science” hvor det praktiske arbejde bruges som mediator til at udvikle et fagsprog. Studerende bør således kende til, hvordan de både kan makro-og mikrostilladsere laboratoriearbejde (Polias, 2018).

3 Research methods

Uden at være informeret om fokus på fagsprog, udførte lærerstuderende gruppevis et laboratorieforsøg i biologi, hvor de lydoptag samtalen undervejs. Denne gav mulighed for en dybdegående og præcis selvevaluering. Lydoptagelsen blev transskriberet til tekst og efterfølgende analyseret med et udarbejdet analyseværktøj.

Hver studiegruppe udarbejdede et fagsprogsværktøj til at rammesætte laboratoriearbejdet. Eget værktøj blev afprøvet med samme laboratorieforsøg og tilhørende lydfil og analysearbejde. Ud fra gruppernes erfaringer blev en fælles bruttoliste med både makro-og mikrostilladserende aktiviteter samlet. Fagsprogsværktøjet blev efterfølgende afprøvet med grundskoleelever.

Studiegrupperne udarbejdede projektlogbøger med refleksioner over eget fagsprog, brug af fagsprogsværktøjet og afprøvning med elever. Formålet med logbogen var formativ selvevaluering. Logbøgerne blev analyseret ved hjælp af tematisk analyse (Braun et al. 2018). Temaerne i analysen var inspireret af PCK-modellen.

4 Results

Gennem de studerendes projektlogbøger blev deres læring og didaktiske overvejelser dokumenteret. De forskellige hjælpemidler til stilladsering af fagsprog var: fagordskort, modeller, dialogisk undervisning med fokus på produktive spørgsmål, tegninger og skriftlig opsamling vha. billeder.

Samtlige grupper vurderede, at deres fagsprogsbrug var blevet forbedret gennem det fokuserede gruppearbejdet med fagsprogsanalyser af lydmateriale (*tabel 1*).

Ud fra de målte parametre ses de største forandringer i evnen til at kunne identificere sætninger med korrekt sprogbrug samt udvælgelse og omskrivning af sætninger.

Tabel 1. *Gruppernes forståelse og brug af fagsprog i analysen af første og anden lydfil. Tallene angiver gruppenumrene.*

	Første analyse	**Anden analyse**
Kan i **høj grad** skelne mellem fagord og hverdagsord	1, 2, 5	1, 2, 4, 5
Kan i **nogen grad** skelne mellem fagord og hverdagsord	3, 4, 6	3, 6
Kan identificere en sætning med korrekt sprogbrug	4, 5, 6	1,2, 3, 5, 6
Kan ikke identificere en sætning med korrekt sprogbrug	1, 2, 3	-
Kan identificere en sætning med ukorrekt/utilstrækkelig sprogbrug	1, 2, 3, 4, 5	1, 2,3
Kan ikke identificere en sætning med ukorrekt/utilstrækkelig sprogbrug	6	4, 5, 6
Kan omskrive en sætning, så fagsproget **forbedres**	1, 2, 4	1, 2, 3, 4, 5, 6
Omskriver en sætning, men **forbedringsforslaget er upræcist**	3, 5, 6	-
Vurderer eget fagsprogbrug til niveau **2**	5	-
Vurderer eget fagsprogbrug til niveau **3**	1, 3, 4, 6	-
Vurderer eget fagsprogbrug til niveau **3,5**	2	-
Vurderer eget fagsprogbrug til niveau 4	-	1, 2, 3, 4, 5, 6
I hvilken lydoptagelse bruges der flest førfaglige ord og fagord?	2(25 -> 13) 4(43 -> 22) 5(17->11)	1(19->26) 3(28->29) 6(14->16)

Der var forskel i gruppernes grad af refleksion over eget arbejde. Gruppe 6, som oplevede en moderat udvikling i fagsprogsbrug (tabel 1), havde kun få refleksioner over egen praksis og udbytte af afprøvningen med elever. Gruppe 1 reflekterede derimod nuanceret over vanskeligheden ved at omsætte teoretisk viden til mundtlighed, når de praktiske aspekter ved undervisningen bød på udfordringer (tabel 2). Andre grupper havde fokus på, at afbrudte sætninger og kropssprog medvirkede til, at undervisningen fremstod "usikker". En enkelt gruppe italesatte, hvad analyserne i tabel 1 underbyggede; at der er stor læringsværdi i at identificere sætninger med utilstrækkeligt brug af fagsprog og formulere forbedringsforslag.

Tabel 2*. Refleksion over de studerendes egen praksis. Udvalgte citater fra logbøgerne*

"Vi bemærkede tydeligt, at arbejdet med mikroskopet tog fokus fra forsøget, så det viser os, at det praktiske skal være håndgribeligt, inden der kan komme fokus på det faglige. Det er altså kun en fordel, at eleverne prøver forsøg flere gange, især arbejde med mikroskop." (gruppe 1)
"Vi er lidt overrasket over, at vi ikke var bedre til at bruge fagbegreberne, men vi tror, det bunder i, at vi ikke er trygge nok pa begreberne til at anvende dem i den faglige kontekst vi stod i. Det er nemmere at gå til de førfaglige- og hverdagsbegreber, vi er tryggere pa, hvad præcis betyder." (gruppe 1)
"Dog kan man se, at vi nogle gange har svært ved at formulere os, og bruger meget "øh", "ja", "hvad er det nu det hedder" og vi peger - altså dagligdags-sprog og kropssprog." (gruppe 2)

4 Discussion and conclusion

Undersøgelsen viser, at studerende får øget opmærksomhed på eget brug af fagsprog, og især hvordan de ubevidst anvender hverdagssprog i laboratoriet. Denne erkendelse blev tydelig efter transskribering af lydfil fra første iteration. I anden iteration, hvor forsøget var kendt og fagsprogshjælpemidlerne skulle afprøves, blev fagsproget både anvendt mere og i en mere præcis kontekst. Ved at sætte fokus på fagsprog på denne måde, synes der at være en større motivation i at gå ind i arbejdet, fordi fagsprogsbrug gennem selvevalueringsdesignet blev oplevet som en personlig udfordring hos mange studerende.

Målrettet analysearbejde af lydfiler i kombination med formativ selvevaluering i projektlogbøger synes således at være en effektiv metode til udvikling af de studerendes fagsprog.

I forhold til det dobbeltdidaktiske perspektiv, oplevede lærerstuderende et stort udbytte ved at undervise grundskoleelever fokuseret og i små grupper. Muligheden for at justere undervisningen mellem to afprøvninger med elevgrupper, gav et udvidet udbytte hos nogle studiegrupper. Selvom afprøvningen ikke er helt autentisk sammenlignet med klasseundervisning, kan sådanne praksissituationer give studerende mulighed for at øve specifikke færdigheder i lærerfagligheden, hvilket kan øge studerendes selfefficacy i forhold til professionen.

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(DIS-)CONTINUITY BETWEEN EDUCATIONAL LEVELS: CLASSROOMS AND MATERIALS AS PREREQUISITES FOR TECHNOLOGY EDUCATION

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Abstract

To engage students in STEM education and careers has been a question emphasised by policymakers worldwide. However, research has shown that students lose interest in technology and science studies in adolescence. Discontinuity in transitions between educational levels could be one explanation. Therefore, the aim of this study is to investigate possible (dis-) continuities in students' technology education transition between upper primary and secondary school levels. More specifically, differences in classroom furniture, materials and tools have been investigated. Fifty-two teachers have answered a questionnaire about discontinuities in how the classrooms are equipped and what kinds of tools and construction materials differ between upper primary and secondary education technology classrooms. This may lead to altering possibilities regarding what technology education will become in the different communities of practice.

1 Introduction

Several European countries, such as Denmark and the Netherlands, have taken initiatives to attract more people into STEM (science, technology, engineering, and mathematics). The Swedish government wants to follow in their footsteps by suggesting a new STEM strategy. The suggestion implies a need for pervasive changes throughout the school system. Moreover, the goal is to get more students to choose STEM education and careers.

In Sweden, one of the STEM subjects, Technology, is taught as a separate subject during compulsory school. Nonetheless, it has an interdisciplinary character, covering content such as construction, solutions to technical problems, and sustainability. From earlier research, we know that students' transitions between levels in the school system can raise problems for students. For example, school years 4-6 (upper primary school) and 7-9 (secondary school) are often viewed as separate contexts with different socio-cultural norms, expectations, roles and structures. The transition between these levels could be challenging for the students and cause negative feelings about the subject (Kaur et al., 2022). There are different (dis-)continuities in transitions between different school levels (Fabian, 2007). Students often lose interest in science and technology studies at these ages (Lindahl, 2003). In the long run, experienced discontinuity could lead to drop-out from further STEM education (Kaur et al., 2022).

This study aims to investigate possible (dis-)continuities in students' technology education transition between upper primary and secondary school levels. The study is part of a larger research project on the technology education transition, and here, we focus on physical continuity, namely how the classrooms are constituted, what furniture is, and what materials and tools are available. The following research questions guide our analysis: 1) How are the classrooms of technology education furnished? and 2) What materials and tools are available for technology education?

2 Theoretical background

This study has its theoretical foundations in a socio-cultural perspective and, more specifically, the notion of situated learning and communities of practice (Lave & Wenger, 1991). A community of practice is a group of people sharing the same goal, exchanging knowledge, and learning from each other. In a community of practice, specific tools, strategies, models, and knowledge define the community. The artefacts available in the classroom are affording different action possibilities for both the teacher and the students within a community of practice. Hence, we argue that transitioning from one school level to the next may lead to the formation of new communities of practice where novel strategies, knowledge and goals are negotiated. In that sense, the artefacts are here seen as essential prerequisites for how the technology subject can be enacted.

3 Research methods

In this study, we have focused on teachers' utterances about the classrooms, materials, and tools for technology education. Data were collected using a web-based questionnaire with open-ended and multiple-choice questions. The questionnaire was distributed in Facebook groups for technology teachers in Sweden and was answered anonymously.

Fifty-two teachers answered the questionnaire. Twenty-five teachers work in upper primary education, and 23 in secondary education. Two of the teachers work at both levels. Related to the focus of this study, five questions have been analysed: "Do you have access to an appropriate technology classroom?" (yes/no), "What type of equipment do you have in your classroom?" (open-ended), "Where do you teach technology?" (open-ended), "Which materials do you have access to?" (materials for simple construction work, materials for programming education, materials for electronic construction), "Is there any equipment that you wish you had access to?" (open-ended).

4 Results

12 of the 23 teachers in secondary education have access to what they describe as an appropriate technology classroom. Seven teachers use the science classroom, and four teachers use the ordinary classroom. 3 of the 25 teachers working in upper primary education have access to a technology classroom, and one also works in secondary education. Eighteen upper primary education teachers use the ordinary classroom, and two mention combining the ordinary classroom with being outdoors, for instance, in the schoolyard. Three teachers use the science classroom. One of the teachers describes that they have furnished a room in the basement for technology education to store the students' work between the lessons.

Teachers teaching technology education in other technology-equipped classrooms have equal access to simple materials for construction work and teaching programming. Regarding materials for electronic construction, almost all teachers (94%) in the upper primary have access to such material, but only 64% of the secondary teachers.

Teachers with access to technology-equipped classrooms have access to, for instance, 3D printers, workbenches, glue guns, tools such as pillar drills, soldering tools, tools for metal cutting, welding machines, and saws. They also have different kinds of materials for construction, such as wood, styrofoam, cardboard, popsicle sticks, and wooden rods. The teachers also have access to programming materials such as robots.

Upper primary education teachers use recycled materials they bring from home. They have access to elementary construction materials, which constrains what they can do. The teachers also emphasise the lack of storage rooms or cupboards for the materials. They need to carry the materials into the classroom for each lesson. So, even if the teachers have access to different kinds of activities, they can offer a greater variety to the students.

5 Discussion and conclusion

The aim of this study was to investigate possible (dis-)continuities in students' technology education transition between upper primary and secondary school levels. The results indicate that teachers working in secondary education have access to appropriate technology classrooms to a greater extent. This also leads to possibilities of storing the materials between lessons and having specialised tools and machines for specific functions such as metal cutting or drilling. In that sense, the prerequisites for technology education in a technology classroom differ from that in an ordinary classroom.

However, teachers working in upper primary education still seem to have a broad range of materials, even if it is simpler than the materials offered at the secondary level. Many of the teachers have possibilities to teach construction, programming and electronics based on the materials they have.

From the results, it is possible to suggest that the students may experience discontinuity regarding technology education in the transition between upper primary and secondary school. Depending on their expectations of what technology education should be, this can be a good experience. Kaur et al. (2022) show that students expect something different regarding secondary education, for example, more practical work. However, there can also be a large difference, so the students experience the transition too challenging. Here, we need more research to scrutinise what the students feel. This is also an exceptionally important age for keeping students interested in STEM subjects (Lindahl, 2003).

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LÆRERSTUDENTERS KOBLING AV UNDERVISNING I NATURFAG I ALTERNATIVE LÆRINGSARENAER TIL BÆREKRAFTIG UTVIKLING

Teacher students' connection of outdoor education in science to sustainable development.

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Abstract

In the primary school curriculum (LK20), sustainable development is one of three interdisciplinary themes that are central to science. Given that out of school teaching is a natural part of science in school, teacher education should give students experience in how they can teach their pupils outside of ordinary classrooms. The context of this study is a 4-hour out of school teaching program with lower or upper secondary school pupils where posgraduate teacher training students (PPU) in science are in charge of the teaching. The study has been carried out at Department of Teacher Education (ILU) at NTNU, and data includes teaching in spring 2019, 2022 and 2023. After the teaching the PPU students described how they believe the pupils benefit from out of school education. The students bring up several positive outcomes related to out of school teaching in science, but none of the students linked the activities to the interdisciplinary theme of "sustainable development".

Innledning

Gitt at uteundervisning er en naturlig del av naturfag i grunnskolen, må det også være en del av undervisningen i lærerutdanningen (Ulvik & Smith, 2016).

Siden høsten 2016 har studenter på Praktisk pedagogisk utdanning (PPU) på naturfag gjennomført tre dager der undervisningen foregår utenfor campus (heretter kalt uteundervisning) hvert studieår, en dag om høsten, og to om våren. Dette er også formalisert gjennom læringsutbyttebeskrivelsene for de naturfaglige emnene i NTNUs PPU-program. Vi har brukt en bred forståelse av uteundervisning i tråd med Jordet (2010 s. 32) sin beskrivelse av uteskole, som inkluderer all aktivitet "ute" av klasserommet.

I denne studien presenterer vi resultater fra spørreundersøkelser blant studentene etter den siste utedagen på våren fra og med 2019, unntatt under pandemien. Vi ønsker å finne svar på følgende spørsmål:

Hva uttrykker studenter på PPU om elevers utbytte av uteundervising etter å ha erfart slik undervisning i sin lærerutdanning?

Metode

Våren 2019, 2022 og 2023 har studentene på Praktisk pedagogisk utdanning (PPU) på naturfag ved Institutt for lærerutdanning (ILU) ved NTNU beskrevet i fritekst hvilket utbytte de mener bruk av alternative læringsarenaer kan ha for elevene. Dette er gjort rett etter at studenten har undervist ungdomstrinn- eller videregående elever utenfor deres ordinære klasserom mot slutten av vårsemesteret. Studentene er fordelt over biologi, kjemi og fysikk, men det er ikke mange nok informanter til at det gir mening å dele resultatene på fag.

Vi har gjennomført en enkel tematisk analyse (Braun & Clarke, 2006; Terry et al., 2017) av studentenes beskrivelser om hvilken verdi bruk av alternative læringsarenaer har for elevene. Kategoriene ble hentet fra litteratur (Remmen og Iversen, 2022) og Kunnskapsløftet (2020), mens utformingen og begrensingen av kategoriene fremkom gjennom fortolkningen av studentenes tekster. Følgende kategorier er beskrevet: lære om naturfaglige begreper, lære om bærekraftig utvikling, sosiale verdier, livsmestring, motivasjon og praktisk/undersøkende arbeid.

I tillegg til å beskrive kategoriene gir vi en summativ beskrivelse av noen av studentenes refleksjoner etter at spørreundersøkelsen var gjennomført.

Resultater og diskusjon

Funnene i denne studien vister at studentene legger mest vekt på at elevene kommer seg ut av skolen og får arbeide med praktiske utfordringer og undersøkelser utenfor skolen (Tabell I). Dette inkluderer også verdien av en variert undervisning. Denne vektleggingen av å legge til rette for at elevene kan høste erfaringer med å løse praktiske oppgaver er i tråd med Dewey (1996) sin beskrivelse av betydningen av erfaring knyttet til læring. Dewey presiserer at erfaringer alene ikke er nok, man må også reflektere over sine erfaringer, helst sammen med andre hvor språket kommer inn som et viktig verktøy (Vygotsky, 2000). Remmen og Frøyland (2017) fremhever at for- og etterarbeid i tilknytning til undervisningen er helt nødvendig for at elevene skal ha et naturfaglig læringsutbytte ved bruk av alternative læringsarenaer.

I vår studie knytter studentene det praktiske arbeidet og praktisk problemløsning til flere av de andre kategoriene relatert til undervisning utenfor ordinære klasserom. Det at undervisning utenfor skolen virker motiverende, både på den aktuelle tematikken og på naturfag generelt, blir løftet frem som nest viktigst etter praktisk arbeid (Tabell I). De beskriver viktigheten av at elevene som ofte ikke lykkes så godt inne i en vanlig klasseromsetting, der arbeidet ofte er av teoretisk karakter, vil lykkes bedre og gjerne blomstre på andre læringsarenaer (Faskunger et al., 2018).

På samme måte er, ifølge studentene, en positiv effekt på det sosiale og klassemiljøet koblet til at man bryter opp den rigide settingen inne i klasserommet. Dette gir elever mulighet for å vise nye sider av seg selv (Frøyland & Remmen, 2019; Remmen & Iversen, 2022; Bølling et al., 2019). Her er det imidlertid stor variasjon mellom studentkullene, uten at vi har informasjon som kan forklare det.

Beskrivelsen av livsmestring kobler studentene til det å bidra med og vise andre sider av seg selv og gjennom å mestre de utfordringer som gis. Viktigheten av å «mestre» knyttet til livskvalitet er beskrevet av Danielsen (2021). Her kan undervisning utenfor ordinære klasserom gi et verdifullt bidrag ved at elever i skolen og studenter i lærerutdanningen får andre utfordringer, som krever andre kompetanser, enn de som er vanlig i klasserommet og i studiene på campus.

Læring av naturfaglige begreper har en kobling til praktisk arbeid og undersøkelse av verden utenfor skolen ifølge studentene. Flere av studentene argumenterer for at dette kan konkretisere og vise betydningen av naturfaglig kunnskap i det virkelige liv utenfor skolen. Det er likevel verdt å merke seg at det er en betydelig mindre andel av studentene som fremhever læring av naturfaglige begreper sammenlignet med motivasjon og utbyttet av praktisk arbeid.

Det er imidlertid oppsiktsvekkende at ingen studenter ser ut til å mene at undervisning utenfor ordinære klasserom kan bidra i arbeidet med bærekraftig utvikling. Heller ikke våren 2022 og 2023, når bærekraftig utvikling som tverrfaglig tema i naturfag i LK20 skal være kjent, nevnte noen av studentene bærekraftig utvikling som en mulighet knyttet til undervisning utenfor ordinære klasserom. I tillegg hadde studentene på PPU hatt undervisning i bærekraftig utvikling i et annet emne på campus relatert til undervisning i alternative læringsarenaer tidlig på høsten. Dette ser imidlertid ikke ut til å ha gitt studentene en varig forståelse av at alternative læringsarenaer er godt egnet til å ta opp bærekraftig utvikling. En indikasjon på hva som kan være årsaken til dette funnet, ligger i studentenes refleksjoner etter undervisningen våren 2022. Noen studenter mente da at bærekraftig utvikling gjennomsyrer det meste av det de arbeidet med i naturfag og derfor ikke var noe de ville fremheve spesielt når undervisningen foregår utenfor det ordinære klasserom. Vi mener likevel at dette argumentet ikke holder i lys av at flere studenter i flere av årene har løftet frem «livsmestring» som et viktig utbytte knyttet til undervisning utenfor ordinære klasserom. Både livsmestring og bærekraftig utvikling er tverrfaglige tema i LK20. Vi undres på hvorfor studentene løfter frem det ene av disse to tverrfaglige temaene og ikke det andre.

En alternativ forklaring på at bærekraftig utvikling ikke nevnes kan være at når vi arbeider utenfor ordinære klasserom og arbeider praktisk, så opplever studentene dette som motiverende og en kjærkommen avveksling til det mer teoretiske arbeidet på campus og skolen. Derfor fremhever studentenes motivasjon og betydningen av praktisk arbeid som viktigst. Bærekraftig utvikling kan oppleves som et teoretisk begrep som de ikke ser koblingen til i de praktiske aktivitetene vi gjør. Enda en forklaring kan være at studentene i praksis i skolen opplever at bærekraftig utvikling er lite fremhevet (egne upubliserte data), sjøl om alternative læringsarenaer kan være brukt.

Tabell I: Tabellen viser antall studenter som har besvart spørreskjema i de årene vi har informasjon om, samt en oppsummering fra alle årene i nederste rad. For hver kategori vises prosentandelen av det totale antall studenter det året som fremhever nettopp den aktuelle kategorien som viktig. Samme student fremhevet ofte flere kategorier.

Tidspunkt	Antall Stud.	Naturfag begrep	Bærekraftig utvikling	Sosialt	Livsmestring	Motivasjon	Praktisk arbeid
V 2019	12	19 %	0 %	67 %	22 %	36 %	61 %
V2022	21	0	0 %	10 %	0 %	52 %	76 %
V2023	15	33%	0 %	7 %	20 %	87 %	93 %
Alle	48	17 %	0 %	28 %	14 %	58 %	77 %

Oppsummert viser våre resultater at studentene legger størst vekt på at bruken av alternative læringsarenaer gir variasjon i undervisningen og påvirker motivasjon og sosiale forhold i elevgruppa positivt. Studentene ser ut til å legge mindre vekt på det faglige arbeidet når undervisningen foregår utenfor ordinære klasserom. Delvis gjelder det arbeidet med naturfaglige begreper, men i særdeleshet gjelder det arbeidet med bærekraftig utvikling.

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THE NORDIC STUDENT TEACHERS' IDEAS ABOUT CLIMATE CHANGE AND TEACHING

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Abstract

Student teachers' perspectives on climate change and their competence in teaching the topic is important to understand since they play a critical role in motivating and empowering pupils to act. This study aims to investigate Nordic student teachers' ideas about climate change, mitigation, and education. The study's theoretical background is based on transformative learning theories. The data was collected through online surveys that included quantitative and qualitative questions, allowing the use of basic statistics and thematic analysis.

The preliminary findings indicate that the Nordic student teachers feel confident about their knowledge regarding climate change. However, few provided rigid examples about climate change, and some showed common misconceptions. The students understand how climate change impacts their country but lacked local examples and examples from other Nordic countries. Many reported that they worried about climate change. Over 70% of the students felt competent in teaching about climate change. However, they primarily focused on teaching approaches that have been found inactive in empowering children to find solutions to problems and take appropriate action. The findings indicate that teacher education should focus on local issues and encourage student teachers to facilitate discussions among children about their worries in this regard.

1 Introduction

The purpose of the study is to develop education about climate change in Nordic teacher training institutions by exploring student teachers' understanding and thinking about climate change. The Álka course is a Nordic Council-funded program that brings together educators from seven Nordic countries to offer courses for student teachers. The course is held in a Nordic country and with climate change as a recurring focus due to its diverse impacts in each country. Different STEM topics are covered, such as renewable energy and innovation.

Investigating student teachers' perspectives on climate change and how they would approach the topic in schools is very important since they will play a central role in motivating and empowering pupils to be involved in the solutions and act. To the best of our knowledge, only a few studies have approached this from a Nordic perspective. In this study, we will explore this main research question: *How do Nordic student teachers think and feel about climate change, mitigation, and education?*

2 Theoretical background

The study's theoretical background is sustainability education as transformative learning, which includes goals such as autonomy, empowerment, ecological awareness, social engagement, citizenship, and democracy (Aboytes & Barth, 2020, p. 996). Sustainability issues, such as climate change, are complex and should be addressed by integrating various perspectives and relationships. Sustainable Development (SD) Goal 4.7 points to the responsibility of education to develop students' abilities to play an active part in the transformation towards a sustainable society. Education for sustainable development (ESD) integrates sustainability issues into teaching and learning, supports students in developing competencies for sustainability problem solving, and should be approached holistically (UNESCO, 2017, p. 9). Ojala et al. (2021) found that people's worry about sustainability issues, like climate change, can motivate action, thus suggesting that teachers enable pupils to discuss their concerns and propose local strategies and actions. Implementing SD teaching and learning practices at schools may be challenging, combining subject specific knowledge with interdisciplinary global challenges, often called wicked problems, with normative issues and a need for action (Laurie et al., 2016; Östman et al., 2019).

Research reveals that many people have misconceptions about climate change, such as attributing it to pollution and the ozone hole (Fleming et al., 2021). Research on student teachers found that they lack an understanding of greenhouse gases´ function and don't recognise the human responsibility for climate change (Ürey et al., 2020).

3 Research methods

The study includes student teachers from Nordic countries who enrolled in Alka courses over three years (2023-2025). Here, we present preliminary findings from the first year with 21 participating student teachers in natural science teacher education.

The data was collected through an online survey, including quantitative and qualitative questions before the course started. The multiple choice and scale questions allow fundamental statistical analysis, but the limited sample size prohibits generalisation. The open-ended questions in the questionnaire allow participants to express their thoughts and provide an opportunity to explore students' understanding, views, and emotions about climate change in greater detail. Braun et al. (2021, p. 1) argue that qualitative surveys can be 'an exciting, flexible method with numerous applications and advantages for researchers and participants alike'. A six-step thematic analysis described by Braun and Clarke (2006) was used. Student teachers received a letter promising anonymity and signed informed consent for the study.

4 Preliminary findings

Student teacher's ideas and worries about climate change

The majority of the participating teacher students (70%) claimed that they had good knowledge about climate change, with only three showing some minor misconceptions. Few students provided examples of what causes climate change, such as how the greenhouse effect works. Most of the students claimed that humans are responsible for the current climate change and most students could provide good examples of general climate change effects from their home country. However, they provided fewer or no examples from their local environment and they could only mention some general climate change effects affecting other Nordic countries, with very few examples for the different countries. Most students claimed, however, that they had good knowledge about how climate change affects other Nordic countries. A majority of the students had considerable worries about climate change with over half claiming that the current climate changes affected their daily decisions.

Student teacher's perceptions of their own competence to teach about climate change and what approaches to use in primary and lower secondary school.

Most of the students reported feeling competent in teaching about climate change (~90%). When asked about important learning outcomes when teaching about climate change, many reported that pupils should acquire knowledge about the causes and effects of climate change. Finding solutions to problems and proactively solving them was also frequently mentioned. Few suggested emphasizing a more holistic view towards sustainability and its inclusion in all education. Also, few suggested the importance of using outdoor education, having pupils conducting their own inquiries and building children's hope instead of fear. Rarely mentioned outcomes were children's connection to nature and willingness to preserve it as well as empowering children by demonstrating that their action matters.

5 Discussions

Previous research reveals that many people have misconceptions about climate change (Fleming et al., 2021), and that student teachers lack an understanding of the greenhouse effect (Ürey et al., 2020). In our study more than 70 % of the participants thought they had good or very good knowledge about climate change while only three students showed some common misconceptions. While most students could provide relevant examples of climate change from their home country, they generally lacked knowledge about the more local effects and also the main climate challenges in other Nordic countries. The use of local environment and a place-based approach are highlighted as appropriate in ESD to offer authentic learning situations that also provide opportunities to develop action competence (Gabrielsen & Korsager, 2018). Such approaches may need to be emphasized to promote deeper understanding about climate change in student teacher education.

Another notable finding in the study was the student teachers' strong emphasis on *knowledge* about the causes and effects of climate change as the main learning outcome of climate change education. However, research shows that it is appropriate to take a holistic approach when it comes to teaching complex wicked problems and consider feelings such as powerlessness and worry, rather than primarily presenting more knowledge about the problems (Laurie et al., 2016; Östman et al., 2019). Ojala et al. (2021) has pointed out that people's worries about climate change can motivate action, thus suggesting that teachers enable pupils to discuss their concerns and propose local strategies and actions. This study showed that only few student teachers mentioned the importance of building children's hope instead of fear. Thus, indicating the need to further improve the student teacher's understanding of appropriate teaching approaches to empower and motivate future generations. The continued work in this research, with a larger sample size of Nordic teacher students, will provide better ideas of improvements and aims regarding student teacher's sustainability education.

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CAN THE SCIENCE STUDY SUBJECT, BE A SUCCESSFUL CONCEPT OF CITIZENSHIP EDUCATION FOR SUSTAINABLE DEVELOPMENT?

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Abstract

This study explores Science study teachers' (sv. naturkunskapslärares) didactic choices in sustainable development education to understand the impact of these choices on citizenship for sustainable development. In connection with a discussion based on Biesta's educational functions—qualification, socialisation, and subjectification—teachers employ various methods to build a factual foundation and foster democratic participation. Findings show that teachers actively engage students in democratic citizenship through deliberative conversations, critical reflection, and creative thinking. However, even if students are expected to give examples of sustainable actions in society, there is a potential gap, where the practical implementation of sustainable actions is not prioritized in teaching. Additionally, there is a reluctance among teachers to prioritize developing students' will to act and developing confidence in the student's ability to affect real change. One explanation could be challenges in the everyday classrooms such as time constraints, large class sizes, and a crowded curriculum, which makes teachers prioritize certain methods and opt out of others. Additionally, there is a concern that unintentional socialization into Western societal norms may influence students' views on sustainable behaviour, shaping their perspectives within specific social, cultural, and political frameworks.

1 Introduction

Education is proposed to be a key pathway to get students - both now, and as future citizens - to engage in issues connected to science and sustainable development (SD). In transforming to a sustainable world, education needs to qualify, subjectify and socialise the students with knowledge, abilities and values to take sustainable actions in society (Biesta, 2009). Here, abilities are something that can be learned through support and practice (Sass et al., 2020), through the teacher's choices of educational framework. Citizens engaging in decision-making processes in sustainability issues need knowledge of science and science-related social issues, which requires knowledge and abilities in and about citizenship, and in and about sustainable development. To educate in and about citizenship, teachers can choose to use a democratic approach where the students are invited to engage in various forms of participation (Lundegård & Caiman, 2019). To educate for sustainable development, teachers can organize a teaching that prepares the students to carry out sustainable actions i.e., Action Competence in Sustainable Development (ACiSD) (Sass et al., 2020). Action competence is thus a complex of knowledge, abilities and values enabling the successful performance of a task, which involves abilities such as critical reflection, problem-solving, decision-making, and cooperation with others to finally perform action (Sass et al., 2020).

In Sweden, education for SD, as well as using a democratic approach in teaching, is incorporated into the Swedish curriculum. In upper secondary school, the subject "Science studies" (sv. Naturkunskap) has a special focus on teaching SD from a societal perspective (Swedish National Agency for Education, 2011; 2012). Science study teachers' didactic choices of content knowledge when teaching for SD has earlier been studied (Brommesson et al., forthcoming), and the present study focuses on the didactic choices of teaching activities and practised abilities in education for SD and citizenship.

2 Theoretical backgrounds

In the discussion of what makes a good education, Biesta (2009) posits three functions, qualification, socialisation and subjectification. Qualification provides the student with knowledge and abilities (Biesta, 2009). In education for SD, this could be knowledge in and about SD and abilities needed in society more generally (Biesta, 2009). The socializing function involves educating students to adapt to a particular social, cultural and political "order" (Biesta, 2009). One type of socialisation could be to teach the "right" sustainable behaviours, outlined by experts or by unreflective norms adopted by Western countries. Subjectification finally, can be seen as the opposite of socialisation, i.e., where the students develop their identity, become autonomous and independent in their thinking and are given an opportunity to identify injustice and oppression and create new ways of organizing social orders.

In practice, these educational functions come down to the didactic choices of content and teaching methods. Two examples of didactic frameworks in educating for SD are Lundegård & Caiman (2019) 'Five forms of participation', and Sass et al., (2020) development of 'Action competence for sustainable development' (ACiSD). Five forms of participation (Caiman & Lundegård, 2019) are based on the conviction that dealing with sustainability issues demands democratic conversations which allow the students to be able to act on them already in teaching. Lundegård & Caiman (2019) urge teachers to make didactic choices where students are invited to participate through agency, deliberation, creativity, criticism, and authenticity, which are to prepare students for democratic citizenship.

In education for ACiSD, didactic choices such as knowledge of SD and SD action possibilities, developing abilities as critical reflection upon norms, together with a willingness to contribute in SD actions and a confidence in one's own influencing possibilities are important (Sass et al., 2020). However, earlier results have concluded that within the current curriculum, science teachers experienced a more crowded syllabus that narrowed their opportunity to educate for SD (Sund, 2022).

I structure my empirical analysis based on these frameworks to explore Science study teachers' education in citizenship for SD.

3 Research methods

The empirical material of this study consists of data from three focus groups with 11 Science study teachers from three upper secondary schools in Sweden. An interview guide consisting of semi-structured and open-ended questions together with follow-up questions were used for the interviews. A content analysis (Mayring, 2000) was performed using Nvivo software.

4 Results

The results show that Science study teachers rely on teacher-centred teaching, integrated with multimedia elements, reading and fact-finding (independent or in groups). First, the teachers want to establish a factual ground which is followed by whole-class or small-group discussions. Other frequently used teaching methods are oral or written debates, where the students construct arguments from different sources. Some teachers include problematic political, ethical, environmental, or economic SD cases where students are to come up with examples of actions for solutions. Additional methods include product lifecycle analyses and practical scientific investigation.

Collaborative teaching with other subjects such as social science and language (Swedish or English) teachers are used by some Science study teachers when including debates or climate-summit role-play. Study visits and excursions are rare.

The Science study teachers mention challenges such as large class sizes, schedule issues, difficulties in grading group-works, student motivation and prior knowledge and abilities gaps, and time constraints facing a crowded syllabus. These challenges lead the teachers to prioritize certain teaching methods and exclude others.

In the discussion of which abilities, the Science study teachers let students practice in teaching for SD, the teachers mention the abilities to argue and to critically examine facts, sources, and the arguments of others. Although, how to make an argument or how to critically examine facts or others' arguments is something the Science study teachers expect the students to know in advance or consider to be the responsibility of language teachers to teach.

Science study teachers also let students practise the ability to plan and perform scientific investigations. Other abilities practised are to take a position in SD issues and to give examples of actions for sustainability. However, to carry out sustainable actions is not practised.

Moreover, Science study teachers would like students to have the abilities of self-motivation and self-confidence upon entering class since they prefer not to invest time in supporting the development of these abilities. However, the teachers note that a considerable number of the students lack these abilities.

5 Discussion and conclusion

The present study sheds light on that Science study teachers mainly focus on building a factual foundation in their teaching for SD, aligning with Biesta's concept of qualification (Biesta, 2009).

Furthermore, the teachers actively engage students in various forms of participation, in democratic citizenship through deliberative conversations, critical reflection, creative thinking, and agency concerning sustainability issues (Lundegård & Caiman, 2019).

However, in alignment with teaching for ACiSD, this study suggests a potential gap; the Science study teachers encourage students to provide examples of sustainable actions, but the actual practice of these actions is not emphasized. Reluctance is observed among the teachers in dedicating time to develop students' willingness to act and to develop their confidence in their opportunity to real influence, which are significant elements in ACiSD (Sass et al., 2020). Also, subjectification is identified as a crucial factor in ACiSD, where critical thinking and challenging norms are elemental in addressing sustainability issues and exploring opportunities for action (Sass et al., 2020). However, these approaches face challenges and are not prioritized by all Science study teachers due to issues like time constraints, large class sizes and a crowded curriculum, which also was demonstrated in earlier studies by Sund (2022).

Regarding how students are socialized within Science study teachers' teaching for SD, previous research suggests that Science study teachers may unintentionally socialize students into norms of sustainable behaviour based on Western societal norms (Brommesson et al., forthcoming). This hints that the teachers in a normative manner may shape the students' views on the "right" and "wrong" ways to act for sustainability, as they become socialised into a specific social, cultural, and political framework (Biesta, 2009).

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NORSKE NATURFAGLÆRERES BESKRIVELSE AV BÆREKRAFTUNDERVISNING

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Abstract

Interdisciplinary and pluralistic sustainability education is highlighted as beneficial if the goal is to develop students' ability to relate critically and, at the same time, democratically to sustainability issues. This presentation shed lights on Norwegian science teachers' description of sustainability education (SE) in lower secondary schools. Ten science teachers have been interviewed, and these teachers have been chosen because interdisciplinary SE has been implemented at their school. The data has been analyzed inductively with thematic analysis. Compared to previous studies on science teachers' understanding of sustainable development (SD), preliminary results show that the science teachers have an understanding that SD is something that encompasses more than an environmental perspective. The teachers also understand what interdisciplinary sustainability education entails, but practical conditions such as time and collaboration place limitations on what they can achieve. This study aims to investigate how science teachers' description of SE can contribute to succeed with interdisciplinary and pluralistic SE, where the goal is to develop students' ability for critical thinking and democratic participation.

1. Introduksjon

Bærekraftundervisning er et etablert konsept i internasjonale styringsdokumenter, og spiller en viktig rolle i hvordan vi tenker og handler for å oppnå bærekraft i en verden i endring (UNESCO, 2017). Tradisjonelt har undervisning handlet om å overføre pålitelig kunnskap og spesifikke ferdigheter innenfor hvert fag. Stevenson (2007) argumenterer for at slik skolestrukturen er uforenelig med bærekraftundervisningens egenart. Bærekraftig utvikling er en sentral del av læreplanene i Norge (Kunnskapsdepartementet, 2017), og i denne studien ønsker jeg å undersøke hvordan naturfaglærere ved norske ungdomsskoler beskriver bærekraftundervisning. Flere forskere mener at en tverrfaglig og pluralistisk tilnærming til undervisning er viktig for å håndtere komplekse bærekraftspørsmål (Walshe, 2017; Öhman, 2008). Tidligere forskning viser imidlertid at en tverrfaglig og pluralistisk tilnærming til bærekraftundervisning ofte blir oversett i undervisningspraksis til fordel for tradisjonell, monofaglig og normativ miljøundervisning (Boeve-de Pauw m.fl., 2015). I Norge har det vært gjennomført studier på barnetrinnet og videregående skole om undervisning på tvers av fag (f.eks., Munkebye m.fl., 2020), men studier som går i dybden på tverrfaglig bærekraftundervisning i ungdomsskoler er mangelfull.

2. Teoretisk bakgrunn

Bærekraftig utvikling er et begrep som vanligvis defineres ut fra tre dimensjoner; økologisk, økonomisk og sosial (Giddings, Hopwood, & O'Brien, 2002). Tidligere forskning viser at når det gjelder naturfagslæreres forståelse for begrepet bærekraft, tolkes det ofte som et miljøperspektiv når det omsettes til undervisningsinnhold i skolen, noe som betyr at de sosiale og økonomiske dimensjonene som trengs for å forstå og forholde seg til hele kompleksiteten i bærekraftspørsmålene ofte går tapt i naturfagundervisning (Borg et al., 2014).

Den pluralistiske undervisningstradisjonen innebærer å gi elevene mulighet til å tilegne seg kunnskap og ferdigheter slik at de aktivt og kritisk kan vurdere ulike perspektiver på problemer (Öhman, 2008). En slik tilnærming til undervisning fokuserer på demokratiske prosesser som involverer ulike verdier og meninger. Boeve-de Pauw og kolleger (2015) gjennomførte en kvantitativ studie med 2413 elever på ungdomstrinn og videregående skole i Sverige, der de undersøkte grad og effekt av pluralistisk bærekraftundervisning. Resultatene viste at elever som opplevde en høyere grad av pluralisme i undervisningen, også viste holdninger og atferd som kan beskrives som mer bærekraftige, enn elever som opplevde en lavere grad av pluralisme i undervisningen.

Tverrfaglighet er gjerne kategorisert som en av flere interaksjoner av disipliner, der ulike begreper, perspektiver, teorier og metoder er organisert på tvers av fag. Kunnskap og tenkemåter fra minst to eller flere fag må integreres for å løse et problem, og det krever at lærere koordinerer og samarbeider om problemløsningsprosessen i undervisningen (Boix-Mansilla & Duraising, 2007). I 2019 undersøkte forskningsprosjektet BRIDGES ved Universitet i Sør-Øst-Norge hvordan norske grunnskolelærere i ulike fag forstår og jobber med de tverrfaglige temaene i læreplanen (Biseth m.fl., 2022). Resultatene viser at lærerne er positive til tverrfaglig arbeid, men at det er uoverensstemmelse mellom hva lærerne anser som viktig med tverrfaglig arbeid, og hva de rapporterer at de gjør.

3. Forskningsmetode

Deltagerne i studien er 10 naturfaglærere fra fem forskjellige ungdomsskoler i et fylke i Norge. Fire av skolene har deltatt på desentralisert kompetanseheving (DeKomp), et etterutdanningskurs for lærere med vekt på bærekraftig utvikling og tverrfaglighet i praksis, mens to av lærerne har deltatt på Den Naturlige Skolesekken som var en nasjonal satsing fra 2009 til 2022 for å støtte norske skoler i å implementere en elevaktiv undervisning for bærekraftig utvikling (Scheie & Stromholt, 2019). Naturfaglærere fra disse skolene ble valgt fordi det er iverksatt tverrfaglig bærekraftundervisning på deres skole. Lærerne er intervjuet, det er brukt lydopptaker under intervjuene, og varigheten per intervju er mellom 45 min og én time. Transkribering og analysearbeid er i startfasen og forventes ferdigstilt innen mai 2024. Det vil være en induktiv tilnærming til dataene, og jeg vil bruke tematisk analyse for å redusere, kategorisere og oppsummere data i koder. Gjennomgang av første fase med å bli kjent med data ved lytting av lydopptak viser noen tendenser for resultat.

4. Foreløpige resultater

På spørsmålet om hva naturfaglærerne tenker på når de hører ordet *bærekraftig utvikling* trekkes ordet sammenheng mye frem.

> Lærer #2: *«At noe skal kunne fortsette med den måten vi gjør det på nå. Og det gjelder jo ikke bare naturfag, det gjelder vel i alle sammenhenger. Så lenge vi bare snakker om bærekraft så kan vi jo bruke det i alle sammenhenger»*

> Lærer #7: *«Det å se sammenhengen mellom det vi holder på med her og det livet vi lever og skal leve (...) ikke så mye på miljøvern, mer med å forstå, ja det der med å forstå sammenhenger.»*

Noen av lærerne beskriver også bærekraftig utvikling som en utvikling som ikke skal ødelegge det naturgrunnlaget man utnytter, men at man forvalter ressursene slik at naturen kan tåle det på lang sikt. Enkelte lærere trekker også inn økonomi og sosiale forhold i deres beskrivelse.

> Lærer #4: *«(…) Også er det selvfølgelig økonomibiten...hvem sitter på pengene, hvem bestemmer, hvem styrer. Også har vi litt politikk opp i det. Så det er kanskje de tingene man må prøve å forklare for elevene da.»*

Når det gjelder bærekraftundervisning ved egen skole beskriver samtlige naturfaglærere prosjekt som en del av bærekraftundervisningen. Skolenes intensjon er at disse prosjektene skal være tverrfaglige, men noen av naturfaglærerne er i tvil om hvor tverrfaglige prosjektene egentlig er.

> Lærer #2: *«Det er vanskelig å drive tverrfaglig. Det er lett for at det blir flerfaglig (...). Jeg oppfatter tverrfaglige tema som at vi faktisk har et mål, ett felles mål, også jobber vi med samme målet i alle fag, og hvor vi har et opplegg sammen...men så ender vi ofte opp med et flerfaglig system der vi vet hvor vi skal på en måte, også driver vi hver for oss.»*

> Lærer #8: *«Sånn rent tverrfaglig, det krever mye ressurser (...) noen ganger er det, aldri viljen, men tid som kanskje setter en begrensning på hvor ekte tverrfaglig det blir.»*

Innholdet i bærekraftundervisningen varierer fra skole til skole. To av skolene jobber mot en debatt i slutten av perioden der elevene skal argumentere for ulike synspunkt på et komplekst og verdilada problem. Noen av skolene er opptatt av nærmiljøet, og én skole tar en del av undervisningen ut for å jobbe med å bevare et område ved skolen. Når det gjelder å arbeide med dilemmaer i bærekraftundervisningen beskriver flere av naturfaglærerne at det er viktig å være åpen for at folk tenker ulikt og at elevene må bli stilt ovenfor motstridende påstander.

5. Diskusjon og konklusjon

Foreløpige funn kan tyde på at norske naturfaglærere har en forståelse for at bærekraftig utvikling er noe som omfavner bredere enn et miljøperspektiv. Økologiperspektivet med naturen og ressurser er fremdeles fremtredende i lærernes beskrivelser, noe som kan oppfattes som naturlig grunnet deres bakgrunn som naturfaglærere. Samtidig påpeker lærerne viktigheten av å se helheten og sammenhenger i bærekraftundervisning. Sammenlignet med funnene fra BRIDGES, kan foreløpige resultater fra min studie tyde på at naturfaglærerne vet hva tverrfaglig arbeid er, men at de ikke helt får til «ekte» tverrfaglig bærekraftundervisning på grunn av at praktiske forhold som tid og samarbeid setter begrensinger. Når naturfaglærerne snakker om bærekraftundervisning, er det noen av skolene som jobber mot en avsluttende debatt, mens andre lærere trekker frem elevers mulighet til å diskutere ulike problemstillinger. Dette kan tyde på at de fleste naturfaglærerne inkluderer elementer fra den pluralistiske undervisningstradisjonen der målet er å styrke elevenes kompetanse til å utforske, og å utvikle elevenes evne til å forholde seg kritisk og demokratisk til ulike perspektiver på komplekse bærekraftsproblemer (Öhman, 2008).

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STRENGHTENING STEM EDUCATION IN DANISH PRIMARY SCHOOL: AN ANALYTICAL MODEL AND APPROACH TO TO PROFESSIONAL DEVELOPMENT

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Abstract

In Denmark, there is a significant need for developing teaching practice and methods for future STEM education in primary schools. However, there is a lack of tradition, structural framework, tools, and professional development to support the practice of the science teachers in everyday teaching. Over the past few years, various continuing education programs have been initiated, but they often experience challenges in the anchoring process when the funding runs out. Therefore, it is crucial to develop professional development designs with a focus on sustainable implementation. In this paper, we present results from a case study of the program Engineering in Schools that aims to implement the engineering method in primary education through professional development of science teachers. We identify several factors that influence the anchoring process and value creation and suggest that the factors can be used as a tool for the planning and evaluation of professional development of teachers in primary schools.

Introduction

School development through continuing education of teachers presupposes a keen understanding of the complexity and rapid evolution inherent in the conditions of both the welfare state and the education system (Rosa, 2019). Evolving contexts, such as health and climate crises, accelerating technological development, and significant social challenges influence society's perspective on both learning and the role of Danish schools. This necessitates ongoing adaptation in schools' tasks and, consequently, places new demands on teachers. A focus on lifelong learning and continuous development, particularly in the teaching practices and expertise of science teachers, has garnered political attention in Denmark in recent years (Nielsen & Krogh, 2017).

In 2017 the Engineering in School project was initiated in Denmark to make teaching in the scientific subjects – including about the climate crisis - more motivating and relevant for primary school students. Since its beginning the Engineering in Schools project has developed and tested various tools and professional development programs of different durations and scopes. In 2023 we investigated the teachers' experiences with the professional development programs, implementation, and integration of engineering as both a didactic practice and method. Based on the empirical data we have identified several factors that influence the anchoring and local value creation.

Theoretical backgrounds

The Engineering project, like several other systemic school development projects in Denmark, such as QUEST (Mogensen et al., 2015; Nielsen, 2021) has been based on extensive international research on professional learning communities. Among these the so-called "consensus criteria" – a core set of features related to supporting teachers professional learning such as being school-based, content focused, inquiry-based, with participation of several colleagues from the school as well as long-term courses with time for implementation and reflection (Nielsen & Nielsen, 2017). In the Danish context, there has been significant work on the concept of a science culture as well (Sølberg, 2006). Overall, there appears to be positive outcomes of capacity building through professional development projects, but many school development initiatives continue to be initiated through top-down decisions (Nielsen & Krogh, 2017). This can pose a significant challenge for schools as they face pressure from numerous external projects and stakeholders, challenging teachers' time, ownership, and motivation to engage in these initiatives (Sølberg, 2022).

Additionally, as described in studies in the field of transfer theory and implementation research there are significant challenges in transferring, translating and anchoring knowledge and learning from professional development programs to practice (Fauth & González-Martínez, 2021; Røvik, 2011; Wahlgren, 2009). In relation to this Wenger-Trayners (2020) have introduced the concept of value creation in the study of social learning process. The focus is on the experienced value creation by the participants and their experience of meaning and the ability to make a difference (Wenger-Trayner & Wenger-Trayner, 2020).

Based on the research on professional development as well as transfer theory and implementation, this paper aims to answer the following research question:

(RQ1) What factors in a large-scale professional development program for science teachers influence the anchoring process and local value creation?

Research methods

A questionnaire survey and group interviews were conducted to investigate the teacher's experiences of the development programs and implementation of Engineering in Schools from February to April 2023. The questionnaire was distributed online among 251 participants. 139 questionnaires were completed by teachers and leaders from 11 different municipalities. The questionnaire centered on various themes, including background information, experiences and outcomes of the professional development program, its impact on teachers' practices, conditions and frameworks for engineering education in schools, and inputs for further program development. The follow-up interviews involved 23 individuals from 10 schools in seven municipalities and were conducted. The interviews were based on a semi-structured interview guide, aligning with the overarching themes of the questionnaire survey supplemented by its results. Subsequently, the interviews were transcribed, and a thematic analysis was conducted on the amassed material, including the open-ended responses from the questionnaire. NVivo 14 qualitative analysis software facilitated the analysis process, where interviews were coded into relevant themes.

Results

We identified six thematic factors influencing the implementation of the Engineering in School program illustrated in Figure 1 and elaborated upon below (Madsen & Poulsen, 2023).

Leadership and management

Local school leadership played a crucial role in supporting the implementation process selecting resources, planning, and integrating the annual event Engineering Day. Despite some leaders showing minimal involvement, successful implementation was delegated to a science consultant or mentor nurturing school engagement.

Strategic focus and schoolwide plans

Many teachers and schools have integrated the method into teaching plans and an annual Engineering Day event. The event's scale depends on local leadership and supportive figures like science mentors. Creating meaningful connection between existing and new projects seems crucial as well, often citing school leadership's role in maintaining valuable learning and collaboration cultures despite formal shifts.

Storytelling and a common language about engineering

Teachers who expressed their curiosity in trying the engineering method were often influenced by engaging stories shared by colleagues and emphasized that the program had provided them with a common language about engineering. In some areas, centralized science consultants facilitate this through newsletters, local discussions, and joint testing of new methods, fostering a collective network among schools.

Professional networks

Establishing and prioritizing professional networks are crucial aspects of school leadership, emphasized by teachers as pivotal for implementing and anchoring the engineering method. Teachers not part of such networks express the need for collaborative forums for insights and inspiration, while those involved in fostering science culture find it natural to discuss and adapt engineering approaches with their colleagues for tailored student engagement.

The teachers' approach and motivation

Teachers' motivation to implement the engineering method stems primarily from inspiration by colleagues and their own experiences with students' benefits. The method's practical way of engaging a diverse student group was seen as a potential asset for inclusive classroom teaching by many. Teachers described the method as fun, meaningful, and community-building. Additionally, teachers often cited "courage" as crucial for adopting the method, as it involves relinquishing control as there is no right solution.

Facilities and materials

Facilities and materials were highlighted by respondents as important. Material kits spark enthusiasm and ease method adoption in classrooms. Updated science rooms signify the prioritization of the science environment, motivating teachers to continue and feel confident in their expertise. In some networks, consultants simplify implementation by providing material kits for science teams to ensure successful Engineering Day events.

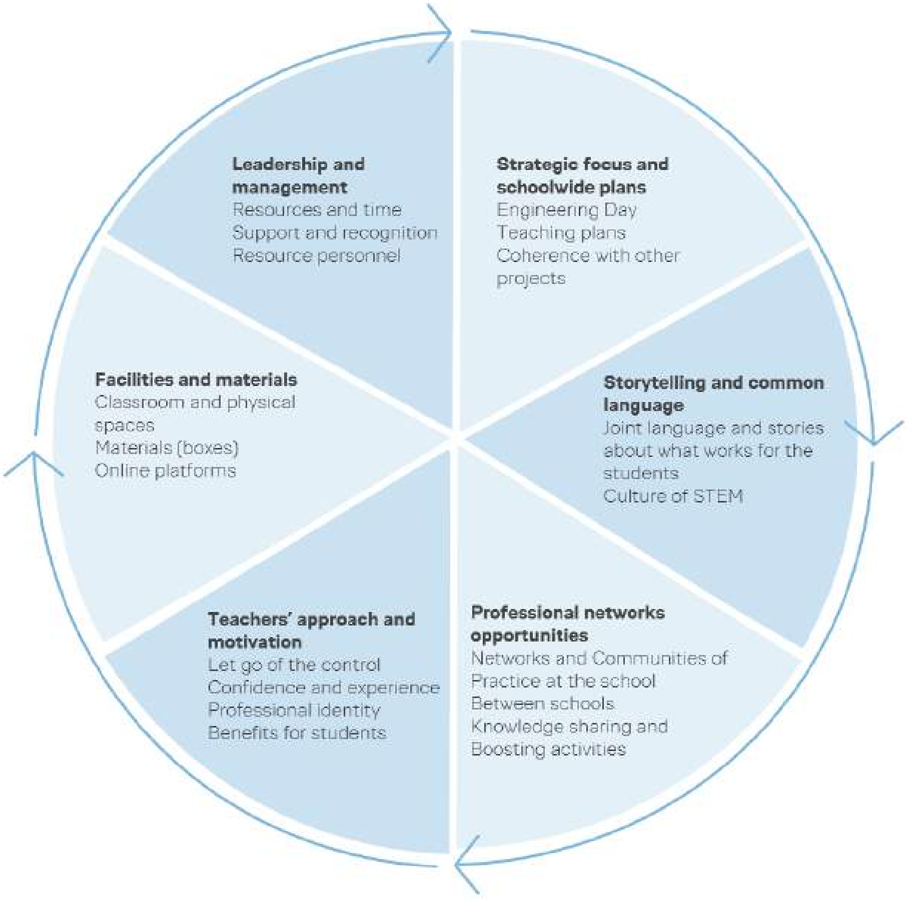

Figure 1. Factors that influence the anchoring process and value creation of professional development in Engineering in Schools.

Discussion and Conclusion

The study of anchoring of professional development is complex as many factors influence the implementation such as the content of the teaching concept, culture, information learning, organizational challenges etc. As argued by Wenger-Trayners (2020) the study of value creation of learning processes is strengthened by combining different kinds of data such as quantitative and qualitative effect data and contribution data for value creation stories focusing on different levels of value creation. Thus, it would strengthen this initial analysis to explore and combine other data in future studies. Additionally, it was difficult to recruit informants for the questionnaire survey and interviews as many teachers experience "evaluation fatigue" as they must fill out many questionnaires related to the many projects they participate in as well as a number of national inquiries. This can lead to bias in the results as those who are most invested in the program and find it valuable may be more likely to participate. Still, we tried to explore the challenges they experienced as well and investigate what made the program sustainable in their school setting.

In this paper we have argued that STEM teachers are challenged by many short-term projects in Denmark and there is a need for more knowledge about what contributes to value creation and long-term anchoring of professional development designs. In the case study of

Engineering in Schools we have identified several factors in the school setting that influence the anchoring process and local value creation. We propose that these factors can serve as valuable tools for reflection, aiding in the planning and support of initial educational designs within schools, as well as for the purpose of anchoring.

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TEACHERS' TALK ABOUT OUTDOOR EDUCATION IN A PROFESSIONAL LEARNING COMMUNITY

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Abstract

This study examines how teachers discuss outdoor education in school-based Professional learning communities (PLC). A total of 132 teachers from three primary schools were observed over a two-month period. The initial findings indicate that teachers primarily focus on the positive benefits of outdoor education, emphasizing its unique advantages that cannot be replicated in the classroom. They also demonstrate a solution-oriented approach by identifying the school's local environment as a valuable learning space and providing specific examples of effective utilization. This highlights the PLC as a constructive platform for teachers to exchange experiences and reflect on their practices collaboratively, which aligns with existing literature. While most teachers acknowledge the benefits of outdoor education, some choose not to implement it. The noted barriers include temporary factors like weather conditions and illness, as well as the structure of the activities themselves. While this seems to be the case for only a minority of teachers, it is important to notice when teachers start to focus on barriers, because it may influence the collaborative learning and development within the PLC. The preliminary findings suggest the need for a clearer introduction to the principles and pedagogy behind outdoor activities for teachers.

1 Introduction

The core curriculum for Norwegian schools states: "Students should have the opportunity to experience nature and view it as a source of joy, health, and learning" (Kunnskapsdepartementet, 2017, point 1.5). The notion that nature can provide benefits is supported by several comprehensive review studies (Becker et al., 2017; Miller et al., 2021; Mygind et al., 2019; Remmen & Iversen, 2022). Overall, these reviews suggest that outdoor education can have numerous positive effects on students, including enhanced social relationships, physical and mental well-being, and academic learning. Additional studies have highlighted various barriers preventing teachers from implementing outdoor education, such as limited access to resources, lack of support from colleagues and management, inadequate knowledge of the local environment, and time constraints due to curriculum demands (Emstad et al., 2020; Gabrielsen & Korsager, 2018). The absence of outdoor education among some teachers poses a challenge to the curriculum's goal of providing all students with outdoor learning experiences. Addressing this issue is essential, and efforts must be made to enhance teacher competence, enabling them to overcome any barriers they may encounter.

Research has shown that involving teachers in school-based professional learning communities (PLCs) may contribute to developing their teaching practices (Stoll & Kools, 2017). In the present study, we aim to combine this knowledge with the need for competence development in outdoor education by exploring: How did teachers talk about outdoor education during their participation in a school-based PLC?

2 Theoretical backgrounds

Professional learning communities (PLC)

The curriculum in Norway emphasizes the importance of active participation in PLC for all school staff members, as it contributes to the continuous development of the school (Kunnskapsdepartementet, 2017, point 3.5). A well-organized PLC can serve as an arena where teachers can collectively enhance their professional competence, exchange experiences, and reflect on their own practices (Korsager et al, 2022; 2023). These aspects are crucial for teachers to overcome common challenges often associated with traditional forms of professional development, such as lack of support and limited time to implement new ideas and competencies after attending external courses (Blank et al., 2008). In the context of outdoor education, PLCs can play a significant role in facilitating the exchange of knowledge about the local environment, which often is seen as a barrier (Gabrielsen & Korsager, 2018), particularly for inexperienced teachers (Emstad et al., 2020). The hypothesis underlying this study is that by involving teachers in a PLC, many of these barriers can be reduced.

3 Research methods

For this study, we observed a total of 132 teachers from three primary schools over a period of approximately two months. The teachers actively participated in two competence development modules on outdoor education, which were conducted within a PLC at their respective schools. Each module comprised two 60-minute joint sessions that took place within the PLC. Between the two joint sessions, a ready-made outdoor activity was conducted with students. (Figure 1). Data collection involved audio recordings of groups consisting of 4-6 teachers, as well as observation notes from the two joint sessions within each module (Table 1 and Figure 1).

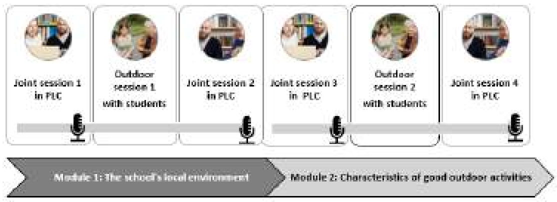

Figure 5. Overview of the two modules

***Table 5**. Overview of data collection.*

School	Grade level	Number of teachers	Number of groups of audio recordings in joint session			
			1	2	3	4
School A	1-7	24	6	4	*	*
School B	1-10	68	6	5	*	*
School C	1-10	40	*	*	*	*
Total		132	*			

After transcribing the audio files, the teachers' conversations were analyzed using a constructivist version of grounded theory, constant comparative analysis (Gabrielsen, 2018).

4 Results

A first non-validated analysis of the joint session 1 and 2 in school A and B is the basis of some preliminary results.

Joint session 1

The teachers were presented with research findings regarding the benefits of outdoor education for students. The overall response from the teachers was highly positive, including a strong agreement with the research findings. Additionally, the teachers emphasized the positive impact on social relationships, both among students and between teachers and students, as well as the facilitation of communication with quieter students. Another noteworthy finding is that the teachers perceive numerous opportunities in the school's local environment and provide examples of how to leverage these resources. However, some teachers mentioned challenges such as chaos, lack of structure, and unfavorable weather as potential barriers to implementing outdoor education.

Joint session 2

Teachers who completed an outdoor activity highlighted how the outdoor space becomes an inclusive learning environment, benefiting a larger number of students and promoting greater engagement within the entire group. Although the teachers mentioned numerous positive aspects, they also expressed some challenges. One challenge was related to students' perception of outdoor activities as free play. Therefore, the teachers emphasized the need to familiarize students with the idea that teaching can also take place outside and that time must be dedicated to this adjustment period. However, some teachers did not carry out the activity as planned. They justified it this way: *But then we realized that we have first graders. So, we must spend some time defining some concepts and words and expressions and the like first. We have planned, but we haven't been able to test it yet.* Other teachers who did not complete the activity explained that it was due to a high amount of illness or excessive snowfall.

5 Discussion and conclusion

Despite the generally positive attitude towards outdoor education and widespread agreement on the potential of the local environment and available activities, some teachers still do not implement outdoor education. Research indicates that teachers' teaching practices are often influenced by their experiences, attitudes, and habits (Kennedy, 2016). Although teachers acknowledge the potential benefits of outdoor education and receive information and resources from colleagues, some still choose not to implement outdoor activities. While this seems to be the case for only a minority of teachers, it is important to notice when teachers start to focus on barriers, to prevent them from dominating the PLC and hindering teachers' learning and development (Hargreaves & O'Connor, 2017). The preliminary findings suggest a need for providing teachers with a clearer and more explicit introduction to the principles and pedagogy behind the outdoor activities they are introduced to. Before the conference, data and results from third school and several sessions will be analyzed to provide a more comprehensive understanding of teachers' talk and identify any potential developments over time.

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COSTS AND VALUES OF STUDYING PHYSICS: IDENTIFYING PROFILES AMONG FIRST-YEAR UNIVERSITY STUDENTS

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Abstract

Motivation and retention are key issues in university physics education. We present a study where 121 first-year physics students responded to a questionnaire built on the expectancy- value model developed by Eccles and colleagues. By means of a K-means cluster analysis, we identified three student profiles. These profiles are gendered but also offer a more nuanced picture. The three profiles have similarities in terms of interest in physics but differ regarding the other values and relative cost of studying physics. The results show a predominantly male cluster with high confidence, and a predominantly female cluster indicating low confidence and that studying physics is associated with a high cost. A third mixed-gender cluster shows similarities with the confident student cluster in terms of utility and attainment values and similarities with unconfident students concerning expectation of success and perception of relative cost. Based on the results, we recommend that university physics education should better accommodate the diversity of student profiles.

Introduction

Several studies indicate that students enrolled in a physics program are primarily driven by interest in the discipline (e.g. Bøe & Henriksen, 2013). However, within the context of our university, we observe a tendency among the physics students to exhibit a relatively low retention rate. Therefore, it is of interest to investigate factors that could explain the students' educational choices and persistence.

As part of this, we investigate physics students' reported interest and perception of utility and attainment value, their expectation of success and relative cost associated with their physics studies. First-year physics students were asked to complete a questionnaire, partially derived from the IMPEL project (Lauvland, Bøe & Henriksen, 2021). The research question is: What expectancy-value choice profiles can be identified among first-year physics students?

Theoretical background

The questionnaire items used in this study are based on the expectancy-value (EV) model, developed by Eccles and colleagues (1983). According to the EV model, choice, persistence, and performance could be explained by individuals' belief in how well they expect they will perform on a certain task, and the subjective value they attribute to this task. The model contains interest, utility, and attainment values, and students' expectation of success.

Furthermore, relative cost denotes the negative cost value associated with the choices, for example in terms of work effort required.

Research method

Data were collected through a questionnaire with 59 items in addition to background questions. Several items in this study (see Table 1) were drawn from the IMPEL study, and based on the Expectancy-value model. The questionnaire was distributed during a lecture in physics midway through the term, thus exhibiting a bias towards students attending the lecture. In total N=121 students, 44 women and 77 men participated. The students are enrolled in a BSc programme in physics, a civil engineer program in applied physics and mathematics, and teacher education. The response rate was 62%.

Five constructs were created based on internal consistency reliability analysis (Cronbach's alpha, Table 1) and construct validity assessment based on expectancy-value theory. Table 1 shows that the expectation of success and cost constructs have strong internal consistency, whereas the interest, utility, and attainment value constructs are less robust. These constructs were used in a K-means cluster analysis to explore groups of students with similar profiles. Number of clusters was chosen based on which solutions produced clusters that were clearly distinct as well as informative.

Table 1*: Items and constructs. Cronbach's alpha shows the reliability of constructs.*

Construct	Items	α
Interest value	I think learning physics is interesting Physics deals with topics I find exciting	0,57
Utility value	What I learn in physics will be useful for me in the future Studying physics will provide me with attractive job opportunities	0,65
Attainment value	I feel that the study of physics fits me I feel like a physics person It is more important for me to succeed in physics courses than in other courses	0,66
Expectation of success	I will perform better than the average of student in the physics course/-s this term I learn the subject matter easily in the physics course/-s I take this term I think I will perform better than the average student in future physics courses I think I will learn the subject matter easily in future physics courses	0,90
Cost	This study costs me more time and effort than if I had chosen a different study I find physics courses much more challenging than other courses Studying physics requires a lot of work I get to do less of other things I enjoy because I study physics I find it is stressful to perform well in physics	0,79

Results

Three distinct choice profile clusters were identified (see Table 2). The largest cluster is the one of *confident students*, showing high interest, attainment, and utility values, strong expectation of success, and who attach low costs to learning physics. This cluster is heavily male dominated (87%). In contrast, the cluster of *unconfident students* is dominated by females (78%) and consists of students with reasonably high interest and utility values, but very low expectations of success and a perception of very high cost. The third cluster has mixed gender and consists of *value-driven students*, showing high interest, attainment, and utility values that motivate them despite quite low expectations of success and high costs in physics. The distribution of students across the three clusters for each construct is illustrated in Figure 1.

***Table 2**: Mean values of the clusters for each of the five constructs. The last row shows the number of students in each cluster, with gender distribution in parentheses (male/female).*

	Confident students	Unconfident students	Value-driven students
Interest value	4,8	4,2	4,6
Utility value	4,5	3,7	4,6
Attainment value	4,3	3,2	4,3
Expectation of success	3,5	1,7	2,5
Relative cost	2,7	4,2	3,9
Number of students (males / females)	47 (41/6)	30 (7/23)	44 (29/15)

The results showed no significant differences in the distribution of clusters across the three study programs, suggesting that variations in motivation are not linked to any specific study program.

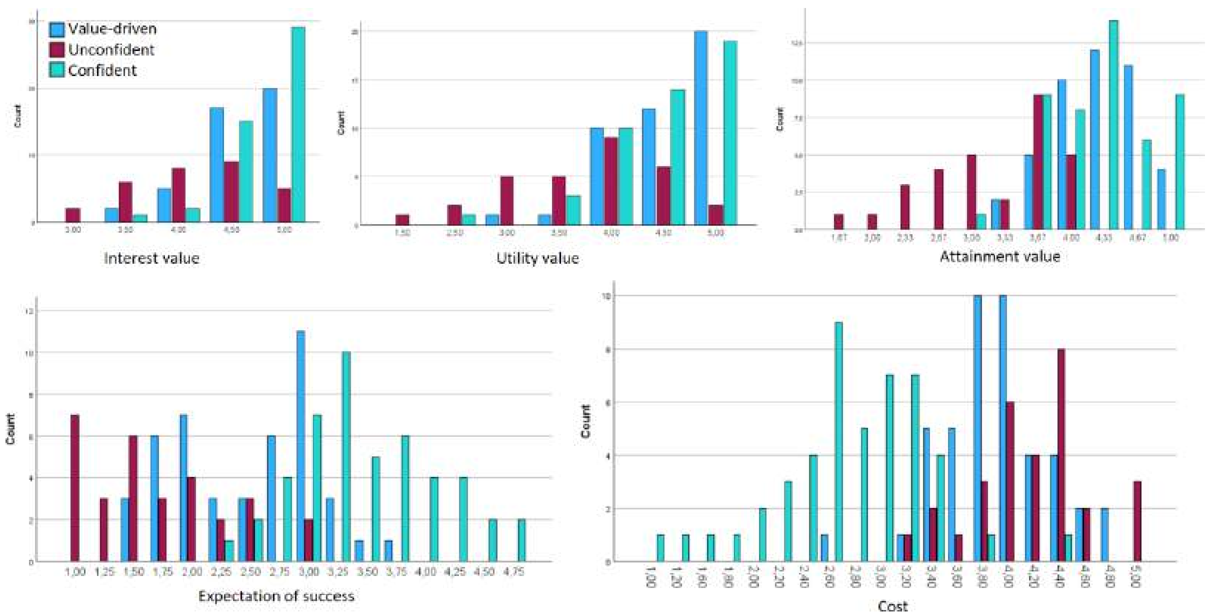

***Figure 1**. The number of students (y-axis) is presented in relation to the average value of each of the five constructs (x-axis).*

Given these results, one might hypothesize that students indicating high cost and low expectation of success would be more vulnerable with regard to persistence. However, all clusters scored high on interest, which could help sustain the unconfident students for some time (Renninger & Hidi, 2015). In addition, as part of the questionnaire the students were asked the question 'I am considering choosing a different study programme'. The results show that those who somewhat or completely agree with this statement are distributed across all three clusters of students, meaning that not only the cluster of unconfident students are considering changing study program.

Discussion and conclusion

Our findings suggest that although our physics students generally find physics interesting, a considerable fraction of them (i.e. students in the unconfident and the value-driven clusters) perceive a high cost associated with studying physics. Furthermore, these students have moderate to low expectations regarding their own success. On the other hand, 39% of the students (the confident cluster) finds that the cost of studying physics is not excessively high, and that they are relatively confident about their future achievements. Although the clusters of confident and unconfident students are clearly gendered, the mixed-gender cluster of value-driven students shows that motivation is not exclusively a gender issue.

The results resonate with a similar study by Lauvland et al. (2021), who also identified three clusters of students along the same axes as the present study. However, we do not observe the same distinct differentiation between study programs as identified by Lauvland et al.

This discrepancy could be due to differences in the construction of the constructs employed or the fact that the samples were drawn from different institutions and study programs.

Furthermore, we observe that not only the unconfident students are considering changing study program, indicating that considerations about persisting or leaving are not only about students being 'pushed' out, but also a matter of students being 'pulled' toward more attractive alternatives (Ulriksen et al., 2010).

In conclusion, university physics education should recognise the diversity among students in terms of their expectation of success and their perception of studying physics as having a high cost, aligning with recommendations made by Lauvland et al. (2021). As suggested by Renninger and Hidi (2015), interest is indeed necessary, but not sufficient for sustaining sufficient motivation when the students encounter the challenges of studying physics. Our results indicate that the majority of our physics students would benefit from initiatives aimed at enhancing their experience of mastering physics and addressing the perceived cost of studying physics. Such initiatives could include the implementation of alternative assessment schemes and adjustments of the scope and pace of introductory physics courses.

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RELEVANT OG YRKESRETTET NATURFAGUNDERVISNING FOR YRKESFAGELEVER?

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Abstract

One of the main goals for the new curriculum in Norway, LK20, was that the subject content should be perceived as more relevant for all students. This study aims to examine to which extent LK20 gives the science teacher space of action to design teaching that can be perceived as relevant for students in vocational education programmes. The data material consists of the curriculum in natural science for vocational students and the curricula in the ten different vocational education programmes. We have developed a two-stage analysis tool that combines Bernstein's framing concept and the concept of relevance.

Preliminary findings show that, unlike in the previous curriculum, most of the competence aims offers a large room for action for the teacher to design relevant teaching for students in vocational education programmes. Fewer competence aims have specified content, and many of them are suitable for adaptation to the different vocational education programmes. Whether this is unequivocally good, is debatable.

1 Introduksjon

I Norge ble skolereformen Kunnskapsløftet (LK06) lansert i 2006. Dette var en kompetanse- og læringsutbyttebasert læreplan, hvor det var opp til det lokale nivået å velge både innhold og metode i fag (Dale, Engelsen, & Karseth, 2011; Sivesind, 2012; Støren, 2022; Aasen, Prøitz, & Rye). Til tross for tydelige intensjoner i læreplanverket om lokalt handlingsrom, viser tidligere forskning at læreplanen i naturfag for yrkesfagelever i LK06 ikke la til rette for dette (Nordby, Reitan, & Jónsdóttir, 2018).

I 2020 ble læreplanverket Kunnskapsløftet 2020 (LK20) innført. Målet med denne revisjonen av LK06 var at fagene skulle få mer relevant og fremtidsrettet innhold. Føringer for revisjonen var at det skal være et stort handlingsrom for læreren i operasjonalisering av den formelle læreplanen (Utdanningsdirektoratet, ikke datert). Det skulle gjøres tydelige prioriteringer i innholdet i fagene, sammenhengen mellom fagene skulle bli tydeligere, og utvikling av elevenes dybdelæring og forståelse skulle prioriteres. For naturfagets del viser dette seg blant annet gjennom at naturfag for yrkesfagelever har fått en andel programspesifikke kompetansemål innrettet mot de ulike yrkesfaglige programområdene.

I denne studien ser vi nærmere på i hvilken grad LK20 gir naturfaglæreren handlingsrom til å utforme undervisning som kan oppfattes som relevant for elever på yrkesfaglige utdanningsprogram. Forskningsspørsmålet vi stiller er: Er det handlingsrom i kompetansemålene i læreplan i naturfag for yrkesfagelever slik at lærer kan utforme yrkesrettet og relevant naturfagundervising?

2 Teoretisk bakgrunn

For å undersøke problemstillingen tar vi i bruk ulike teoretiske perspektiver; Goodlads (1979) læreplanteoretiske begrepsapparat, Bernsteins (2003) begreper *sterk* og *svak innramming* og begrepet *relevans* (se for eksempel Stuckey m.fl(2013). I overgangen fra en formell læreplan til en læreplan slik den blir oppfattet av lærere, vil læreplaner gjennomgå en rekontekstualiseringsprosess. Bernsteins teorier om hvordan makt og kontroll overføres mellom ulike læreplannivåer er egnet til å undersøke slike transformasjoner (Hovdenak, 2011). Ved sterk innramming vil den formelle læreplanen legge tydelige føringer for lærers fortolkninger. Hvis temaet som skal undervises er entydig gitt, undervisningsmetoden er forhåndsdefinert, og det i tillegg er stofftrengsel i faget, vil lærer ha begrenset handlingsrom. Ved svakt innrammet læreplan vil temaet som skal undervises være åpent for fortolkning, lærer vil ha frihet til å velge undervisningsmetode, og læreplanen vil være romslig med hensyn til mengde lærestoff som elevene skal tilegne seg. En svakt innrammet læreplan vil gi lærer et stort handlingsrom til å utforme undervisning tilpasset elevgruppens interesser, nivå og læringspreferanser. Handlingsrom et relativt begrep, hvor både for stort og for lite ikke nødvendigvis er bra.

For å besvare problemstillingen er det ikke tilstrekkelig å undersøke om læreplanen er sterkt eller svakt innrammet. Det er også nødvendig å undersøke om innholdet kan være *relevant* (Kolstø, 2003; Osborne & Dillon, 2008; Sjøberg, 2009; Stuckey et al., 2013) for elever på de yrkesfaglige utdanningsprogrammene. På bakgrunn av en gjennomgang av forskning på relevans bruker vi i studien relevans fra tre perspektiver; for enkeltindividet, for samfunnet og for yrkesfagene. Sammen med Bernsteins innrammingsbegrep er disse kategoriene brukt i analysen av læreplanene.

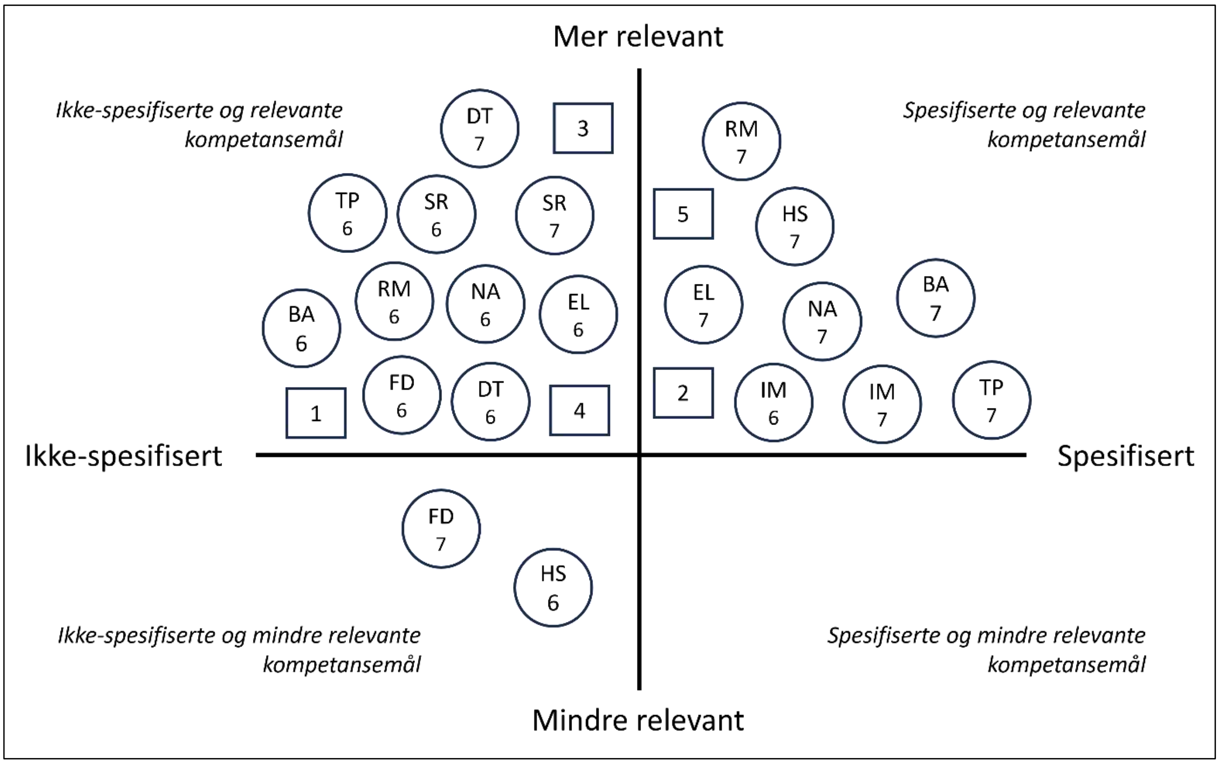
3 Forskingsmetode

Studien er en dokumentanalyse (Asdal & Reinertsen, 2021), en iterativ prosess som veksler mellom overfladiske undersøkelser, grundig eksaminasjon, og tolkning (Bowen, 2009). Tekstene som er analysert, er læreplanene i naturfag for de 10 ulike yrkesfaglige studieprogrammene på vg1. Vi har utviklet et to trinns analyseverktøy som kombinerer innrammingsbegrepet til Bernstein og begrepet relevans. Først undersøker vi innrammingen av det tematiske innholdet i hvert kompetansemål i naturfaglæreplanene for å avgjøre om et kompetansemål er *spesifisert* eller *ikke-spesifisert*. Deretter undersøker vi de samme kompetansemålene med hensyn til de tre perspektivene av relevans; yrkes-, samfunns-, og individuell relevans. Samfunnsmessig relevans definerer vi fra et perspektiv som handler om et naturfag som setter innbyggerne i stand til å mestre egne liv, bli aktive og reflekterte samfunnsdeltakere og kompetente yrkesutøvere. Individuell relevans definerer vi fra elevens perspektiv, og rommer naturfaglig innhold som har betydning for elevenes hverdagsliv her og nå. Yrkesfaglig relevans definerer vi ved å sammenligne innholdet i kompetansemålene i naturfag, med de tilhørende læreplanene for de yrkesfaglige studieprogrammene på vg1. Vi velger å analysere hvert kompetansemål under ett, til tross for at graden av spesifisert eller relevant innhold kan variere innenfor ett kompetansemål. Kriteriet vi har satt for at et kompetansemål skal kunne defineres som relevant, er at målet blir vurdert som relevant i minst to perspektiver.

4 Resultater

De foreløpige resultatene viser at læreplan i naturfag for yrkesfagelever gir læreren stort handlingsrom. Vi finner at omtrent halvparten av kompetansemålene er ikke-spesifiserte, noe som betyr at læreren har muligheter til å gjøre innholdsvalg tilpasset sine elever. Med hensyn til relevans finner vi at de fleste kompetansemålene i naturfag for alle utdanningsprogrammene er yrkesrelevante. Dette innebærer at det enten er tematisk overlapp mellom læreplanene i naturfag og de yrkesfaglige programfagene, eller at det er eksplisitt spesifisert at kompetansemål i naturfag skal tilpasses elevenes yrkesfaglige utdanningsprogram. Vi finner også at de fleste av kompetansemålene er samfunnsrelevante. Det vil si med innhold som er nødvendig for å fremme aktive samfunnsdeltakere og kompetente yrkesutøvere som mestrer egne liv. Et eksempel på dette er kompetansemålet: "drøfte aktuelle helse- og livsstilspørsmål og vurdere pålitelighet i informasjon fra ulike kilder". Rundt halvparten av kompetansemålene vurderer vi til å være individuelt relevante. Dette perspektivet handler om at innhold skal kunne oppleves personlig relevant for eleven her og nå. Kompetansemålet "utforske en selvvalgt problemstilling..." vurderes som individuelt relevant, da læreren har anledning til å la elevene velge.

Resultatene er fremstilt i *Handlingsrom-modellen*, hvor vi kombinerer Bernsteins innrammingsbegrep og de tre perspektivene av relevans, se figur. Kompetansemål i kvadrant 1 vil gi størst handlingsrom, mens kompetansemål i kvadrant 3 vil gi minst handlingsrom.



Figur: *Handlingsrom-modellen: Naturfaglige kompetansemål som er felles for alle utdanningsprogram er nummerert fra1 til 5, mens de programspesifikke kompetansemålene er benevnt med utdanningsprogrammets forkortelser*.

4 Diskusjon og konklusjon

Det å vurdere om det er handlingsrom i kompetansemålene i læreplan i naturfag for yrkesfagelever slik at lærere kan utforme yrkesrettet eller relevant naturfagundervisning, er slett ikke uproblematisk metodisk. Vår rolle som fortolkere av læreplanene og analysebegrepenes egnethet er to momenter som bør ses nærmere på. De analytiske begrepene *innramming* og *relevans* er begge egnede for å utforske handlingsrom, men de har svært ulik reliabilitet. I motsetning til innrammingsbegrepet til Bernstein, som er godt utprøvd (Hovdenak, 2011), er relevans lite dokumentert som analytisk begrep. Stuckey (2013) viser tvert imot at begrepet brukes med ulike betydninger. Vi forsøker derfor å være eksplisitte på hvordan vi definerer begrepet, og kanskje kan studien bidra til en samtale omkring bruk av ordet relevans i utdanningssammenheng. Relevans defineres alltid av noen, og fra et gitt ståsted. Studien er gjennomført av forskere i naturfagdidaktikk, med tidligere erfaring som lærere i naturfag for yrkesfagelever i LK06. Våre fortolkninger av læreplanene gjør vi derfor med et utenifra blikk. Til tross for disse betenkningene mener vi at studien kan bidra med verdifulle betraktninger om læreres handlingsrom.

Våre funn er entydige. Det er større handlingsrom i kompetansemålene læreplan i naturfag for yrkesfag slik at lærer kan utforme yrkesrettet eller relevant naturfagundervisning i LK20 enn det var i LK06. Færre kompetansemål har spesifisert innhold, og flere kompetansemål er egnede for yrkesretting. Om dette er entydig bra kan diskuteres.

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SAMISK TRADISJONELL KUNNSKAP SOM BIDRAG TIL Å UTVIKLE ELEVERS NATURFAGLIGE ALLMENNDANNELSE

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Abstract

The school has an important role in teaching about the Sami as an indigenous people, and the natural sciences schould contribute to teaching students about Sami traditional knowledge. In this study, we have investigated how participation in reindeer herding can make Sami traditional knowledge visible to students and how such practical participation can promote students' scienctific litteracy. In the autumn of 2021, seven 10th grade students took part in reindeer herding together with a siida in Finnmark. The students observed and participated in the siida's activities. This is documented through video observations with four GOPro cameras. Thematic analysis of the video material shows that the students participated in activities in the three main categories; reindeer in the mountains, camp life and reindeer in the fence. Preliminary analyses of the students' participation in the activities, indicate that they practice all aspects of scientific literacy; context, competence, knowledge and attitudes, and that there is a good balance between the aspects. This study shows that students participation in reindeer herding makes visible a diversity of Sami traditional knowledge and that the reindeer fence is a learning arena that can promote students' scientific literacy.

1 Introduksjon

Skolen har en viktig rolle i å synliggjøre kunnskap om samene som urfolk, og undervisningen skal bidra til kunnskap og være holdningsskapende, der elevene skal lære om samisk tradisjonell kunnskap i naturfag (Kunnskapsdepartementet, 2019). Samisk tradisjonell kunnskap er samenes kollektive kunnskap om naturen og menneskers samspill med naturen. Det er kunnskap opparbeidet gjennom generasjoner sammen med kompetente gjennom muntlig overføring og praktisk arbeid. (Guttorm, 2011, Kvivesen et. al, 2023).

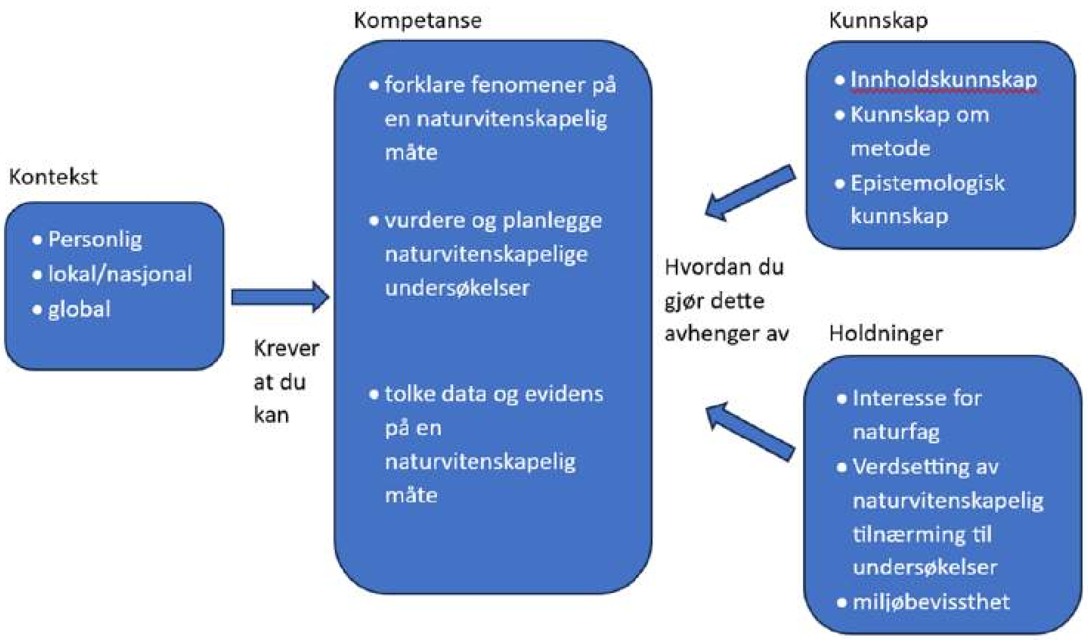
Vi kan møte samisk tradisjonell kunnskap i ulike tradisjonelle næringer som fiske, sankning, høsting, jordbruk og reindrift (Nergård, 2019). Samisk reindrift er en sentral bærer for samisk kultur og språk, og har stor betydning for den samiske befolkningen (Henriksen & Hydle, 2021). I dag drives reindrift i hele Sápmi, som i Norge strekker seg fra Finnmark i nord til Hedmark i sør (Meløy, 2019). Reindrifta er en familiedrevet næring, og flere familier går sammen i siidaer og utøver reindriften i fellesskap. Reinen går på utmarksbeite hele året og reindriftsutøvere flytter flokken mellom sommerbeite og vinterbeite. I deler av året er reinen spredt over store områder. Siidaen samler reinflokken på høsten, der kalvene blir merket og det blir tatt ut slaktedyr før flyttingen til vinterbeite. Reindriftsutøvere må beherske ulike tradisjonelle kunnskaper slik som: kulturell forståelse, årstider, klima, reinens fysiologi, forståelse for samspillet i naturen, geografi, birget (overlevelseskunnskap).

Reingjerdet er en læringsarena hvor praktisk arbeid kan bidra til nye læringserfaringer og kulturell forståelse (Enoksen & Krempig, 2023). Tidligere studier viser at arbeid med samisk tradisjonell kunnskap kan bidra til naturfaglig kunnskap (Kvivesen et. al, 2023). Ut ifra hva en reindriftsutøver må beherske har vi en hypotese om at deltagelse i aktiviteter med reindrifta kan bidra til å øve elevers naturfaglige allmenndannelse. Gjennom å ha deltatt med elever og en siida på høstsamling av rein, undersøker vi følgende to forskningsspørsmål.

- Hvordan kan deltagelse på høstsamling av rein synliggjøre samers tradisjonelle kunnskap for elever?
- Hvordan kan deltagelse på høstsamling bidra til å forme elevers naturfaglige allmenndannelse?

2 Teoretisk bakgrunn

Naturfag skal bidra til at elever kan beskrive og forstå den fysiske verden, og begrepet naturfaglig allmenndannelse er et begrep vi bruker i norsk faglitteratur (Kolstø, 2006). Internasjonalt brukes betegnelsen «scientific literacy» som evnen til å bruke naturfaglig kunnskap i ulike sammenhenger (Roberts & Bybee, 2014). Vi har valgt å bruke en bearbeidet versjon av det internasjonale rammeverket for «scientific literacy» Pisa 2015 utarbeidet av Kjærnsli og Jensen (2016, s. 32). Rammeverket tar for seg kontekst, kompetanse, kunnskap og holdninger i naturfaget, slik vist i figur 1. Gjennom bruk av dette rammeverket undersøker vi hvilke aspekter ved naturfaglig allmenndannelse elevene øver gjennom å delta på høstsamling av rein.



***Figur 1**. Bearbeidet versjon av rammeverket til Kjærnsli og Jensen (2016, s. 32).*

3 Forskningsmetode

Høsten 2021 deltok sju 10. trinns elever ved en skole i Finnmark, sammen med to lærere, på en siidas høstsamling av rein, som et alternativ til den ordinære undervisningen. Høstsamlinga var planlagt og organisert av siidaen selv, og de styrte elevenes deltagelse på ulike aktiviteter. Forfatterne og to studenter var med som deltagende observatører. Ved bruk av fire GoPro kamera festet med brystsele gjorde vi videoobservasjoner av elevene mens de deltok i- og observerte siidaens aktiviteter. Alle observatørene hadde en moderat deltagelse (Spradley, 1980) hvor vi vekslet mellom å være fullstendige observatører og deltagende observatører som deltok i dialoger med elever og reindriftsutøvere samt praktiske arbeidsoppgaver ved behov. I tillegg gjorde en av forfatterne feltnotater fra dagene.

Vi har gjennomført en tematisk analyse (Braun & Clark, 2006) ved bruk av NVivo. Analysen av forskningsspørsmål 1 startet med at hver forfatter så gjennom videoene og identifiserte aktiviteter hvor samisk tradisjonell kunnskap ble synliggjort. Underveis i dette steget ble tanker som dukket opp notert. Deretter sammenlignet vi aktivitetene hver enkelt hadde identifisert, diskuterte uoverensstemmelser og organiserte i fellesskap aktivitetene i tre hovedkategorier. For å undersøke hvordan elever kan øve sin naturfaglige allmenndannelse gjennom aktivitetene identifisert i forskningsspørsmål 1, planlegger vi å analysere forskningsspørsmål 2 ved å gjøre en deduktiv koding av videomaterialet i henhold til de fire aspektene ved naturfaglig allmenndannelse (Kjærnsli & Jensen, 2016). Studien er godkjent hos Sikt, og alle deltagere ga samtykke til å delta i studien.

4 Resultater

Aktivitetene som elevene observerte og deltok i på høstsamlinga fordelte seg i de tre hovedkategorier slik figur 2 viser.

Figur 2. *Aktiviteter elever har observert og deltatt på i forbindelse med høstsamling av rein, fordelt på tre hovedkategorier.*

Rein i utmark

Den første dagen elevene deltok var de med å samle reinen fra fjellet. De ble fraktet med båt til den andre siden av fjellet, og fikk beskjed om å vente der til det kom en reindriftsutøver som skulle lede elevene resten av dagen. Det ble ikke gitt informasjon om hvor lenge elevene skulle være ute eller hva de trengte i løpet av dagen. Elevene måtte vente til reinflokken var på tur ned fra fjellet, før de kunne lede den over et skar til reingjerdet (figur 3A). Reindriftsutøverne grupperte seg i terrenget og brukte droner og samband for å lokalisere og lede rein gjennom naturlige korridorer i terrenget. Reindriftsutøverne instruerte elevene hvordan de skulle bevege seg i terrenget i forhold til reinflokken. Når reinen var i gjerdet, reparerte elevene gjerder sammen med reindriftsutøvere.

Leirliv

På ettermiddagen ryddet elevene leirområdet og satte, sammen med lærerne og reindriftsutøverne opp to Venor gammer og lagde sengeleier av reinskinn. Elevene fikk servert bidos (tradisjonell reinkjøttsuppe) med brød. På kvelden kom to av reindriftsutøverne og fyrte bål sammen med elevene. De fortalte gamle sagn og egne opplevelser fra reindrifta.

Rein i gjerdet

Høstsamlingas andre dag ble brukt på arbeid i reingjerdet. Etter å ha observert hvordan reindriftsutøverne ledet grupper av rein fra en innhegning og inn i kverna (en liten sirkelformet innhegning) deltok elevene i dette arbeidet. Når en gruppe rein var ledet inn i kverna, sto elevene utenfor og så på at reinoksene ble sortert inn i en egen innhegning. Deretter deltok elevene med å sette merke rundt halsen til kalvene (figur 3B). Når alle kalvene i kverna hadde fått merke ble de og simlene flyttet til et eget gjerde. Arbeidet med å skille og merke reinen tok flere timer, og elevene fikk en pause midt på dagen der de fikk hamburger laget av reinkjøtt. Etterpå observerte elevene at reindriftsutøverne tok ut slaktedyr, slaktet, flådde og parterte reinskrotten. Høstsamlinga ble avsluttet med at elevene fikk servert skavet reinkjøttgryte før de ryddet leiren og pakket sammen sakene sine for å dra hjem.

A B

Figur 3. A) viser reinflokk som ledes over et skar og ned mot skillegjerder. B) Viser rein i kverna og en elev som setter merke på en kalv.

5 Diskusjon og konklusjon

Foreløpige funn indikerer at elever som deltar i en siidas høstsamling av rein får erfare hvordan reindriftsutøvere bruker tradisjonell kunnskap som en nødvendig del av sin arbeidshverdag. Blant annet brukte reindriftsutøverne kunnskap om terrenget og hvordan reinen den reagerer på mennesker for å lede flokken. Dette er kunnskap som samiske reindriftsutøvere har opparbeidet gjennom generasjoner sammen med kompetente (Kvivesen et. al, 2023). Ved å lede reinflokken fra fjellet så elevene hvordan terreng, dyr og mennesker påvirker hverandre, og hvordan teknologi kan bidra i dette samspillet. Elevene fikk naturopplevelser og øvd sine kompetanser om samspillet mellom natur, individ og teknologi. For å utøve kompetanse trenger elevene kunnskap (Kjærnsli & Jensen, 2016). Naturopplevelsen elevene fikk kan påvirke holdningene deres og ønske om å verne om naturressursene. Vi ser indikasjoner på at elevene som deltar på høstsamling får muligheter til å øve alle aspekter ved naturfaglig allmenndannelse.

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NAVIGATING IN A COMPLEX EDUCATIONAL TERRAIN FOR SUSTAINABLE DEVELOPMENT: ASSESSING KNOWLEDGE ABOUT CLIMATE CHANGE AND TECHNOLOGICAL SOLUTIONS IN EVOLVING INFORMATION BATTLES

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Abstract

Education for Sustainable Development (ESD) implies teaching about how to change or transform the world to become more sustainable, and to challenge status quos. This includes that students shall develop abilities to critically examine how different actors present information in different formats, with the aim of influencing society. However, this is a complex terrain to navigate in for educators, and questions regarding accuracy, fact acquisition, assessing information and source criticism have become particularly important.

In a previous study, free teaching materials directed to education about sustainable development were analysed. The analyses show that the stakeholders claim that they already take responsibility; there is no reason to worry, since the challenges humanity faces can be solved with various technical solutions. An implicit message is that no lifestyle changes are needed.

Based on these results, the aim is to outline how to research ESD further, amidst a planetary crisis, climate change, technological solutions, and evolving information battles. An interdisciplinary pilot study will be performed. It will be composed of a survey sent to teacher students, and students in strategic planning and global studies, where they will be faced with scenarios including dilemmas.

1 Introduction

"At the heart of our fight for a livable planet lies an information battle, one we ignore at our peril. The spread of lies about climate change, and the apathy they induce, undermines all other efforts. To survive, humanity must wrest control from those seeking to distract from and delay climate action." (Melissa Fleming 2023)

This statement was expressed by the Under-Secretary-General for Global Communications at United Nations in March 2023 in social media. She directs the attention to how we live in a rapidly changing world with challenges linked to the ongoing climate crisis and environmental destruction. In connection with this, information battles are taking place, where various actors and stakeholders present their explanations and solutions to these challenges (Fleming, 2023). In the flow of information different viewpoints compete in defining what sustainable development and sustainability mean. Some put faith in technical fixes and science (cf. Skill et al., 2022), and even solutions that do not yet exist, and others argue that it is not free from political and scientific controversies or value conflicts (Kronlind & Öhman, 2013; Laurie et al., 2016; Kronlid & Öhman, 2010). Additionally, we are faced with arguments about "fake news", conspiracy theories, misinformation and what can be seen as facts. Many information battles regard climate change and energy production. There is a concern that the spread of misinformation contributes to apathy or political inaction (Benegal & Scruggs, 2018; Cook et al., 2018; Fleming, 2023). On the other hand, scientific information about climate change and planetary crises may generate anxiety, which have pros and cons in education for sustainable development (ESD) (Ojala, 2022; Martin et al., 2022) and encouragement to take action.

According to the Swedish curriculum for compulsory school all teaching is to be an education for sustainable development (Skolverket, 2022) – not just about sustainable development. Education for Sustainable Development (ESD) implies teaching about how to change or transform the world to become more sustainable, and to challenge the status quo (Rieckmann, 2018; Spiropoulou et al., 2007). In the curriculum it is stated that students shall develop an ability to critically examine how different actors present information in different kinds or sources, with the aim of influencing society (Skolverket, 2022). In the context of evolving information battles the terrain to navigate in for educators becomes complex. As a result, questions regarding accuracy, fact acquisition, assessing information and source criticism becomes increasingly important (Bhatt et al., 2019; Nygren, 2019; SOU, 2021:70).

Many Swedish schools lack resources for purchasing teaching aids such as updated textbooks and rely on online sources or free print material. Based on this, we performed a qualitative content analysis (Erlingsson & Brysiewicz, 2017; Attride-Stirling, 2001) of free teaching materials originated from 2008 to 2019. In this process we posed critical questions to interpret knowledge claims about sustainable development (Skill et al., 2022). Much of the free material was produced by stakeholders in fields connected to natural sciences and technology (e.g., nuclear energy production, sustainable forestry, construction material) and can therefore be used in technology and science education.

Based on the results of our previous study, the aim here is to outline how to research ESD further, amidst a planetary crisis, climate change, technological solutions, and information battles. An interdisciplinary pilot study will be performed, composed of a survey sent to teacher students, and students in strategic planning and global studies.

2 Theoretical framework

Most sustainability problems relate to knowledge and expertise, as we depend on science to define and explain them, and for motivating solutions. Yet, there is an increasing contestation of science. In science and technology studies, researchers have shown how the presentation of knowledge as neutral facts make it appear as 'closed' for further interpretation (Pinch et al., 1987), by omitting the origin of the knowledge, including conflicts and controversies (Latour & Woolgar, 1986). Current studies of online activism among climate deniers show that the aim is to contribute to confusion and doubt about scientific findings (Benegal & Scruggs, 2018).

Scientific communication strategies can obscure alternative ways of understanding and delimiting phenomena, and are therefore about power (Porter, 1996). Central to studies of knowledge production and sustainable development is the question of what comprises certain and reliable knowledge, evidence and probabilities, and what we can know about the present and the future (Kronlid & Öhman, 2010). This is of interest in relation to climate change and other environmental risks (Beck, 1992). However, the positive tone around sustainable development has achieved more attention than, for example, the idea of risk society (Blowers, 1997; Dauvergne, 2019; Skill et al., 2022). Related questions regard how to handle the identified problems and risks, whether to continue on the beaten track, how to mitigate effects, change lifestyles and behaviour, take individual or collective action etc.

Teaching ESD involves action competence (Almers, 2009); a problem-oriented approach to learning and can be defined as “the ability to critically make value judgments” (Hedefalk, 2014), and “capacity of critically selecting and conducting possible actions that may solve societal problems through democratic mechanisms” (Odabasi et al., 2011:1).

3 Discussion of the results

In our study (Skill et al., 2022), the analysis of the free teaching materials, directed to education about sustainable development, we identified nine themes. Among these were facts rather than a focus on uncertainties or risk, technical fixes/solutions (rather than systemic changes), one-sided anthropocentric perspective often from the point of view of enterprises, and a homogenous human ‘we’.

Examples of topics covered in the free material were climate change, combatting poverty, energy production, waste handling, clothing production and food consumption. They often contained information about certifications that for example guarantee that a forest has been grown in a sustainable way, or production with less environmentally damaging methods. In some cases, the producers of the teaching materials stated that they wanted to give pupils “hope for the future” (Skill et al., 2022). We interpreted this statement as a commentary on how many problems pupils can cope with.

In summary, we show how stakeholders who produce free teaching material claim that they already take responsibility regarding sustainable development. They signal that there is no reason to worry about the future, since the challenges humanity faces can be solved with various technical solutions or fixes (cf. Robinson, 2004; Dauvergne, 2019). An implicit message is that no lifestyle changes are needed. The analysed materials justify perpetual economic growth with resource extraction as the only way forward (cf. Spiropoulou et al., 2007). We notice that this message also has been reinforced lately in the political discourse, related to information battles. An example is the discourse around nuclear power, where the focus on nuclear waste and the consequences of uranium mining has changed in Sweden from a strong hesitance (Confederation of Swedish Enterprise, 2022), to a discourse about building new nuclear power reactors to cope with the transition to fossil-free energy production (Holmberg, 2022).

A question we pose is *if*, and in that case *how* information battles including fake news, conspiracy theories, and novel information technologies will influence ESD and possibilities to assess knowledge and information at all educational levels, from pre-school to higher education?

A related issue to consequences of misinformation (Benegal & Scruggs, 2018), fake news and knowledge communication is about hope and despair amidst crises. There are currently calls to include work on climate change anxiety (Ojala, 2022; Martin et al., 2022). Scholars in ESD argue that it is “vital that educators take emotions into account when teaching about global problems such as climate change” (Ojala, 2022) both as individuals and in professional life.

4 Further research

There are thus several pertinent topics to research further: How are the beliefs in technological solutions reflected in students' understanding of sustainable development and alternative futures? In what ways can university education develop students' action competence to teach for sustainable development based on scientific foundations, as well as handle information battles?

During 2024 we will perform a pilot study composed of a survey to teacher students, and students in strategic planning and global studies. This makes it an interdisciplinary project, which enable both comparisons and collaborations. The survey will build on questions related to scenarios and dilemmas where the students need to motivate their replies. The purpose is to identify views on sustainable development in relation to dilemmas regarding climate change and alternative solutions and how they relate to the abundance of information (e.g., increasing use of generative AI). In the scenarios, we will face the students with different perspectives (e.g., anthropocentric, ecocentric, technocentric etc.), including ethical dilemmas where they need to identify 'winners and losers' (Robinson, 2004; Kronlid & Öhman, 2013).

The reason we propose to work on scenarios, is that it is a method to envision alternative (uncertain) futures. This method is well established, e.g., in strategic planning (Schwenker & Wulf, 2013). We want to test the method in an educational setting to stimulate critical thinking about sustainability alternatives, which not only lock in technical fixes (Robinson, 2004), but also contribute to action competence (cf. Almers, 2009; Hedefalk, 2014; Odabasi et al., 2011).

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EDUCATING THE ATTENTION TO ACKNOWLEDGE AND RESPOND TO THE NATURAL WORLD

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Abstract

In a world facing climate change and species loss, attention and nature awareness are declining. I explore the role of attention in STEAM education through three statements from interviews with fifth-grade teachers and students about their experiences with observing living nature. In the first statement one of the teachers highlights the significance of prior knowledge in observing natural phenomena. I discuss how teaching that invite students to pay attention and respond to nature may be an alternative to teaching as telling the students what to look for. In the second statement one of the students emphasizes the advantages of observing real plants in nature instead of relying on representations like pictures. I discuss the importance of embodied experiences to facilitate a deeper dialogue with nature. In the third statement another student addresses the requirements of being a good observer, particularly when observing living beings like birds, where the ability to silence oneself is vital. This statement underscores the need for establishing relationships with living phenomena, and acknowledging the limitations imposed by the natural world. Given the global crises, redirecting attention to nature, and engaging in meaningful dialogue with other living beings is essential for promoting a more sustainable future.

Introduction and background

We live in a rapidly changing world and in a time of several global crisis. In addition to global climate change, there is an ongoing massive loss of species and nature. Young people loose experiences in nature (e.g. Edwards & Larson, 2020). Several studies across nations speak of plant blindness and report a loss of knowledge of local flora and fauna among both students and teachers, and also address plant-blindness as an issue in sustainability education and practice (Thomas et al., 2022). In the digital age, our attention has become a highly exploited resource, and the attention economy is in danger of leading to “an exhaustion of limited attention resources” (Lorenz-Spreen et al., 2019, p. 1).

I will argue that how students learn to practice their attention is critical to how they recognize and respond to a changing natural world. An existential orientation to education entails “an act of (re)directing the attention of students to the world, so that they may encounter what the world is asking for them” (Biesta, 2021, p. vi). In the various disciplines within STEAM-education there are similarities and differences in how researchers both direct their attention and make something visible. Historically, different modes of observing living nature have led to different kinds of knowledge and representations of the phenomena in nature (Lien, 2024). In the article Art and anthropology for a sustainable world, Ingold (2019) claims: “Research as correspondence is a condition for sustainability” (p. 667). Research as a practice of correspondence implies a dialogue and a process where the researcher responds and is being responded to. In such a dialogue, the researcher pays attention in terms of caring, joining and following someone or something, rather than observing and explaining it at an arms’ length. Ingold (2019) argues that the role of anthropology, as of art, is not to hold a mirror to reality. “It is rather to enter into the relations and processes that give rise to things so as to bring them into the field of our awareness” (p. 659)

Emphasizing various practices of attention in STEAM education, the role of science may be challenged and expanded along the same lines. With such an approach, recognizing the entities in living nature also means acknowledging and responding to other living beings, not merely identifying them (as is typical in science class). Learning science is understood as a process that includes bodily experiences and that go beyond the conceptual and cognitive dimensions of learning (e.g. Dahl & Østern, 2019)..

I will discuss the role of attention for the students in both knowing the natural world and in enabling them to acknowledge and respond to the natural world. I will use results from my PhD-project (Lien, 2024) and discuss teachers' and students' experiences with exploring living nature to answer the following research questions:

1. How can students practice attention as a process of knowing the living nature?
2. How can students practice attention in ways that enable them to acknowledge and respond to nature?

Methods

As part of my PhD-project I have undertaken a case study with five teachers and their students in fifth grade. In the case study, my investigations have a phenomenological approach with the purpose to examine the students' and the teachers' lived experience with observing living nature. During the case-study, I made classroom observations, collected notes and reflection logs, and conducted interviews with both teachers and students.

Results and discussion

I will use three statements that result from my interviews with teachers and students, to structure my discussion of the research questions. The three chosen statements are like knots in a network of manifold experiences the students and teachers have with observing various phenomena in living nature. I will use the two first statements to discuss the role of attention in knowing the phenomena in nature. Then I will use the third statement to discuss the role of attention in enabling the students to acknowledge and respond to the natural world.

1) *"You have to know what to look for, so you don't just look for anything that doesn't matter" (Lisa, teacher in 5th grade).*

The above statement is an answer to the question posed to the teachers of what is important when the students practice observation in school. With this statement, the teacher implies that the students need some kind of knowledge beforehand to know what to look for when observing phenomena in nature, and that there are some things that does not matter in such an observation. The statement by the teacher brings forward the essential questions of what is significant when observing living nature, and who decide what matters. In science education, there is a tendency that students get knowledge of the phenomena in the natural world, rather than participating in processes of knowing them (cf. Dahl & Østern, 2019), including discussing what is significant in an observation. An alternative to teaching as telling and explaining the students what to look for may be teaching observational practices that invite the students to pay attention and respond to what the phenomena in nature present to them.

2) *"If you are looking at real plants [in nature], you get more than a picture, since then you can turn the plant around and look closely" (Elise, student in 5th grade).*

The above statement is an answer to what it means practicing observation of plants according to this student. The student describes how it is possible for her to position herself and see the plant from several angles in nature, compared to observing a two-dimensional picture. In her experience she sees more of the plant in nature. The student seems to demonstrate how she is enabled to fine-tune her perceptual skills in a dialogue with the living phenomena in nature (cf. Ingold, 2019). To be in such a dialogue, the students need to experience more than representations of the phenomena and apply embodied modes of experience (Dahl & Østern, 2019).

3) *"It's a bit difficult [to be a good observer] …If you are going to get some things to come close to you, for example a bird, then you must sit completely still, if you make a noise, you might scare it away" (Peter, student in 5th grade).*

The above statement is an answer to what it means to be a good observer according to the student. The student describes a situation in which he suppresses his self-concern by sitting still and being quiet, and where he is receptive to the bird's needs and to what might scare it. He silences himself to let the bird show itself. He enters relations and processes that bring the living phenomena in nature into the field of his awareness (cf. Ingold, 2019). By this act, he acknowledges and responds to the living bird. According to Biesta (2021), "To exist as subject "in" and "with" the world is about acknowledging that the world, natural and social, puts limits and limitations on what we can do with it and desire from it" (p. 3). Experiencing that a living bird restricts how you can act if you want to observe the bird, is one way to encounter and respond to what the world is asking of you.

Conclusions

Observing living nature is a relational practice. Living nature provides manifold experiences, but to be able to discover that, both teachers and students need to educate their attention. They need to fine-tune their perceptual skills by experience to bring the phenomena in living nature into the field of their awareness (cf. Ingold). To practice attention as a process of knowing living nature includes both cognitive and embodied practices. In these practices, there is an interplay between knowing what to look for and paying attention by using one's senses. Acknowledging and responding to the living beings in nature, requires that the students practice silencing themselves to let the phenomena in nature show themselves. Paying attention to living nature is not just about what kind of knowledge the students or teachers get, but how the things in living nature, the students, and the teachers come into being through these practices.

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CULTURALLY RELEVANT SCIENCE EDUCATION FROM A SÁMI PERSPECTIVE – IMAGINING A SCIENCE EDUCATION INCLUTING ÁRBEDIETHU

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Abstract

Swedish education carries many traces of colonial history within the education system, not the least in relation to the Sámi population. For example, the Swedish curriculum mentions knowledge about Sámi perspectives to a limited extent. In other parts of the world, efforts have been made to advance culturally responsive pedagogies in education in general, and in science education specifically, aiming to include and nurture indigenous perspectives. In addition, there has been no research in science education regarding relations between Sámi traditional knowledge and science education. This study draws on the framework of culturally responsive teaching and Sámi traditional knowledge, árbediehtu. Árbediehtu considers human and environment as a whole, and is a collective knowledge carried by individuals. The aim of this study is to envision a culturally responsive science education where árbediehtu is not framed as a special interest, but as a resource for gaining more nuanced understandings of wicked sustainability problems. The study is conducted as an action research study drawing on theories of culturally responsive science education. Preliminary results from the initial mapping and analysis will be presented. The results will contribute to new knowledge on how indigenous perspectives may be incorporated into science education.

1 Introduction

In the modern history of Swedish schools, few Sámi students were allowed to use their mother tongue in school before the late 20th century (Samiskt informationscentrum, 2023). In fact, the governing of land and education in Sweden reflects a lack of recognition of an almost thousand year long colonial history in relation to Sámi culture (Svonni, 2023). Although the situation has improved, and there is now a separate education system for Sámi children, where Sámi cultural heritage is incorporated into the curriculum, there are still many traces of colonial history within the education system. Thus, there is a need for elaborating pedagogies aiming to include indigenous students' perspectives in relation to Sámi students.

In a report on the global sustainable development goals (SDG:s), UNESCO has called for a development of new ways of thinking about sustainability solutions considering cultural aspects (UNESCO, 2023). It is stated that our ability to solve the problems that exist increases by including multiple cultural perspectives. Cultural considerations are taken into account in relation to several of UN global goals and for the fourth goal, quality education, it is emphasised that a target for this goal is equal access to education at all levels for the vulnerable, including indigenous peoples. One way to achieve this is through culturally responsive education (D'Andrea Martínez, Peoples & Martin, 2023).

Culturally responsive science education has proven beneficial in different parts of the world. There are projects where indigenous perspectives have successfully been included in science education, for example from New Zealand (Glynn, Cowie, Otrel-Cass, & Macfarlane, 2010). However, in the Nordic countries, there has been little research and indigenous perspectives have been addressed differently in the different countries. Since 2017, Sámi are recognized as indigenous people in the Norwegian curriculum (Olsen, 2020). The Norwegian curriculum acknowledges both the rights of Sámi students to a Sámi-based education and the rights of all Norwegian students to an education including knowledge about Sámi perspectives and indigenous issues (Olsen, 2020). In contrast, the Swedish curriculum includes Sámi issues to a very limited extent (Swedish National Agency of Education, 2022). Also the curriculum of Swedish Sámi school has shifted since the middle of the 20th century, to a focus on Sámi language. In particular, the envisioned futures of Sámi children have changed from preparing for a life within a Sámi reindeer herding community, to preparing for participation in a broader Sámi community (Svonni, 2023). A conclusion is that students in Sweden receive significantly more limited teaching about Sami perspectives than Norwegian students. However, there are areas that could be included in science syllabuses. One example, from historical curricula in Sweden for Sámi schools, include ecology e.g., aspects associated with reindeer herding (Svonni, 2023). In sum, there is reason to explore how Sami perspectives could be made part of a culturally responsive science education in Sweden.

The aim of this study is to trouble the colonial legacy of science education in Sweden with an aim to explore possibilities for overcoming institutionalised blindness and developing ideas for a culturally responsive science education. More specifically, the study aims to explore how Sami perspectives can be included in science education for all in Sweden.

2 Theoretical backgrounds

The study draws on a framework of culturally responsive teaching to make learning encounters more relevant to and effective for ethnically diverse students (Gay, 2010). In short, culturally responsive teaching seeks to contribute to emancipatory and liberating processes (Gay, 2010). However, Sleeter (2012) warns of a risk that culturally responsive pedagogy has sometimes been understood in limited and simplistic ways. In addition, researchers with no, or invisible, indigenous roots need to remind themselves of the importance of "first listening to the colonized other" before engaging in 'post-colonial' theorising (Blenkinsop et.al., 2017, p. 349). Incorporating and paying tribute to Árbediehtu traditional Samí knowledge thus involves challenges and tensions associated with disrupting colonial history.

In relation to science education practices of knowledge incorporating traditional Sámi knowledge may pose challenges related to views of what counts as valid and valuable knowledge in science classrooms. Whereas Árbediehtu considers human and environment as a whole, there is a history of knowledge in science education being treated as objective, free of values and a commodity transferable across any context (Beach, 1999). Árbediehtu is both immaterial and material, a collective knowledge carried by individuals and linked to specific places in nature (eg., where you wade across streams, or as cultural remains in the nature of sacred places) (Blid et. al., 2011). Also, the Sámi languages carry Árbediehtu through nuanced ways of expression regarding nature (Blid et.al., 2011).

3 Research methods

The study is designed as an action research project (cf. McNiff & Whitehead, 2006). Action research can be a "powerful and liberating form of professional enquiry" because it involves practitioners investigating, challenging and developing new ways of practice (McNiff & Whitehead, 2006, p. 8). The research group consists of two researchers and two teachers, who are also members of a Swedish Sámi association.

This presentation zooms into the first part of the action research cycle (cf. Fig. 1) of observation and reflection to identify a concern regarding the ways in which young people in Sweden encounter Árbediehtu and to begin thinking of a possible way forward. In this step, we have explored the concerns and imaginaries of how traditional Sámi knowledge could be incorporated into and acknowledged in science education. By imaginaries we refer to the imagination of alternative ways and practices, the radical imagination, "a collective practice that arises from within social movements against imaginaries that uphold the status quo" (Dyke, Meyerhoff & Evol, 2018). In a second step, the research group plans to conduct focus-group interviews with teachers teaching science in the Swedish lower secondary Samí school (Williams & Katz, 2001). The focus groups are planned to be organised around the imaginaries of Árbediehtu in science education and will be audio and video recorded.

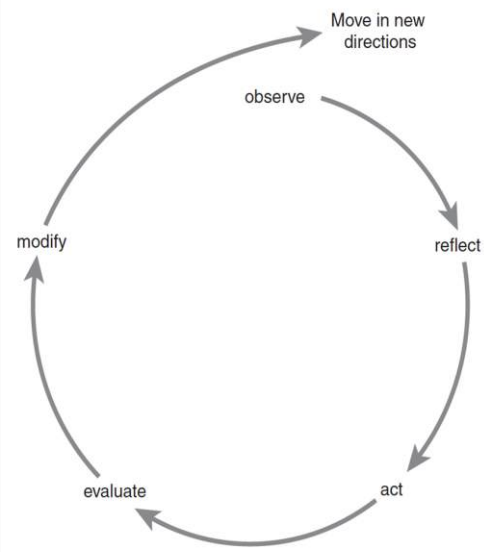

Figure 1 An action–reflection cycle, reprint after McNiff & Whitehead (2006, p. 9)

4 Results

Preliminary results from the first and second step of the study will be presented since the first step of the study will be conducted during the spring 2024 and the second step data collection will be initiated but not finalised.

4 Discussion and conclusion

The conclusions will be presented as (I) *Concerns*, what is at stake regarding the ways in which young people in Sweden encounter and/or do not traditional Sámi knowledge, árbediehtu, and (II) *Imaginaries* of alternative ways and practices of how traditional knowledge, árbediehtu, could be incorporated into, acknowledged, and made relevant in science education to all students in Swedish compulsory school. The implications for taking action in classroom practices according to the subsequent action research cycle will be discussed.

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INTEGRATING SPECIES IDENTIFICATION IN CREATIVE LESSON PLANNING

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Abstract

This study is an attempt at a new didactical approach to species identification and species knowledge for Norwegian teacher students. By leaving identification tests and moving towards a methodology that lets the student work with species over time, and to challenges them to create creative lesson planning involving species. Being able to use the outdoors as a learning arena can be the first step towards creating a deeper knowledge of biodiversity and in turn sustainability. We created a project where twenty-six students made a physical collection of thirty species and five lesson plans. We interviewed five students about their experience with the project. The students found it motivating working with the project over time since it allowed them to follow the natural progression of diversity through the seasons spring, summer, and autumn. They experienced both the collection and the lesson plans as relevant for their later work and created authentic learning opportunities.

1 Introduction

Its commonly known that knowledge about species identification has been in decline the last decade in teachers, teacher students, pupils in school and in the public. Knowledge about nature, species, and the outdoor space as a learning arena is known to increase engagement and knowledge of species (Palmberg, 2012). It is difficult to see how this can change if the teachers are not invested in teaching about species and don't have knowledge of species themselves. In several teacher education institutions species recognition is measured by a test. However, this has not been conductive to retention over time. We wanted to see if another methodological approach could result in more dedicated knowledge about species, and how to use them in teaching. Its commonly known that knowledge about species identification has been in decline the last decade in teachers, teacher students, pupils in school and in the public. Knowledge about nature, species, and the outdoor space as a learning arena is known to increase engagement and knowledge of species (Palmberg, 2012). It is difficult to see how this can change if the teachers are not invested in teaching about species and don't have knowledge of species themselves. In several teacher education institutions species recognition is measured by an identification test. However, this has not been conductive to retention over time. We wanted to see if another methodological approach could result in more dedicated knowledge about species and this led to our research question: Which reflections about species, and the use of species in education, does the students make after working with a nature diary for six months?

2 Theoretical backgrounds

The current national guidelines for natural science in the teacher education in Norway (UHR - Nasjonalt fagorgan for GLU, 2017) and the national curriculum for school in science (Utdanningsdirektoratet, 2020) both use implicit terms when it comes to knowledge of organisms and about the process of identification of species. Biology as a discipline has a tradition of teaching species identification explicitly, and this has also been done in the teacher education. A species/ identification test as the only entry point to measure and create commitment to species knowledge seems to work poorly in, for example, teacher education in Norway (Grindeland, 2015; Kvammen & Munkebye, 2018; Wolff et al., 2020).

There is a call for new didactical approaches to teaching species identification and giving this the context of biodiversity, sustainability, and how to use knowledge about species in teaching. This project was an attempt to create a longitudinal project in teacher education where the students had the opportunity to work with self-selected species over time within a framework of creativity.

If the students are given the opportunity to recognize the species, a positive attitude towards the environment, biodiversity and possible deep learning about the species can be created (Hooykaas et al., 2022; Härtel et al., 2023). Steps of sustainability, as it is used in Kasin and Langholm (2019) shows a lot of what Chawla (2006) states; that in order to take an active part in conservation you must have an attachment to nature by having positive experiences in nature. Introductions by knowledgeable elders creates meaningful experiences as is shown in the steps of sustainability.

3 Research methods

We wanted to develop a method where student teachers spent time in nature and were allowed to choose the species that they themselves were interested in. For this purpose, we developed a project where the students were asked to gather thirty species, either by photography, drawings or prepared plants. Ten of the species had to be plants covering the following categories: ferns, mosses, conifers and flower plants. The students also created five lesson plans where three were left to their creativity and one should focus on interdisciplinarity and one on sorting as a method. The students were student teacher in science education for primary school. The project went on for a period of six months, from Easter to September.

The project is approved by SIKT, the Norwegian agency for shared services in education and research, after ethical consideration. In the project we gathered data in the form of pictures of the finished product and interviews with five of the students. The interviews were conducted as semi structured interviews with a guideline, but the interviewer was free to ask follow-up questions. We chose interviews to get more information about the students experience with the methodology, identification of species in the field and using a particular species in a teaching situation. The interviews were transcribed, analysed by thematic analysis giving the deductive themes knowledge of species/plant blindness and interdisciplinarity and the inductive themes motivation, alternate learning arenas and product.

4 Results

The most mentioned categories were knowledge of species/plant blindness and motivation. Motivation included both the student's own motivation in working with the assignment and the students' thoughts on their pupils' motivation. The category that was mentioned the most was knowledge of species/plant blindness. The students mentioned the discoveries they made while collecting species and funny moments while collecting species and discoveries they had made during the work. The discovery that dandelions were not in fact one, but several species were mentioned by several students. The students expressed how they wanted to work with species knowledge in future classrooms. Motivation was covered both when the students talked about their own experiences and thoughts on working with species recognition with the pupils in school.

We also asked the students about interdisciplinarity, and more specifically about sustainability. One of the criteria for the project was that one lesson plan should include multiple disciplines, and the students mentioned working with several subjects and that once you started thinking about interdisciplinarity, it got easier to keep adding disciplines and integrate them into the lesson plans. Only one of the students talked explicitly about sustainable development but several students talked about sustainability implicitly.

When working with species it is natural to work with alternate learning arenas. None of the students talked explicitly about alternate learning arenas. However, the category was mentioned when talking about how motivating it was to be out in nature.

We did not ask the students specifically about the project's individual product, still several students mentioned how happy they were with making a product they later could use when teaching. A couple of the students had already planned how they would use the product later and incorporated possibilities for expansion in the design.

4 Discussion and conclusion

The students felt it was meaningful to work with a project over time that is relevant to their current and future work experience. It was motivating to created authentic learning experiences. If the student teachers are given the opportunity to recognise species helped by creating a narrative in a lesson plan, it may help to create positive attitudes towards the environment, biodiversity and possibly create a deeper learning about species (Hooykaas et al., 2022; Härtel et al., 2023). Testing species identification through a test as the only way to measure engagement towards knowledge of species seems to not work in teacher education in Norway (Kvammen & Munkebye, 2018; Melis et al., 2021; Wolff et al., 2020).

The students discovered a higher sensitivity towards variation and perceived nature and the beings in it differently. We know that starting with experiences, wonder and exploration in nature is the verry first step towards wanting to know more about nature. We hope that this firsthand experience with discovering nature in a different way will be something the students bring into their future classrooms and outdoor education.

By making interdisciplinary lesson plans centred on a species the students found it easier to incorporate interdisciplinarity in their thinking and made sustainability more accessible in their teaching.

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STUDENTS' INTEREST IN SCIENCE AND TECHNOLOGY INVESTIGATED AS COLLECTIVE IDENTITIES

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Abstract

The research field of students' interest in science and technology (S&T) has a belonging to the Nordic countries by for example the international large scale comparative relevance of science education (ROSE) study realized in the beginning of the 21st century. ROSE has been developed to the relevance of science education second (ROSES) study. This paper report ongoing ROSES work in Sweden. National data from secondary students were collected in 2020 by a questionnaire. In this paper results from the "What I want to learn about" category is presented. There is a message in the literature to connect the research field more strongly to identity which is done in this paper by factor analysis with a varimax rotation. Identified factors are related to the concept of collective identities. Seven factors, which explain 50% of the variance in the material, are presented with belonging content items and names. The results are also compared with earlier studies. The result shows for example that environment and sustainability has become more important and technology less. This alteration is pointed out and discussed connected to the theoretical development of collective identities to understand internal and external dimensions of identity which influence students' willingness to engage in S&T education..

1 Introduction

Students' low interest in and perceived lack of relevance in school science and technology (S&T) is well documented (Anderhag et al., 2016; Oskarsson, 2012; Stuckey et al., 2013). The concepts of interest and attitude are common in such studies (Jenkins, 2006). During the first part of the 21st century the field has become increasingly involved with the concept of young people´s identity formation (Tolstrup Holmegaard et al., 2014; Carlone et al., 2015). Identities are of importance for students' agency and willingness to participate in S&T in society and in education. Identity is not an individual process. Collective identities are central to human interaction and should therefore be more empirically investigated (Hosek & Soliz, 2016). Oskarsson and Karlsson (2011) showed ways that student's interest cluster in collective identities. Human Health, Space, Spectacular phenomena, Environment, Technology, and Supernatural phenomena came out conspicuously in those studies. Westman et al. (2022) added by showing collective identities of critical trust together with a willingness to engage in S&T.

2 Theoretical background

Students' interest has been viewed from several different angles. Krapp and Prenzel (2011) surveyed the concept and argued that it is best described as having an intrinsic character, which means that an individual has his or her own, internal motivation to gain increased knowledge of something. This 'something' can be content specific because it is: "directed towards an object, activity, field of knowledge, or goal" (Krapp & Prenzel, 2011, p. 30). The internal dimension of interest can be expressed as what I would like to learn but is rather about who I am and who I want to be (Oskarsson, 2012). The internal dimension is related to the external by the way it is directed. Interest depends on previous experiences and which group of people an individual identifies with. Hence, students' interest and commitment to learn has an interconnected character and are influenced by both internal and external dimensions.

3 Research methods

Data comes from the Swedish part of a large international research study called the Relevance of Science Education Second (ROSES) which builds on the ROSE study (Sjøberg & Schreiner, 2019). Background, rationale and questionnaire design is described in the ROSES handbook (Jidesjö, Oskarsson, & Westman, 2020). Data were collected in spring 2000 with a national sample of 610 secondary students. The category used in this study is a part of 78 items concerned with "What I want to learn about". The items are composed of a topic of S&T content, presented on a four graded Likert scale ranging from "not interested" to "very interested". Data are analysed with exploratory factor analysis with a varimax rotated solution, meaning that all factors are linear independent, with zero correlation between the different factors (Oskarsson & Karlsson, 2011).

4 Results

Several of the 78 items, regarding what students want to learn about, ask about similar content. An explorative factor analysis reveals latent factors (interest profiles) behind the students' answers. Seven different factors explain 50 percent of the variance and are presented below in Table 1.

Table 1. *Extraction & Rotation Sums of Squared Loadings (SSL) for each factor 1-7 with loading and percent of variance, which explains how much of the variance each factor explains and cumulative variance.*

	loading	% of Variance	Cumulative %
1	*9.15*	*11.7*	*11.7*
2	*6.30*	*8.1*	*19.8*
3	*5.63*	*7.2*	*27.0*
4	*5.34*	*6.8*	*33.9*
5	*4.79*	*6.1*	*40.1*
6	*4.26*	*5.4*	*45.5*
7	*3.95*	*5.1*	*50.5*

Table 2 presents examples of content with high loading (correlation) for each factor. These contents determine the name of each factor.

Table 2. *Seven factors presented with their respective Sums of Square Loadings (SSL), examples of content items and proposed names.*

1. SSL 11.7%, “Environment & sustainability”.

- How energy can be saved or used in a more effective way
- Renewable sources of energy from the sun and the wind
- The greenhouse effect and how it may be changed by humans

2. SSL 8.1%, “Spectacular phenomena, chemistry & space”.

- How the atom bomb functions
- Biological and chemical weapons and what they do to the human body
- Rockets, satellites and space travel

3. SSL 7.2%, “Nature of science”.

- Big blunders and mistakes in research and inventions
- Why scientists sometimes disagree
- Inventions and discoveries that have changed the world

4. SSL 6.8 %, “Health, drugs & the body”.

- What we know about HIV/AIDS and how to control it
- How different narcotics might affect the body
- Sexually transmitted diseases and how to be protected against them

5. SSL 6.2%, “Hearing and vision”.

- How the eye can see light and colours
- How the ear can hear different sounds
- How different musical instruments produce different sounds

6. SSL 5.5%, “Earth and natural science”.

- Earthquakes and volcanoes
- Tornados, hurricanes and cyclones
- How meteors, comets or asteroids may cause disasters on earth

7. SSL 5.1%, “Supernatural phenomena and wonder”.

- Thought transference, mind-reading, sixth sense, intuition, etc.
- Ghosts and witches, and whether they may exist
- Why we dream while we are sleeping, and what the dreams may mean.

4 Discussion and conclusion

The research field of students' interest in S&T (Anderhag et al., 2016; Stuckey et al., 2013) is updated in the Nordic context by the development of ROSE to ROSES (Jidesjö, A., Oskarsson, M., & Westman, A.-K., 2020). The need to involve identity in the research field of students' interest in S&T to more deeply investigate collective identities (Hosek & Soliz, 2016) is empirically accomplished by presented work in this paper. Collective identities can be seen as markers of identity formation. The first seven factors described in this paper explains as much as 50% of the variance in the data. In comparison with earlier studies (Oskarsson and Karlsson, 2011) environment and sustainability has become more important and technology less important. One way of framing such alterations of collective identities is to discuss them in relation with societal development and experience, which is important for further studies. Another continuation is to make use of other data in the ROSES study to relate these factors with others. Such work contributes to develop understanding of interconnectedness of internal and external dimensions of identity which in turn influence students' willingness to engage in science related issues in society, as well as in S&T education. This approach will be pursued and reported in relation with the theoretical development of the field.

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TRANSITIONING FROM THE ROLE OF THE LEARNER TO THE ROLE OF THE TEACHER. EXPERIENCES FROM A STUDENT TEACHER TRAINING IN INQUIRY-BASED SCIENCE EDUCATION

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Abstract

Teacher education plays an important role in fostering inquiry-based science education (IBSE) in the teaching profession. Explicit modelling, reflection, and implementation of IBSE in school placement are suggested as ways to support student teacher’s enactment of IBSE as future teachers. Two interventions were developed, aiming to support student teachers in the role of the learner and the role of the teacher. This study investigates the intervention's shift between roles, and whether it supported student teacher's transition from learning inquiry to teaching inquiry. Two analytical frameworks were merged, aimed to describe meaning making, and relations between knowledge and practice. Preliminary analysis of 3 focus group interviews indicated that modelling and reflection supported student teachers transition from learner to teacher. However, mimicking or adapting activities from the interventions were not without challenges. Further analysis is needed to better establish what insights our data might give to describe the student teacher's transition from learner to teacher in IBSE. This will be worked on towards NFSUN 2024.

1 Introduction

Inquiry-based science education (IBSE) has been highlighted as an ideal model for good science teaching (European Commission, 2015; Gericke, Högström, & Wallin, 2022; NRC, 2012; Rönnebeck, Bernholt, & Ropohl, 2016). Despite increased focus in curricula and research, evidence suggest that teachers meet several challenges in implementing IBSE (Akuma & Callaghan, 2019; Gericke et al., 2022). Science teacher education plays an important role in fostering IBSE in the teaching profession (Crawford & Capps, 2018; Strat, Henriksen, & Jegstad, 2023). A tension between theoretical perspectives learned in teacher education and science teaching met in school placement, are adressed by several studies as a specific challenge for student teachers implementing IBSE (Bansal, 2021; Binns & Popp, 2013; Strat et al., 2023). Explicit modelling of scientific practices, ways of thinking, and how to facilitate, guide and scaffold inquiry through different activities in teacher education, are suggested as ways to support student teachers in enacting IBSE as future teachers (Avalos, 2011; Lunenberg, Korthagen, & Swennen, 2007; Strat et al., 2023). However, evidence suggest student teachers often see few connections between conceptualizing IBSE as learners and enacting IBSE as teachers (Bansal, 2021; Gunckel & Wood, 2016). Research highlighting student teachers transition between these roles are called for (Strat et al., 2023).

In this study, two interventions were developed aiming to support student teachers as both learners and future teachers in IBSE. Exploring the tradition between these roles was another. We address the following research question:

How can a shift between the role of the learner and the role of the teacher in the interventions support student teacher`s transition from learning inquiry to teaching inquiry?

2 Theoretical frameworks

Crawford and Capps (2018) argue integrated knowledge combined with experiences, views on science, and taking a metacognitive stands towards own practice are aspects of teacher cognition needed for teaching inquiry. Although many models of teacher knowledge exist, this study emphasize knowledge-practice relationships as a way to describe student teachers transition from learners to teachers. Cochran-Smith and Lytle (1999) distinguished formal knowledge for practice from informal knowledge in practice. Knowledge *for* practice include a range of foundational and applied topics that together constitutes what is viewed as a knowledge base for teaching (e.g., content knowledge, pedagogical knowledge, etc.). Cochran-Smith and Lyte posit that teachers also depend on situated knowledge *in* practice, constructed in response to particularities in the classroom and acquired through experience and reflection (p. 262). A third conception is the knowledge *of* practice. From this perspective, both generation and use of formal and informal knowledge leads and shape the conceptual and interpretive frameworks teachers develop to make judgements, theorize practice, and connect their efforts to society (p. 273). The two latter images of knowledge are also related to what Polanyi referred to as *tacit knowledge*, where language is viewed as a toolbox for tacid awareness (Polanyi, 2009). In their transition from learner to teacher, and in knowledge-practice relationships, student teachers might also have tacid knowledge that are not expressed explicitly.

3 Research methods

3. 1 DBR-process and educational design of interventions

Two interventions were piloted and tested through several iterations (Anderson & Shattuck, 2012). Inquiry in the role of the learner was emphasized by explicitly modeling scientific practices and ways of thinking (Bailin & Battersby, 2016; Crawford, 2014). In *Facilitating exploratory talk* a teacher directed inquiry-based activity (Dobber, Zwart, Tanis, & van Oers, 2017) was modelled, based on principles from POE (Liew & Treagust, 1998). *Inquiry-based fieldwork*, had a semi-open direction (Knain & Kolstø, 2019), and were based on recommendations from Remmen and Frøyland (2017). In both interventions, teacher educators modelled teacher roles and different kinds of teacher involvement. The student teachers received explicit instruction in IBSE in both interventions, and reflected on the role of the learner and the teacher. In *Inquiry-based fieldwork*, pre-service teachers (PST`s) reflected on how to adapt modelled activities to school practice. In-service teachers (IST`s) planned and tested adapted versions in own practice. In *Facilitating exploratory talk* PST`s planned and carried out an exploratory talk-activity (Kolstø, 2016) on campus in a short microteaching session, inspired by the modelled activity. They were then tasked with planning and carrying out another such activity in school placement, which was evaluated at campus after their school placement period.

3. 2 Methods and data sources

A preliminary content analysis was conducted on 3 video-stimulated, semi-structured focus group interviews (Table 1). The interview guide had 3 main questions on informants views on: a) outcomes in the role of the learner, b) outcomes in the role of the teacher, and c) the interventions' relevance to teaching profession. Additional sources of data were also collected, but will not be addressed in this proposal.

Table 6*: Interview data gathered 2022 - 2023*

Focus group	Informants	Course in education	Implemented interventions
1	2 In-service teachers	Science cource for teachers, 1.-7. grade (30 ECTS)	Inquiry-based fieldwork
2	3 pre-service teachers	2nd year in teacher education, 2nd cource in science, 5.-10. grade (60 ECTS)	Inquiry-based fieldwork Facilitating exploratatory talk
3	3 pre-service teachers	2nd year in teacher education, 2nd cource in science, 5.-10. grade (60 ECTS)	Inquiry-based fieldwork Facilitating exploratatory talk

3. 3 Analytical frameworks

We combined Wickman and Östman`s (2002) framework for meaning making with conceptions of teacher learning by Cochran-Smith and Lytle (1999). According to Wickman and Östman (2002), learning happens trough use of language in *meaning exchanges* (Table 2) situated in *encounters*. *Stand fast`s* represent already shared meaning, or meaning constructed in the *exchanges*. Between what is standing fast, *gaps* are tensions where new meaning is needed. Gaps are noticed and can be filled by *relations*. However, if learners are not able to fill gaps, they become *lingering gaps*. In our analysis, this framework could deal with situational aspects of teacher learning related to the interventions and school practice and give insights on how meaning changes in face of experiences.

Table 2: *Analytical framework for meaning making.*

Meaning Exchange	Stand fast, Relations and Gaps	Encounters
A discursive learning sequence.	- Stand fast - Gap - Relations - Lingering gap	Closely related to situations and/or interactions. Experiences, people, artefacts etc. are also included.

We also applied a modified version of Cochran-Smith and Lyte`s (1999) framework for conceptions of teacher learning. In adaptation to our context (Table 3) we used the knowledge-practice relationships but distinguished between informants expressed relationships as learners or teachers.

Table 3: *Analytical framework for knowledge-practice relationships in different roles.*

Knowledge-practice relationship	Knowledge *for* practice	Knowledge *in* practice	Knowledge *of* practice
The role as learner			
The role as teacher			

4 Preliminary Results

4. 1 Merging frameworks for meaning making and knowledge-practice relationships

Preliminary analysis showed that merging the two analytical frameworks described above worked in our analysis. Informants noticed IBSE-related gaps and filled them with relations. Some gaps were noticed, but not filled. Informants' experiences with campus-based activities at teacher education, as well as experiences in school practice, were clarified. This linked the meaning making to knowledge-practice relationships and gave opportunity to distinguish whether they expressed knowledge *for*, *in* or *of* practice in the role as learners or teachers. If presenting at NFSUN we will show how the frameworks were operationalized.

4. 2 Teacher knowledge situated in interventions and school practice

In both PST`s and IST`s encounters, connections were made between experiences from school practice and activities in teacher education. Informants expressed knowledge *for*, *in* and *of* practice in both the role as learners and teachers. Explicit modelling and reflection were argued to be productive. Trying out adapted versions in school was argued to be productive but frustrating. Preliminary analysis indicated some lingering gaps in such encounters. IST`s and PST`s pointed out that when mimicking or adapting activities from the interventions, they often met unexpected challenges. Choosing suitable questions or discursive moves, when scaffolding ISBE, was argued as much harder than anticipated. PST`s expressed that reflection and evaluation after testing activities in school placement was necessary, and argued microteaching supported them in enacting the role of the teacher.

5 Discussion

5. 1 Bridging the gap between formal knowledge and reality in school practice

Preliminary analysis indicated that student teachers connected experiences in the interventions as learners to experiences in school practice enacting IBSE as teachers. This nuances arguments from Bansal (2021). However, mimicking or adapting activities from the interventions were not without challenges. This aligns with obstacles' teachers are struggling with when implementing IBSE in school (Akuma & Callaghan, 2019; Gericke et al., 2022), and, challenges student teachers often meet in school placement (Bansal, 2021; Binns & Popp, 2013; Strat et al., 2023). It also supports arguments from Strat et al. (2023) on implementing IBSE in school placement and bridge the gap between formal knowledge in teacher education and school practice reality. Further analysis is needed to establish what insights our data might bring on the student teachers transition from the role of the learner to the tole of the teacher, and describe their knowledge-practice relationships in grater detail. This will be worked on towards NFSUN 2024.

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MODELING SCIENCE TEACHER EDUCATION AS SECOND ORDER TEACHING

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Abstract

Research in science Teacher Education frequently uses the term Second-order Teaching when addressing how to teach someone to make them competent to teach others science. This paper presents the development of an expanded model for Second-order Teaching with three different orders of Second-order Teaching. The model is unfolded in a context of boundaries, here the boundaries between the science Teacher Education at university campus and the corresponding teaching by teacher students at school, particularly using the concepts of boundary zone, boundary crossing and boundary objects. The presentation will give a first take on how the discussions in the boundary zone helped new knowledge to emerge between student teachers, teacher educators, and mentors, afforded by the boundary crossing mechanisms.

1 Introduction

Research in science Teacher Education (TE) frequently addresses how to teach someone to make them competent to teach others science with the term Second-order Teaching (SOT) (Jackson and Burch, 2019).

An updated understanding of SOT and its significance for science TE was to form the basis for the Danish large-scale initiative NAFA (2021-2028) with the overall aim of developing science teaching in TE as well as lower secondary and primary schooling in Denmark (https://nafa.nu/about-nafa/). The SOT model informs and guides the development processes within NAFA and makes them resonate with contemporary international research and developments within science teaching.

This paper presents the development of a model for Second-order teaching with three different orders of SOT. The model is unfolded in a context of boundaries, here the boundaries between the science TE at university campus and the corresponding teaching by teacher students at school, particularly using the concepts of boundary crossing and boundary objects (Akkerman and Bakker, 2011).

The use of the model will be illustrated by using the concepts of *bildung* and *competences* in Danish science TE for compulsory schools as boundary objects.

The guiding research question is:

How can an extended model of second order teaching qualify science teacher education through a more fine-grained understanding of second-order teaching and through applying the concept of boundary crossing?

2 Theoretical backgrounds

SOT has a core of teaching about teaching as a meta-relation that no other profession practices (Jackson and Burch, 2019). SOT can be practiced as *modeling*, where the teacher educator model educational practices without drawing attention to their pedagogical choices (implicit modeling) or teacher educators have meta-conversations with their students around choices they make while teaching (explicit modeling) (Mork et al. 2021). SOT requires some kind of mutual transfer between the campus arena of TE and the arena of school. It is a bi-directional transfer where the campus arena and the professional arena mutually influence one another (Nielsen and Jelsbak, 2018) and not unidirectional as in a traditional transfer conceptualization.

In an *activity system* approach (Engeström, 1987), this interaction between the two arenas is seen as an interaction between two different activity systems, two *communities of practice* (Wenger, 1998). Each community – the TE arena and the school – has its own set of practices and expertise that define its *boundaries* and by the crossing of these boundaries, new insights and developments can occur. *Boundary crossing* involves introducing elements from one community to another community. These elements are called *boundary objects*, and they can be present in a so-called *boundary zone*, where the boundary objects are discussed with the discourses and positions from the two arenas. During this discussion, contradictions are clarified and new learning takes place, through the mechanisms of identification, coordination, reflection, and transformation (Akkerman and Bagger, 2011).

The Danish compulsory school science curriculum is stated in terms of competences pointing towards cooperation between students to find solutions to problems or challenges. This enables a broad and inclusive perception of knowledge and skills in compulsory school based on a general bildung tradition in the purpose clause of the Danish compulsory school. In the project, the concepts of competence and bildung are defined based on mainstream literature and operationalized for science teachers and for students.

3 Research methods

Through a scoping review, we identified key studies in the field using several resources, such as database searches, reference lists, snowballing, networks, and expert groups, to select relevant studies and map the breadth and depth of the field at an initial level. This was represented in a mindmap of related concepts (Figure 1). We had a seminar with invited researchers to learn their understanding of and approach to the idea of SOT. This resulted in the first model of second-order teaching (figure 2). This model received feedback – and acceptance - from members of the science TE community.

In order to make the model more useful for reflection and development for TE, we defined three steps in the transitions between the campus activities and the school activities. This extended model is shown in figure 3.

Finally, we introduced the extended model in science TE together with elements linking two activity systems. We studied the learning that was afforded by the discussions in the boundary zone mediated by the concepts of competence and bildung. This was done by analysing how the boundary crossing mechanisms were unfolded in meetings between actors.

4 Results

Based on the above iterative interpretation of the literature and dialogue with other researchers, we distinguished between *core concepts*, *central concepts,* and *related concepts.*

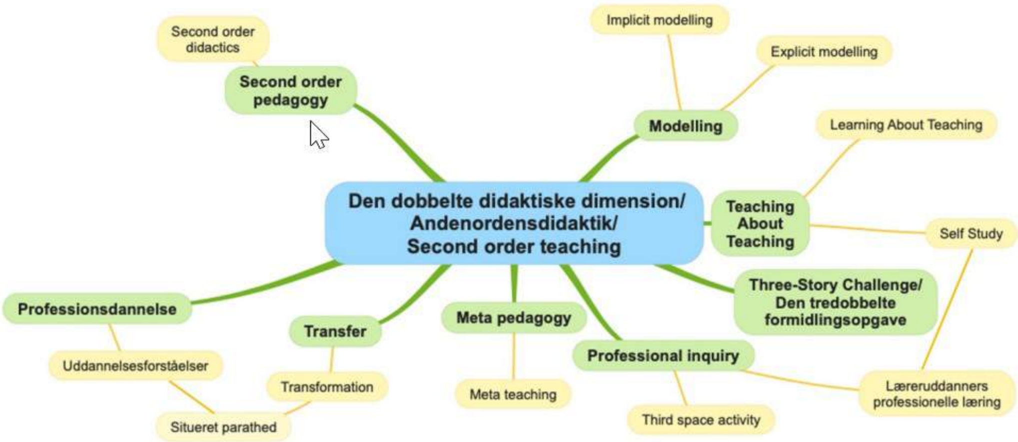

Figure 1. *Blue box: Second order teaching (SOT) and equivalent Danish core concepts. Green boxes: central concepts close to the meaning of SOT but not equivalent. Yellow boxes: related but distant concepts often used in connection with SOT.*

Based on our study of the concepts presented in the mind map in Figure 1, we have proposed a definition of SOT:

Second-order teaching encompasses the educative reflections concerning planning, enactment, analysis, and development of teaching that actors in the TE contexts address and the praxis they unfold in order to facilitate coming teachers' ability to future teaching.

The campus arena has two main actors: teacher educators and teacher students. The school arena has three actors: Teacher students in practicum facilitating the teaching of science content, students, and a mentor (the ordinary teacher of the practicum class). The two arenas are related through transfer, where teacher students transform campus- related teacher knowledge into actual teaching in school practice and back again.

This is illustrated in figure 2.

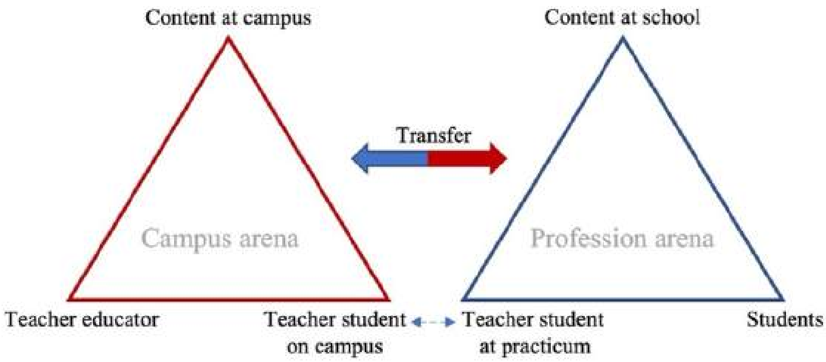

Figure 2. *Actors and transfer between the two arenas of TE: The campus arena and the school arena.*

Within the campus area, education is organised around teaching about teaching where teacher educators are teaching content to students to be used in compulsory school. We define this as the *SOT of the first order*, see figure 3.

The relation between the two arenas addresses the teacher student's work with transforming knowledge and skills within science education between the two arenas. It also addresses the feedback from teaching at school to the development of TE. Here student teachers and teacher educators are working together with school mentors. We define this as *SOT of second order.* Within the school arena, the student teacher enact teaching based on educational reflections. We define this as *SOT of third order*.

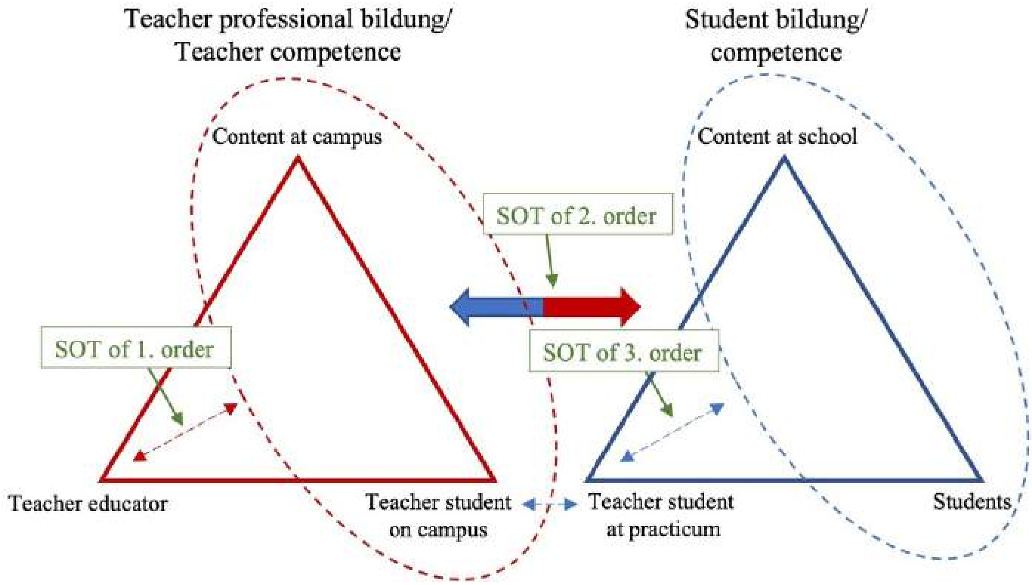

Figure 3. *SOT in the tree different orders at campus and school arenas and their relation to bildung and competence.*

The SOT of 2. order constitutes the boundary zone between the two arenas. It is here the boundary objects are discussed using the narratives from TE and from school. Typically, in meetings with the actors from the two systems representing different cultures and allowing negotiation of meaning. This is also described as *third spaces* or *hybrid spaces* (Jackson and Burch, 2019; Akkerman and Bagger, 2011).

We have used various boundaries objects, but will in the presentation focus on competences and bildung. A number of concrete boundary zone discussions (at the moment three, more will be added during the next months) have been condensed into a case. The case has been analysed for the actors' use of *identification* (defined one practise in the light of another), *coordination* (communicating and translating), *reflection* (making perspectives and points of view explicit), and *transformation* (confrontation, recognition of shared understanding etc.). The presentation will give a first take on how the discussions in the boundary zone helped new knowledge to emerge between student teachers, teacher educators, and mentors, afforded by the boundary crossing mechanisms.

4 Discussion and conclusion

Figure 3 illustrates and conceptualizes the double aim of TE, stating three significantly different orders of SOT, giving a more detailed understanding of SOT. The model has broad acceptance in Danish TE, and it offers a framework for operationalizing key concepts such as bildung and competences in a common manner for both teacher educators and teacher students. The activity system approach with boundary objects and boundary zone offers a productive mechanism seeing learning as boundary crossing. In our concrete example, the model provides teacher educators and student teachers a tool to reflect on student competence and bildung and the corresponding teacher competences and bildung in a more dynamic and clearer way.

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CREATING AGENCY AND VALUES FOR STUDENTS IN CO-CREATION PROCESSES

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Abstract

Students are well aware of sustainability challenges such as global warming and pollution however they often express inability and agency to tackle these issues. In this study we explore how co-creation processes may affect students' agencies and actions, but also what values co-creation may create. Fifth grade students and teachers collaborate with Natural Science professionals (NSP) around real-world problems from NSP vocations, for creation of new knowledge and inspire agency to the participants. 18 hours of video recordings were analysed according to Payne et al. (2007) and Ansell et al. (2022). The preliminary results suggest that co-creation processes create new knowledge for all participants but also personal and community values. Furthermore, co-creation seems to support taking action.

Creating agency and values for students in co-creation processes

Students are well aware of and has knowledge about sustainability challenges such as global warming, pollution, emissions of greenhouse gases, and chemicals in nature. However, many young people also express hopelessness in how to act in relation to these vast socioscientific challenges (Evagorou et al., 2020). One way to increase agency is to engage in real world problems.

The aim of the study is to explore how co-creative processes around socio-scientific challenges in formal science education may affect students' agencies and actions, but also what values co-creative processes may create. The research questions for the study are accordingly:

- *How does a co-creative process affect students' agencies and actions?*
- *What values are created in the co-creative processes?*

Co-creation

Co-creation as a method has mostly been used in business models and health-care where establishments and clients collaborate to improve products/services (van Dijk-de Vries et al., 2020). Rill & Hämäläinen (2018) define co-creation as a creative, collaborative method where every participant's potential is utilized. They argue that the aim of the method is to empower participants to take action in collective creativity to develop new knowledge. Horvath et al. (2020) describe co-creation as a process where stakeholders from diverse backgrounds, with various experiences and knowledge, participate in collaborations with the purpose to examine a social issue. The aim of co-creation is to utilize creative approaches to generate mutual understandings and dialogue rather than a methodological toolkit which can be applied reflexively regardless of the context. Voorberg et al. (2017) argue that what drives the process is the inclusion and involvement of participants as active co-creators of their environment, making them owners of the setting as well as accountable of the process.

Co-creation as a method has been commended for its possibilities and criticized for its shortcomings. Ansell et al. (2022) present different co-creative processes to investigate what conditions are optimal for a positive experience. The results indicate that a knowledge development in the process generate mutual understanding between participants resulting in empowerment to take action. This is something that Ansell et al. (2022) claim is essential in co-creation where opportunities for growth of new knowledge and skills generate power to impact your surroundings. According to Payne et al. (2007) co-creation is an innovative collaboration that involves sharing experiences and values/benefits which require respect, understanding, planning and implementation of results. However, difficulties with policies, technicalities, time, resources and power differences effect participants feelings of value and agency contributing to impressions of the process being more valuable for governments then individual citizens.

In this paper, co-creation is utilized in a process engaging stakeholders from diverse parts of society as participants in formal science education. Middle school students and natural science professionals (NSP), meaning professionals who have post-secondary education in science and are specialists in science vocations, engage in co-creative processes to solve authentic dilemmas that the NSPs' face in their vocations. The intention is for the participants to use their experiences and knowledge to find beneficial solutions and take action.

Method and analysis

In order to approach the aim and research questions for this study, co-creative processes were planned together with an in-service middle school science teacher. The co-creative processes were the final activities on a three-week long science project on water and water supply. Three NSPs were engaged based on their specific area of expertise. 30 fifth grade students participated in the study resulting in three groups of one NSP and 10 students. The NSPs utilized authentic dilemmas from their workplace for the co-creative collaboration. The dilemmas were:

A. How can we extend the course of rainwater from perspiration on our schoolground to rivers and ocean aiming to lessen erosion of riverbanks and reduce pollution of water reserves?
B. How can we reuse material to minimize the excavation of raw material such as silviculture and crude oil?
C. How can we inspire people to minimise usage of water in households?

Each group organized their collaboration. Group A had a collective introduction then selected to split the students in pairs who each made a prototype illustrating their ideas using Lego. The NSP circulated between the pairs and engaged in discussions concerning the dilemma at hand. Group B firstly engaged in a joint discussion concerning the dilemma whereafter the students divided in two groups when deciding to act in various ways. These groups discussed who to contact and engaged in taking action while the NSP circulated between the groups. Finally, group C decided to collaborate and take action as a collective group with all participants.

The discussions in the daylong co-creative collaborations were video recorded. In all, the data material consists of 18 hours of recordings. Furthermore, students answered pre- and post-intervention questionnaires while NSPs and the teacher were interviewed postintervention. The questionnaires and interviews are not part of this paper. The study was preceded by an ethical review and all participating students assented, and their guardians gave consent for the students' participation in this study.

The first research question, "how does a co-creation process affect students' agencies and actions?", was approached by deploying Ansell's et al (2022) description of co-creation as a) generating new knowledge and skills, and b) take action and impact your surroundings. This means that participants' dialogues where deductively categorised into these two main themes. From this initial analysis we can see that there are expressions of learning both from students and NSPs. We also find several incidents on taking action, mainly from the students.

The second research question, "what values are created in the co-creation process?", was approached by deploying Payne et al. (2007) description of inclusion and empowerment of engagement in societal issues based on stakeholders' a) individual values as well as b) community values. The participants' dialogues were also here deductively categorised into these two categories. Initial analysis show that co-creative collaboration based on inclusion of stakeholders' individual and community values result in empowerment of participating in solving problems.

Preliminary results

From the initial analysis, we found several examples where the participants generate new knowledge and skills. In Excerpt 1 Adrian and Hugo discuss reusage of wastewater from households with the NSP. They come up with the idea of implementing an extra circular system for different wastewater from new houses.

Adrian - *can't you do it on new houses, I mean right from the start? Instead of changing everything that already exists...*	
	NSP: *You could do that on all new houses... Why don't we do it then?*
Hugo - *you have to have a new treatment plant... that is... which takes the water for it...*	
	NSP: *Yes, you actually have a great point there, we have to have a new sewage treatment plant. That's true, because otherwise there will be different water coming to the sewage treatment plant.*
Hugo - *But if we do it now ... then in a hundred years, maybe it will work out ...*	

Excerpt 1: *Discussion in group C on what would be needed for reusage of specific wastewater from households.*

The second part in Ansell's description of co-creating is taking action and also here we found several examples. In the following excerpt (Excerpt 2) Oscar, Axel, Elva and Sandra want to pitch their idea of saving water to a fast-food restaurant and initiate a contact. As seen in the excerpt the students are forwarded to an employee that works with sustainable issues and the students get very excited.

Take action:

	Reception - *Hello and welcome to Company, how may we help you today?*
Oscar - *Hi! ehhh we fifth graders from Skola in Stad and we are collaborating on water and environment. Would you be able to help us with ehhh spreading awareness about why people shouldn´t throw their garbage in water?*	
	Reception - *I will put you in contact with the right person for that, hold a moment please.*
Oscar - *Thanks! ... Ok, thanks.*	
Axel - *It´s going great.*	
Elva - (whispers) *a boss*	
Sandra - (whispers) *we are calling the boss.*	

Excerpt 2: *Students (group B) take action by contacting the local headquarters of a worldwide organisation to pitch their idea on how to promote recycling and caring of water supplies.*

The final example refers to creating personal and community value (Payne et al., 2007). As seen, Liam and Tim find the work inspiring as a personal value but also, in discussion with the teacher, find a possible community value.

Liam - *This is the best lesson ever!*	
	NSP - *Oh! WOW! That is … all of this that you are considering now you could bring home.*
Tim - *Yes* Liam - *Bring home?!*	
	NSP - *Yes, we might use the water from downpipes and have a tillage at home too.*
Liam - *Or you could use the design at home and make a prototype.*	

Excerpt 3: *Students (group A) and teacher discuss how they can use their prototypes and implement their ideas at home.*

Discussion

The result from this study can be utilized as stimulus for research on how to apply authentic socioscientific issues in formal science education engaging participants from various parts in society. We argue that co-creative processes involving diverse stakeholders could support students in their understanding of why they need different forms of knowledge and competences as well as engagement in taking action in sustainability issues.

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SEXUALITY, RELATIONSHIPS, AND IDENTITY IN SWEDISH TEACHEREDUCATION

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Abstract

Comprehensive Sexuality education has been criticized for not meeting new societal demands and failing to forward the work in Swedish schools. As an answer to the critique, the knowledge area called sexuality, consent, and relationships was developed. For the changes to be feasible, a new degree goal was added to the Swedish statutes of teacher education, whereas the higher education institutions must transfer the degree goal into their syllabuses. The purpose of the study is to identify how the teacher education degree goals is transformed into course syllabuses. Course syllabuses from twelve Swedish teacher education programs for both primary and secondary student teachers were analysed. 34 syllabuses from seven universities were analysed using critical discourse analysis. The findings show a high degree of intertextuality with respect to degree goal and course syllabuses, as many syllabuses are almost copies of the governmental degree goal. The findings raise the question of transparency regarding how the new degree goal is implemented in courses and how the change of the comprehensive sexuality education will be implemented. During our presentation, we are interested in discussing teacher training with respect to comprehensive sexuality education and transformation of degree goals to course syllabuses.

1. Introduction

Swedish comprehensive Sexuality education has been criticized for not meeting demands from individuals and society, for example in the form of conflicting cultural sexuality norms and increased access to pornography. As a reaction to the shortcomings, changes have been made, and in Swedish schools the knowledge area is now called sexuality, consent, and relationships. For the changes to take place, a new degree goal has been added to the teacher training courses for elementary and subject teachers stating that the student must demonstrate the ability to communicate and reflect on issues related to identity, sexuality, and relationships (Regeringen.se, 2020; The Swedish National Agency for Education, 2022). Speaking in favour of this change are studies pointing to a relationship between teachers' willingness to teach about sexuality and relationships, their perceived knowledge and training in the area, and that they see sexuality and relationships as an important area of knowledge (Cohen, Byers & Sears, 2012; Costello et al., 2022). For the teacher training to contribute that knowledge to students, the degree goal needs to be transferred into learningactivities and course goals in syllabuses of today's teacher training courses.

This project sets out to examine how teacher training transforms governmental requirements into curricula. This will be made through discourse analysis (Fairclough, 2003),implying an analysis of particular ways of talking and understanding cultural aspects of the world, in this case course syllabuses. The purpose of the study is to identify how the requirements expressed in the teacher training degree goals are transformed into course syllabuses. This is the first step in a project where changes in teacher training for the knowledge area of sexuality, identity and relationships are investigated. The research question is: What discourses appear in the knowledge area of identity, sexuality and relationships?

2. Theoretical backgrounds

Discourse can be explained as a certain way of talking about and understanding the world (or a part of the world) (Potter and Wetherell, 1987). Potter and Wetherell include all formsof spoken interaction in discourse, formal and informal, and written texts of all kinds.

Discourse analysis focuses on how people use language to do things. In this paper, Fairclough's critical discourse analysis (CDA) is used. CDA is based on questions about howdifferent resources are constructed or made available to individuals to identify possible changes (Fairclough, 2003). Analysis of a discourse that is part of a discursive practice focuses on production, distribution and consumption of texts (Fairclough, 1992).

3. Research methods

In the study, course syllabuses from twelve Swedish teacher education programs for both primary and secondary student teachers were analysed. In total, 34 syllabuses from seven universities/teacher education programs were analysed with critical discourse analysis (CDA) (Fairclough, 2003). Within CDA, *intertextuality* (I), and *modality* (M) were chosen since they focus on how texts are transformed on different levels. Intertextuality means that all texts to some extent contain parts of other texts although developed, reinterpreted, simplified, and changed in different ways. Modality refers to the interpersonal function of language. An utterance can be more or less categorical, and modality is associated to modal auxiliary verbs such as must, may, can and should. The modality analysis was combined with Blooms taxonomy (Armstrong, 2010). In this use of Bloom's taxonomy, verbs are analysed and categorized at different levels. These "action words" describe the cognitive processes by which thinkers encounter and work with knowledge. As an example, the verb remember is on level 1 and the verb create on the highest, level 6.

4. Results

A total of 19 syllabuses were found to include learning objectives that were related to identity, sexuality, and relationships. These 19 syllabuses contained 24 learning objectiveswithin the knowledge area. Some examples of leaning objectives are: *The student must beable to identify and critically review norms and values relating to sexuality and relationships*; *After completing the course, the student should be able to: reflect on andcreate conditions for students' health and well-being in matters of identity, sexuality and relationships and The student must be able to reflect on the relationship between subject didactics and the knowledge area of sexuality and relationships and The student must be able to reflect on the relationship between subject didactics and the knowledge area of sexuality and relationships.*

In nine of the learning objectives the wording in the syllabuses were exactly the same as in the governmental degree goal: *to communicate and reflect on issues related to identity, sexuality, and relationshi*ps. The intertextuality is high also in several other syllabuses, wherethe governmental degree goal is used, but complemented with a concept such as ethnicity or norms. These two kinds of wordings in the syllabuses where no or only small adjustments are made form two discourses; copy and small adjustments. Another two discourses that are suggested in the syllabuses are labelled teacher related and deeper knowledge.

To sum up, four different discourses are identified:

- Copy

- Small adjustments
- Teacher related
- Deeper knowledge

In the teacher related discourse, the syllabuses were adapted to support knowledge connected to becoming a teacher. For example, in the deeper knowledge discourse, the verbs were on a higher level in Bloom's taxonomy than the degree goal, for instance *criticallyreview*, instead of remember or use knowledge.

5. Discussion and conclusion

The dominating discourses are Copy and Small adjustments. Why these dominate is not possible to explain with a document analysis. This will instead be investigated in the next step of the project where teacher educators will be interviewed. The explanation could be both lack of time to specify the syllabuses and that the graduation goal is regarded as beingon an accuracy sufficient level. However, the Teacher related discourse demonstrate that there is an ongoing work at some universities to develop the degree goals for the benefit ofstudent teachers.

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ASSESSMENT OF SCIENCE COMPETENCIES IN PRIMARY AND LOWER SECONDARY EDUCATION IN DENMARK - EXPERIENCES FROM THE NATKOM PROJECT

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Abstract

This study addresses, through a Design Based Research (DBR) approach adapted by the NATKOM project, the challenge of assessing science competencies in primary and lower secondary schools in Denmark. New formative assessment designs, guided by a shared understanding of competency and competence-oriented teaching characteristics, were developed and tested with 28 teachers representing 18 schools. Over 13 months, the 28 science teachers participated in first a one-day course on competency concepts and hereafter three workshops focusing on inquiry, modelling, and perspective-taking competencies. Teachers shared their lesson plans and collaborated with educators from University College Absalon to refine assessment designs. Between workshops, teachers implemented planned lessons and associated assessments, with educators conducting observations and post lessons interviews. The findings indicate that the developed rubrics and forms were effective in assessing students' science competencies, contributing to an enhanced understanding among teachers of designing and implementing formative assessments for learning in the context of competence-based teaching.

1 Introduction

Competency found its way into the Danish education system relatively late. In 2003, the FNU reports proposed science competencies for Danish science education (Andersen *et al*., 2003; Busch *et al*., 2003), and in 2014, the Danish Ministry of Education introduced Simplified Common Goals to enhance the relevance of lower secondary school exams. Despite these efforts, assessments still predominantly focus on knowledge and skills rather than competencies (*e.g.* Dolin, 2016; Nielsen & Dolin, 2016). This study aims to address the challenge of assessing science competencies in primary and lower secondary schools by exploring the characteristics of competence-oriented teaching and identifying beneficial assessment tools.

2 Theoretical backgrounds

Both the understanding of the concept of competence in general and its content have varied over time. Competence can be seen as a changing construction, which is characterized by the dominant discourses that apply at the time and in a profession (Hodges, 2012). However, in more recent interpretations of competence, it is mentioned that competences are more than knowledge and skills (see Rychen & Salganik, 2000; Oyao *et al*., 2015; Chiriacescu *et al*., 2023). Being able to act competently in new and unfamiliar situations is central to several recent understandings of the concept of competency (see e.g. Mathelitsch, 2013; Oyao *et al*., 2015; Wiesner & Schreiner, 2020), which is why teaching should be based on a definition of competence that includes the possibility, perhaps even requires, that students are brought into situations of uncertainty and choice (Christiansen, 2022; Christiansen *et a*l., 2023).

In Denmark, primary and lower secondary school science education is currently organized into four science sub-competencies; inquiry competence, modelling competence, perspective-taking competence and communication competence (see Ministry of Children and Education, 2019).

3 Research methods

The NATKOM project employs the Design Based Research (DBR) approach, involving continuous iterations of design, enactment, analysis, and redesign (Brown 1992), adopting the basic assumption of DBR; that only by intervening with new designs can we develop better theories of practice at the same time as we seek to improve practice. Over 13 months, 28 science teachers from 18 Danish schools participated in a one-day course on competency, followed by three workshops. An initial interview and subsequent three interviews after each visit to the schools were conducted with the participating teachers, in order to obtain information about their views on competence-oriented teaching and assessment.

After gaining a common understanding of the concept of competency, we investigated and agreed on what characteristics competence-oriented science teaching have, and then it became appropriate to investigate and test different formative assessment designs that are capable of assessing science competencies.

Three workshops (WS1-3) were conducted, focusing on inquiry (WS1), modelling (WS2), and perspective-taking competencies (WS3) respectively. The communication competence was embedded in all workshops and teaching designs, as it was considered a fundamental aspect of the other three competencies and contributes to the students' ability on a scientific basis to argue, discuss, etc. (see Christiansen, 2022).

4 Results

Twenty-seven of the participating teachers took part in an initial interview to uncover their pre-understanding of competence-oriented science teaching and assessment of competencies. Overall, the participating teachers acknowledge the importance of competency-oriented teaching. However, when asked, *"what do you think is characteristic of competence-oriented science teaching?"*, only about 8 % expressed that it is characteristic of competence-oriented teaching that the students are the ones who are the active part. Three of the twenty-seven teachers link the concept of curiosity to competence-oriented teaching. However, overall, the majority of the participating teachers find it difficult to characterise competence-oriented science teaching.

When asked *"How do you think competence-orientated science education can be assessed?",* one third of the teachers expressed, in different ways, that it is difficult to assess competencies. For example, one teacher said, *"I actually think that's one of the things that's difficult. That's why we're here. That's what we want to get better at"*. Another teacher has the same general opinion, albeit expressed friskier: *"Oh my gosh, that's why I've taken this course, isn't it? How can it be assessed? Christ, that's what's so damn difficult [........]. I think that was a really difficult question, I don't know what to answer".*

In five cases, the time-consuming aspect of assessments was mentioned as an obstacle to assessing science competencies.

Conversations as a mean of assessing competencies showed a relatively high level of agreement, with twelve out of the twenty-seven teachers specifically mentioning conversations as a mean of assessing competencies.

However, it was clear that the majority of the participating teachers struggled to describe a competence-orientated assessment as distinct from a more traditional assessment.

In order to get a common understanding of what competence-oriented teaching is, we, together with The Natural Sciences Evaluation and Development Centre (NEUC), identified six criteria for competence-oriented teaching adapted by the project:

1. Teaching is based on a concrete (science) problem.
2. Teaching has a clear science competence focus.
3. Teaching contains significant freedom for students.
4. Teaching contains collaboration and dialogue.
5. Teaching provides enough time for reflection.
6. Teaching is based on science knowledge and skills.

However, observations of teachers in action showed challenges in meeting these criteria, particularly criteria 3 and 5 (student freedom, and reflection time), but also in some extent criteria 1 (clarity on the concrete problem), was apparently challenging.

A formative assessment practice focussing on science competencies was also challenging for many teachers, whereas an assessment practice focussing on scientific knowledge and skills was apparently much easier.

4 Discussion and conclusion

Assessment of competency in education requires, as we see it, a framework of unknown and uncertainty. Consequently, pedagogical strategies must be structured to provide students with a considerable degree of autonomy, incorporating collaborative opportunities and dialogical elements and clearly scaffolded by the teacher. This framework establishes the foundation for competency assessment, wherein learners are observed in specific and authentic situations.

In this project, this was typically conducted within the context of problem-based learning and group collaborations. Students formulated, for example, their hypotheses or research questions, and designed and explored their own self-directed trajectory from question to answer.

Competence-oriented science teaching was a challenge for many of the participating teachers in the project, even though the participating teachers seem to have better prerequisites than many other science teachers for carrying out competence-oriented teaching (several had additional training as a science supervisor). Consequently, there is still a need for efforts that can support more teachers to be able to work in a competence-oriented way and be able to conduct assessment practices supporting a competence-oriented science teaching.

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CONCEPT ANCHORS: PROVIDING A PATH TOWARDS SYSTEMS THINKING PCK

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Abstract

UNESCO suggests eight key competencies to be crucial for education for sustainable development (ESD). Systems thinking is one of these. This article reports an interdisciplinary intervention across four science courses in Danish teacher education. We introduce cross-disciplinary **concept anchors** (time, numbers, scale, concentration, cycles, reversibility) into course content focusing on the carbon cycle. Concept anchors are presented as a practical tool to help recognise key system elements, interdependency and time dynamics within the subject area. We investigate how student teachers employ the concept anchors when given the task of developing teaching plans for a lower secondary science class. Using a concept mapping analysis, we show how concept anchors scaffold student teachers' ability to link concepts across fields. Based on the student teachers' teaching plans, survey and interview data, we evaluate the effective implementation of concept anchors into the teaching practice of the student teachers. We argue that concept anchors can strengthen both the development of systems thinking competencies for the teacher students themselves, and also scaffold the process of transferring this complex understanding into their own teaching. Making systems thinking part of student teachers' pedagogical content knowledge (PCK), is key to successful ESD-teaching in their future practice.

1 Introduction

Systems thinking is gaining recognition as a central competency when learning about complex phenomena. Gilissen et al. (2019) investigated how systems thinking is implemented in biology teaching in Dutch teacher education and secondary school. They argue that systems thinking is particularly important to teaching biology, because topics in the secondary biology curriculum require understanding of interrelated dynamic networks. According to their study, systems thinking is a well-integrated approach within the scientific field of biology, plays a less prominent role in teacher education, and is largely absent in secondary biology classes. While teacher educators, to some extent, introduce aspects of systems thinking explicitly in their teaching, secondary biology teachers rarely teach systems thinking. When it does occur, the system aspects are taught implicitly in a situated context. The authors argue that a more explicit use of systems thinking theory could result in more coherent understanding of the interrelatedness of biology topics. However, secondary school teachers tend to view systems thinking as "too complex" for their students.

Recent studies aim to introduce systems thinking as an explicit topic in science teaching in upper secondary (Gilissen et al. 2020) and teacher education (Rosenkränzer et al. 2017). The latter study found that content knowledge about systems thinking, when integrated with teaching explicit pedagogical strategies, significantly increased the ability of teacher students to implement systems thinking in their teaching practise (systems thinking PCK). However, this study did not investigate enacted PCK; a pen-and-paper test was used to assess PCK.

If systems thinking can be considered crucial to understanding the interrelated nature of biology topics, the same argument certainly applies to topics in sustainable development. Rieckmann (2012) conducted a delphi study with a panel of 70 sustainable development expert from three countries in the global south and two in the global north, to obtain a ranking of competencies perceived as the most relevant for ESD. Systems thinking and handling of complexity were the overall top priorities in both groups. When the UN introduced their 17 sustainable development goals, UNESCO published recommended learning objectives for ESD teaching (UNESCO 2017). The report identifies systems thinking as the first among seven key competencies contributing to the overall “integrated problem-solving competency”.

In teacher education, we face additional challenges: Students need to develop both their own systems thinking competencies, in order to understand the complexity of sustainability problems, but also to transfer this complex knowledge into their own practice as part of their pedagogical content knowledge (Carlson and Daehler 2019). Moreover, since ESD involves cross-disciplinary content, and since secondary teachers in Danish teacher education are field specialists, teaching ESD requires certain amounts of boundary crossing between the school subjects in which teacher students are specialised, and those in which they are not (Akkerman and Bakker 2012).

In this study, we introduce cross-disciplinary **concept anchors** (time, numbers, scale, concentration, cycles, reversibility). We focus on the carbon cycle as exemplary content that is easily related to all fields of science and has strong implications for sustainable development. By providing concrete connections between fields, we hypothesize that concepts anchors have potential to reduce the perceived complexity of a complex topic. Our research question addresses the value of these concept anchors in developing coherent understanding of the carbon cycle, and in assisting the transfer of this content knowledge into teaching practise (PCK):

Can the explicit introduction of concept anchors in an interdisciplinary science course provide a useful tool to develop student teachers’ systems thinking and systems thinking PCK?

2 Theoretical background

Novak and Cañas (2006) introduced concept mapping as a tool for organizing and representing knowledge, particularly reflecting knowledge of patterns and connections. In a study of 48 Israeli high school students, Tripto et al. (2013) investigated the effectiveness of concept mapping to test systems thinking competency. The study identified several challenges to students‘ system thinking, including their ability to transfer domain specific knowledge, and concluded that concept mapping provides a useful analytical tool to assess systems thinking.

We recruited students across four different science classes in Danish teacher education. Students were instructed to use concept anchors (time, numbers, scale, concentration, cycles, reversibility) to identify similarities between fields, between topics, and as explicit elements in developing their teaching plan. Throughout the intervention, concept maps are used to outline students’ understanding of the carbon cycle to construct their teaching plan.

3 Research methods

Our intervention involves 52 teacher students recruited from classes in physics/chemistry (integrated course), earth sciences, biology and general science (an integrated course aimed at primary school). Twelve four-hour workshops provided a cross-disciplinary focus on the carbon cycle, with students assigned to interdisciplinary groups and given the task of developing a teaching plan on this topic.

We use an adaptation of the analytical method of Tripto et al. (2013), modified to employ the systems thinking model of Gilissen et al. (2020). We analyse concept maps from early and late stages of the intervention to assess student teachers' systems thinking competency, and the degree to which the concept anchors are actively employed in teaching plan development.

Towards the end of the intervention, student teachers test their teaching plan on two 5th and 6th grade classes (ages 12-14). We use observations of the student teachers' practice to assess the degree to which the concept anchors are operationalised in enacted PCK (Carlson and Daehler 2019). At the end of the intervention, we conduct focus group interviews to assess the extent to which student teachers engaged in boundary crossing outside their perceived field of expertise (Akkerman and Bakker 2012). We evaluate the extent to which students found the anchor concepts useful for boundary crossing, as systems thinking tools, and in planning their own teaching.

4 Results

Early analysis of student concept maps show a fragmented and incomplete understanding of the carbon cycle at the beginning of the intervention. The number of both concepts and connections increased throughout the intervention. Students readily adopted the use of anchor concepts in concept map construction, although some anchor concepts were more widely used and achieved more connections (time, scale) than others (reversibility, concentration). At the time of submission, the intervention is still ongoing. Results regarding the role of anchor concepts in the enacted PCK of teacher students will be presented at the conference.

Figure 2. Constructing an early concept map while developing content for a teaching plan

4 Discussion and conclusion

Through the explicit use of anchor concepts, our study provides an operational tool to make complex teaching topics such as interdisciplinary ESD-content and systems thinking more accessible to students. By integrating students from four different science classes, we also created an arena for exploring the role of boundary crossing (Akkerman and Bakker 2012), and the use of concept anchors as boundary objects.

Students found anchor concepts useful in transferring domain-specific knowledge from their own specialised field into an interdisciplinary context. As such, concept anchors came into use as boundary objects making the cross-disciplinary nature of ESD-teaching potentially more accessible in their future practise.

We see the introduction of anchor concepts as a practical method addressing some of the complexities that may seem daunting to student teachers when teaching interconnected, interdisciplinary concepts such as ESD. The particular concepts in our study (time, numbers, scale, concentration, cycles, reversibility) can certainly be adapted, and as we show, some were more easily accessible to student teachers than others. Regardless, the general approach of introducing cross-disciplinary concept anchors to assist students in building coherent understanding within complex fields can potentially strengthen both systems thinking and systems thinking PCK.

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MÅNNISKANS HOT MOT DEN BIOLOGISKA MÅNGFALDEN – LÄRARSTUDENTERS UPPLEVELSER OCH FÖRSLAG PÅ UNDERVISNING OM BIOLOGISK MÅNGFAGLD I GRUNSKOLANS TIDIGARE ÅR

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Abstract

Teaching about biodiversity is seen today as significant by several researchers because human survival depends on biodiversity. The study aims to describe and understand student teachers' experiences of biodiversity and what student teachers identify as central to teaching about biodiversity. In the present study, student teachers have been seen as particularly important because they will meet many young students as future preschool and primary class teachers. The data collection was carried out through semi-structured interviews with three focus groups. The preliminary results show that the students express feelings concerning the loss of biodiversity related to their future, present, and past, as well as feelings directed toward a universal future. The preliminary results also show ideas about what they consider central to teaching. The student teachers, for example, describe the importance of young students experiencing nature, facing different resource dilemmas, discussing different values, and doing something practical that positively affects biodiversity. They put more emphasis on students developing awareness of the consequences of biodiversity loss than on developing knowledge of the concept of biodiversity.

1. Introduktion

I det här forskningsprojektet studeras lärarstudenters upplevelser av biologisk mångfald och vad lärarstudenter urskiljer som centralt vid undervisning om biologisk mångfald. Biologisk mångfald innefattar allt liv på jorden, alla dess former och all dess interaktion. Mänskliga aktiviteter hotar denna mångfald på flera nivåer och läget är allvarligt (IPBES 2019). Biologisk mångfald är en förutsättning för människans välfärd, till exempel genom matproduktion. I relation till detta anses utbildning utgöra en av flera faktorer för att öka medvetenheten om förlusten av biologisk mångfald (Wiegelmann & Zabel 2021). Olika studier har också genomförts för att främja undervisning om ekologi och biologisk mångfald (Wiegelmann & Zabel 2021). Lindemann-Matthies et al. (2009) har exempelvis studerat i vilken utsträckning biologisk mångfald integreras i några europeiska länders lärarutbildningar. Alla lärarutbildningar innehöll naturvetenskapliga aspekter av biologisk mångfald men endast ett fåtal av lärarprogrammen behandlade frågor som berörde bevarande av biologisk mångfald i relation till ekonomiska, etiska, sociala och politiska perspektiv (Lindemann-Matthies et al. 2009). Wang et al. (2020) som genomfört en bibliometrisk kartläggning av ”hot topic” av forskning inom ”Science Education” från 2001 till 2020 fann dock att sociala frågor relaterade till naturvetenskap var under tidsperioden ett område som studeras frekvent. Kilinc et al (2013) har undersökt elevers förståelse av begreppet biologisk mångfald och fann att begreppet främst associerades till mångfald av arter. Flera studier har undersökt i vilken utsträckning elever och lärarstudenter känner igen olika arter. Genovart et al. (2013) fann att elever i större utsträckning känner igen exotiska arter än de arter som fanns lokalt och Palmberg et al. (2015) som undersökt lärarstudenters förmåga att identifiera vanliga lokala växt- och djurarter fann att få studenter kunde identifiera alla eller nästan alla arter. Genovart et al. (2013) menar att om vi vill att elever skall engagera sig i bevarande av den lokala biologiska mångfalden så behöver de också få ett intresse för den biodiversitet som finns lokalt. Olika dimensioner av lärande såsom kognitiva, affektiva och handlingsinriktade beskrivs som betydelsefulla för att skapa ett intresse för frågor som handlar om biologisk mångfald. Beery och Jørgens (2018) beskriver den affektiva dimensionen som relationen till levande organismer och kärlek till naturen och betonar vikten av barns känslomässiga erfarenheter av naturen. Manni et al. (2017) studerade elevers erfarenheter och meningsskapande om biologisk mångfald och fann att tidigare erfarenheter i naturen, liksom känslor och sociala interaktioner i naturen var viktiga för elevernas meningsskapande processer. Även Magntorn och Helldén (2005) lyfter fram undervisning i naturen som viktig för lärarstudenters kunskaper om biologisk mångfald och dess roll i ekologin. Om relationer till naturen grundas tidigt under barndomen så är det viktigt att lärare för yngre åldrar ser betydelsen av att undervisa yngre elever i och om naturen (Miller 2005). Undervisning om förlusten av biologisk mångfald kan tillsammans med medias förmedling också framkalla känslor som rädsla, oro, skuld, skam, och hopplöshet kallat, *eco-anxiety* (Ojala et al. 2021). Dessa känslor kan fungera som drivkraft för förändringar men de kan också medföra mindre konstruktiva reaktioner. Oavsett så behöver känslorna tas om hand i undervisningen (Ojala et al. 2021).

I relation till förlusten av biodiversitet i naturen och undervisning därom har i föreliggande studie lärarstudenter setts som särskilt betydelsefulla eftersom de som blivande F-3-lärare kommer att möta ett stort antal elever.

Syftet med studien är att beskriva och förstå lärarstudenters upplevelser av biologisk mångfald och vad lärarstudenter urskiljer som centralt vid undervisning om biologisk mångfald.

- Hur upplever lärarstudenter förlusten av biologisk mångfald i relation till mänsklig verksamhet?
- Hur beskriver lärarstudenter att undervisning om biologisk mångfald kan utformas i grundskolans tidigare årskurser?

2 Teori och metod

Med utgångspunkt i Deweys (1958) teori om erfarande möjliggörs att studera vad som ses som betydelsefullt och engagerande i frågor som rör ekologi och biologisk mångfald. Estetisk kan på så sätt ses som ett sätt att uttrycka värderingar och känslor såsom att något är viktigt eller oviktigt, engagerande eller ointressant (Wickman, 2006).

Datainsamlingen har genomförts i form av semistrukturerade intervjuer med tre fokusgrupper; varje intervju varade i 40–50 minuter. Deltagarna i fokusgrupperna var blivande lärare för årskurserna F-3. Intervjuerna genomfördes via zoom, spelades in och transkriberades därefter. Intervjuerna genomfördes via zoom eftersom studenterna befann sig på vitt skilda platser i landet. Vid intervjuerna läste studenterna sin tredje termin och de hade precis avslutat en 10 veckors kurs i naturvetenskap. Forskningsprojektet följer Vetenskapsrådet (2017) forskningsetiska principer. Det har varit frivilligt att delta i intervjuerna och skriftligt samtycke har samlats in från deltagande lärarstudenter. För frågeställning ett har analyserna guidats av Deweys teori om erfarande, därigenom har lärarstudenternas beskrivningar av upplevelser och uppfattningar som inkluderar känslor i relation till biologisk mångfald tematiserats (Braun & Clarke 2006). Därefter har de analyserats utifrån teman som baserats på de känslor som studenterna uttrycker. I analysen framkom flera teman; oro, uppgivenhet, frustration, ilska, brist på tillit, ansvar, tillit och hopp. Frågeställning två har analyserats utifrån de fyra moment i undervisningen som beskrivs som betydelsefulla av Weelie och Wals (2002); 1) om olika resursdilemman som har betydelse för biologisk mångfald, 2) att kunna uppleva och observera biologisk mångfald, 3) att kritiskt granska den begreppsliga användningen av biologisk mångfald och 4) att hantera värderingar som beskriver biologisk mångfald (Weelie och Wals 2002).

3 Resultat

Utifrån den första frågeställningen, hur lärarstudenter upplever förlusten av biologisk mångfald, framkom olika känslor som oro, frustration, ilska, uppgivenhet, ansvar och tillit. Dessa olika känslor riktas dels mot studenternas privata framtid, nutid och dåtid, dels mot mer universella skeenden. Känslor som *oro* och *uppgivenhet* riktas mot hur förlusten av biologisk mångfald kan komma att påverka studenternas egen framtid och på vilka sätt andra människors handlingar kan komma att ha betydelse för den egna framtiden. Känslor som *frustration* riktas exempelvis mot studenternas tidigare utbildningar eftersom de menar att de inte har fått tillräckliga kunskaper om allvaret i situationen. *Ansvar* handlar om att de själva som blivande lärare, som privatpersoner och som samhällsmedborgare har ett stort ansvar, nu och i framtiden. *Oro och uppgivenhet* är också känslor som riktas gentemot universella skeenden, som oro för människans existens och för förlusten av arter och ekosystem på jorden. Andra känslor som *frustration* och *ilska* riktas mot politiker och media. Dessa känslor handlar om att något borde ha gjorts tidigare, att ekonomin tillåts vara styrande.

I resultat av lärarstudenternas idéer kring undervisning framkommer flera förslag som handlar om *resursdilemman*, för att hantera sådana dilemman med yngre elever uttrycker studenterna flera olika krav, resursdilemman behöver vara konkreta, finnas i närområdet och beröra eleverna. De resursdilemman som beskrivs tar utgångspunkt i olika mänskliga intressen som kan relateras till ekonomiska, etiska och sociala perspektiv. Studenterna lyfter också vikten av att möjliggöra så att eleverna får *uppleva naturen och olika typer* av natur. I samband med att besöka olika naturtyper menar flera studenter också att eleverna ska *kunna göra något som har positiv betydelse för biologisk mångfald*, ”att man kan göra bihotell eller man kan göra fröbomber och så vidare”. I intervjuerna uttrycker studenterna också vikten av att hantera olika *värderingar* som kan vara en del av undervisning om biologisk mångfald. I studenternas beskrivningar framkommer dock att de inte vill att eleverna ska ha vilka värderingar som helst utan målet är att eleverna skall respektera jordklotet och alla organismer som finns på planeten. Vid flera tillfällen lyfter studenterna vikten av att tala om biologisk mångfald men ingen student uttrycker på ett tydligt sätt att det finns ett värde i att eleverna har förståelse för innebörden i begreppet biologisk mångfald. Snarare uttrycker studenterna att de vill att eleverna blir medvetna och utvecklar kunskaper om konsekvenserna av förlusten av biologisk mångfald. Här handlar det mer om att skapa en medvetenhet om betydelsen av förlusten av biologisk mångfald och mindre om att kritiskt granska den begreppsliga användningen.

4. Diskussion och slutsatser

I likhet med den studie som genomfördes av Ojala et al. (2021) framkommer i denna studie att negativa effekter på miljön orsakar många olika känslor hos lärarstudenterna, bland annat frustration över tidigare skolgång. Vikten av att uppmärksamma frågor om miljö och förlusten av biologisk mångfald i olika utbildningar blir på så sätt åter tydlig (Lindemann-Matthies et al. 2009). I den här studien lyfter flera studenter olika idéer som handlar om *resursdilemman* i relation till biologisk mångfald och hur sådana dilemman kan vara en del av undervisningen med yngre elever. Wang et al (2022) visar i deras studie hur forskning under 20 år haft ett relativt stort fokus på argumentation och sociala frågor som är relaterade till naturvetenskap. Ett sådant forskningsfokus kan ha haft inverkan på lärarstudenternas utbildning och därmed även påverkat lärarstudenternas uppfattningar om undervisning. De resursdilemman som lärarstudenterna beskriver tar utgångspunkt i olika mänskliga intressen som kan relateras till ekonomiska, etiska och sociala perspektiv. Andra moment som naturupplevelser betonas som viktigt av studenterna vilket även beskrivits som betydelsefullt av tidigare studier (Magntorn och Helldén, 2005; Manni et al., 2017).

Sammanfattningsvis bidrar studien med kunskaper om lärarstudenters upplevelser av hoten mot och förlusten av biologisk mångfald vilket kan ha betydelse för hur lärarutbildningar implementerar studier som tillåter känslor, upplevelser och värderingar i undervisning om komplexa skeenden som förlusten av biologisk mångfald. Studien bidrar även med idéer från studenter om hur undervisning i och om biologisk mångfald kan planeras och genomföras på ett sådant sätt att elever i årskurserna förskoleklass och grundskolans tidigare år kan erbjudas en ökad förståelse för ekologi och biologisk mångfald.

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PRESERVICE TEACHERS GROUP TALK WHILE PROGRAMMING MICRO:BIT

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Abstract

This study investigates preservice teachers' (PSTs') talk and computational thinking practices while collaboratively working in groups of 2-3 PSTs. The task is to develop a prototype for a technology aimed at solving a problem in sustainable development and includes programming micro:bits. The PSTs' work and talk have been analysed from video observations. During programming algorithm design, debugging and tinkering dominate the CT practices employed by the PSTs. The talk is dominated by monologue, in the form of teaching, confirmatory and cumulative talk, rather than exploratory talk during problem-solving. We find that the levels of experience with programming between the group members seem to greatly influence the dialogue. And we suggest that in order for PSTs to learn by engaging in exploratory talk, this must be especially accommodated for.

1 Introduction

Computational thinking (CT) is a form of problem-solving using strategies similar to those applied by computer scientists (Wing, 2006). However, applied in other contexts than programming, CT is considered a 21st century skill useful to everyone. For this reason, CT is now part of compulsory education in many countries (Bocconi et al., 2022). CT is a new topic in teacher education as well as in school and preservice teachers (PSTs) today did not learn CT and programming in school. In their teacher education, they need to learn both CT and programming, as well as how to teach these competencies to pupils. Debugging is a key element to CT and programming, in which errors must be detected and fixed. Teachers will need to both aid pupils in this and teach them strategies for debugging (McCauley et al., 2008). As this is challenging for PSTs who are new programmers, they need to learn systematic debugging in order to teach programming to pupils (Kim et al., 2018).

In this study, we investigate how to support PSTs in their development of CT skills and present preliminary findings based on two student groups. The PSTs are given a task that could be given to pupils, learning to create and program a prototype for technology aimed at sustainable development. We aim to understand more about how this type of teaching provides learning opportunities for CT in the classroom. We analyse what aspects of CT the students are employing while collaboratively solving this task and how they talk while problem-solving.

2 Theoretical backgrounds

There are multiple definitions of computational thinking in the literature (e.g. Shute et al., 2017) with different emphases but many common elements. Shute et al. (2017) identify six CT facets which are decomposition, abstraction, algorithms, debugging, iteration, and generalisation. Barefoot Computing (2023) additionally introduce computational thinking approaches for practicing computational thinking, which are tinkering (trying something out to understand how it works), creating, debugging, persevering, and collaborating. Debugging is as such understood as both a facet of CT, and a way to practice CT.

Small-group discussions may provide opportunities for PSTs to express their understanding and test their ideas with their peers. Collaborative problem solving may therefore provide a higher learning gain than individual work for the students and be fruitful to their development of CT debugging skills. Bungum et al. (2018) identified four categories of student talk in small-group discussion adapted from the framework developed by Mercer (2004). Their framework consists of *independent statements, confirmatory talk, cumulative talk, and exploratory talk* (Bungum et al., 2018). Independent statements and confirmatory talk do not evolve the students understanding and new knowledge is not created. Cumulative and exploratory talk, where students build on each other's statements, is productive in the sense that their understanding is evolved. During programming, the two latter categories are expected to be essential in debugging activities, as students strive to test their hypotheses and develop causal models for the bugs.

3 Research methods

Context and data collection

The video was analysed qualitatively by coding based on CT employed by the students and the group dialogue to discover the characteristics of the group work. Then, qualitative description of the dominating aspects were made. For the dialogue, the categories developed by Bungum et al. (2018) were used in addition to monologue which was used to describe instances where one of the students in the group was talking and response was not expected. For each 5 minute interval, a total of four points were distributed between the categories depending on their dominance. For CT, the facets developed by Shute et al. (2017) were used in addition to tinkering (Barefoot Computing, 2023). Notes were made of what CT facets or practices were employed by the students, disregarding the emphasis put on each of them within each 5-minute interval. The categories used for analysis are presented in Table 1.

Data analysis

The video was analysed qualitatively by coding based on CT employed by the students and the group dialogue to discover the characteristics of the group work. Then, qualitative description of the dominating aspects were made. For the dialogue, the categories developed by Bungum et al. (2018) were used in addition to *monologue* which was used to describe instances where one of the students in the group was talking and response was not expected. For each 5 minute interval, a total of four points were distributed between the categories depending on their dominance. For CT, the facets developed by Shute et al. (2017) were used in addition to *tinkering* (Barefoot Computing, 2023). Notes were made of what CT facets or practices were employed by the students, disregarding the emphasis put on each of them within each 5-minute interval. The categories used for analysis are presented in Table 1.

Table 1*: Categories used in the analysis. Student talk adapted from (Bungum et al., 2018), computational thinking based on Shute et al. (2017) and Barefoot Computing (2023).*

Student talk	**Computational thinking**
Monologue	Decomposition
Independent statements	Abstraction
Confirmatory talk	Algorithms

Cumulative talk	Debugging
Exploratory talk	Iteration
	Generalisation
	Tinkering

4 Results

When analysing the types of student talk, there were clear similarities as well as differences between the two groups. In both groups cumulative and confirmatory talk were dominant. Exploratory talk was largely absent, showing that the students generally do not question each other's ideas, but encourage these and build upon them. The two groups differ largely in that the Duo, monologue is majorly present as one of the students continuously functions as a master teaching the other student programming. This teaching is not domineering and the receiver contributes in the conversation when appropriate. The talk in the Trio has more independent statements. Here, two students are more experienced than the third, who struggle to participate in the collaborative talk. This appears to split the group and generate independent statements between the pair and the third student.

When analysing the student talk for CT we find that debugging dominates in the Duo, as expected, whereas in the Trio algorithms most used. Both groups employ tinkering as a method of working. The Duo managed to have a steady progression throughout and to create a product in line with their plan. In their debugging, they continuously referred to their original plan. The Trio mainly discussed what to make and how to design this, rather than making a code and trying it out. This group spent much time googling algorithms online. The Trio took a long time before managing to create a functioning code, but still managed to create a working result in the end.

5 Discussion and conclusion

It is an interesting feature that both groups' talk is strongly influenced by the students' differing levels of experience. In the Duo, this leads to a master and apprentice relationship which appears fruitful both in solving the task and practicing CT. In the Trio, however, this difference caused breaks in the student talk in terms of independent statements, which is non-productive (Bungum et al., 2018). This seems to inhibit the learning for all parties and group constellation appears to be important for student learning in this type of work. The Duo, which has the most constructive dialogue, was also focused on debugging, thereby practising a key CT competence for PSTs (Kim et al., 2018).

CT is a form of problem-solving and this is one of the reasons for including CT in education (Bocconi et al., 2022) and exploratory talk is central to creative problem-solving. The general lack of exploratory talk in both groups indicates that this does not happen spontaneously. In order for programming tasks to be arenas for practising problem-solving as a 21st century skill, exploratory talk needs to be encouraged and further accommodated for.

Our findings indicate that the context of inventing prototypes for technology provides learning opportunities for CT in the classroom through collaborative problem-solving. However, to achieve the desired learning outcome, the students' experience levels should be comparable, so that everyone can contribute to the talk and the students need to be given tools to turn the student talk towards more cumulative and especially exploratory talk.

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THE PEDAGOGICLA POTENTIALS OF WONDER FOR SUPPORTING STUDENTS' ENGAGEMENT AND LEARNING IN SCIENCE

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Abstract

In this project, we investigate the pedagogical potential of making room for wonder in science teaching. Focusing on grades 4-6 (ages 10-12), we use formative interventions (Penuel 2014) where researchers and teachers collaboratively engage in iterative cycles of team meetings and classroom implementations to create teaching models for making room for wonder in science teaching. Our research question is: What emanate as important aspects for making room for wonder in school science context? Field notes from observations of the first intervention cycle with a 4th-grade class were analysed through content analysis, guided by theoretical frameworks of teaching for wonder (Trotman, 2014; Wolbert and Schinkel, 2021), and academic emotions (Pekrun, 2014). The results show that achievement emotions, linked to success or frustration during independent explorations prevailed among students' expressed emotions during science class. Expressions of wonder, an epistemic emotion, were associated with lesson structures that provided sensory experiences and allowed students time to deeply engage with unfamiliar phenomena that for them lacked an immediate explanation.

Introduction

Worldwide, studies show that students' interest in science declines with increasing school years. This trend has been attributed to an impersonal, transmissive, and fact-oriented approach to teaching science, rather than a genuine loss of interest in science per se (Bonnette, et al., 2019; Potvin & Hasni, 2014). This project focuses on exploring the pedagogical potential of making room for wonder in the science classroom posing that this emotion could invite students to a more meaningful engagement with science. The importance of wonder for engagement in the scientific process is frequently described by leading scientists (e.g. Dawkins, 1998) and has repeatedly been hypothesised to be of particular interest in relation to students' engagement in, and learning of, science (Gottlieb et al., 2018; Hadzigeorgiou & Schulz, 2014). However, there are currently few empirical studies on how teachers may shape their science teaching to make room for wonder. In addition, science curricula today lack both guiding instructions and motivation for science teachers to make room for emotions (Fortus et al., 2022). This project is focused on science teaching in grade 4-6 (ages 10-12), where students typically develop a sense of whether science is 'for them' or not (Potvin & Hasni, 2014). Our research question is: What emanate as important aspects for making room for wonder in school science context?

Epistemic emotions and the concept of wonder

Wonder is classified as an epistemic emotion, falling within one of the four categories of academic emotions — epistemic, social, topic, and achievement emotions (Pekrun, 2014). Epistemic emotions are emotions directly related to cognitive activities and challenges, such as learning, problem solving and engagement in complex information. Epistemic emotions encompass a spectrum of affective experiences, including surprise, curiosity, wonder, and awe (Hadzigeorgiou & Schulz, 2014; Valdesolo et al., 2017). The sense of wonder is specifically triggered by objects and events that in a profound way make us aware of what we do not know and cannot explain, and forces us to question our worldviews (Candiotto, 2019). Therefore it has been hypothesised to be unique for motivating students to engage in school science (Dewey, 1910/1995, Valdesolo et al., 2017, Wolbert & Schinkel, 2020), open for an emotional relationship with nature and science content knowledge (Hadzigeorgiou & Schulz, 2014) and foster a more accurate understanding of how science works (Gottlieb et al., 2018)

How do we make room for wonder in school science?

Although there are many theoretically grounded arguments for including wonder in science teaching, empirical studies on the pedagogical potentials of wonder and how teachers can make room for it in science class, are still few. Our project draws on results from three available school-based studies that aim to explore the pedagogical potentials of wonder; Hadzigeorgiou (2012) describe a classroom intervention in 9th grade physics education, Gilbert & Byers (2017) used wonder as a pedagogical tool to help future elementary teachers overcome negative associations with science, and our own formative intervention in 7th grade explored students wonder in relation to evolutionary concepts (Sundberg & Andersson, 2023). Together these studies show that articulating wonder and its place in the scientific endeavor provides important insights and context for the students' evolving relationship with science and scientific thinking. Also, the studies indicate that the pedagogical potentials of wonder argued for in theory can be translated into classroom practice.

Theoretical background and research method

We use formative interventions, a form of collective learning, where stakeholders of different professions together construct new ideas and concepts that the participants could not develop on their own (Penuel 2014). Formative interventions draw on the theory of Expansive learning (Engeström & Sannino, 2010) which has a dual aim: to gain new knowledge important for researchers, and to make way for participants' agency. In our case researchers and teachers collaborate in teams to create teaching models for making room for wonder in science teaching. This is accomplished through iterative cycles of team meetings (workshops, lessons planning, evaluations) and implementations in the science classroom.

Data collection and participants

Our empirical data are derived from the initial intervention cycle conducted in one of the participating schools. During team meetings, the concepts of wonder and epistemic emotions were discussed in relation to theoretical frameworks of teaching and learning with wonder by Trotman (2014) and Wolbert and Schinkel (2021). Guided by the teachers' suggestions, the first intervention cycle was carried out in a grade 4 class and structured to include: I) an introductory lesson where the concept 'lesson emotions', i.e., emotions commonly experienced during class, was discussed with the students, II) elements of unpredictability and encouragement of students' independent explorations during science class, and III) an engaging classroom atmosphere during science class. Team meetings involving two or three researchers and two elementary school teachers were documented through audio recordings. Classroom observations were documented through field notes and photos. Data was analysed through content analysis, employing an abductive approach guided by the theoretical frameworks of teaching for wonder (Trotman, 2014; Wolbert & Schinkel, 2021), and theoretical perspectives on academic emotions (Pekrun, 2014).

Results

In the introductory lesson, the students collaboratively identified a spectrum of academic emotions that they had experienced during lessons. Primarily, these emotions were categorised as social emotions, including anger, disappointment, and happiness, with fewer references to topic emotions and limited mentions of epistemic and achievement emotions. During science class, the most prevalent emotion expressed by students was achievement emotions - manifestations of success or frustration stemming from challenges in handling equipment during independent explorations. Expressions of wonder occured during students' encounters with an optical illusion, observations through a stereo microscope and physical encounters with air pressure and a worm. Important aspects for making room for wonder during these activities were sensory encounters, time, and agency. Students expressed wonder when provided with occasions to physically manipulate materials combined with time to absorb and reflect on new sensory encounters. This reflective time could be planned by the teacher or created by the students themselves by withdrawing from ongoing activities, thereby also fostering agency. The teacher also promoted agency by providing tools, such as stereo microscopes, that students could manage on their own, and by allowing variations in the investigation process.

Discussion and conclusion

Our results indicate that making room for wonder in the science classroom, based on theoretical frameworks (Trotman (2014; Wolbert and Schinkel, 2021) makes room for a wide range of emotions, thus inviting students to a more meaningful engagement with science (cf. Gottlieb et al., 2018; Hadzigeorgiou & Schulz, 2014). Notably, in the instances where wonder was expressed, all were associated with a lesson structure that provided sensory experiences and allowed students time, or to find time, to engage deeply with an unfamiliar phenomenon that for them lacked an immediate explanation. These outcomes will be further explored in our longitudinal project.

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THE ROLE OF WONDER IN SCIENCE PRACTISES. A DELPHI STUDY OF DIFFERENT STAKEHOLDERS' VIEWS

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Abstract

Many different emotions are described to influence students' engagement and learning. In this study we focus on wonder because this emotion is, according to the literature, of particular interest in relation to engagement in the scientific work process. When transforming scholarly science to school science different types of knowledge and metacognitive attributes might be lost in this transposition process. However, no studies have yet focused on describing and comparing the perceptions of wonder in science among stakeholders. We used a Delphi study to examine views on the role of wonder in science practices, and science teaching from a range of important stakeholders of different areas of science and science teaching: scientists, science curriculum developers, and science teacher educators. Our findings show no major differences between the expert groups. All respondents were positive towards including wonder in teaching and their suggestions for content and lesson structures that make room for wonder in science education were very similar.

1 Introduction

In the literature many different emotions are described to influence students' engagement and learning (Valdesolo et al., 2017). The sense of wonder is, according to this literature, of particular interest in relation to students' engagement in, and learning of, science. Wonder is a so-called epistemic emotion that is triggered by objects and events that in a profound way make us aware of what we do not know and cannot explain (Candiotto, 2019; Paulson et al., 2021), and particularly relevant for scientists (Cuzzolino, 2021). Wonder might be triggered by various sorts of objects; a star filled night sky, a sound, an idea, or a work of art. Regardless of what is triggering wonder, the emotion is defined by how it forces us to question our worldviews, stretch our minds and how it can evoke learning. One of the aims of this project is to inform teachers and curriculum developers with empirically based knowledge of the pedagogical potentials and limitations of science teaching that makes room for wonder. We use a Delphi study to examine views on the role of wonder in science practices, from a range of important stakeholders of different areas of science and science education: scientists, science curriculum developers, and science teacher educators and researchers in science education. Our research question is:

How do scientists, science curriculum developers and science teacher educators and researchers in science education, position wonder in relation to their area of expertise and in science teaching and learning?

2 Theoretical backgrounds

A need to include emotions into science teaching

In this project we focus on examining the pedagogical potential of wonder posing that this emotion is an 'idea-about-science', that could invite students to a meaningful engagement with science. The concept 'Nature of Science' is commonly used in educational contexts to describe 'ideas-about-science' that need to be included in science teaching, i.e., methods, values and assumptions that are shared among the members of the academic scientific community (Osborne et al., 2003). However, unlike most content of science, for which there is established consensus, there seems to be much less consensus about the essential elements that should be included in the contemporary school science curriculum. Particularly interesting for this project is that emotions like wonder have been hypothesised to be unique for motivating students to explain and explore the physical world (e.g., Valdesolo et al., 2017), and for fostering a more accurate understanding of how science works (Gottlieb et al., 2018).

Is wonder lost in transposition?

When scholarly science is reshaped into "teachable" science in school contexts, it must pass from the scientific practices through a range of different communities, such as the scientific publication system, educational authorities (policy makers) and teachers, before reaching the students. At each step the members of the community will adapt the knowledge to fit their social and epistemological frameworks of what counts as science and scientific. According to the theory of didactic transposition (Chevallard, 1989; Lombard & Weiss, 2018) different types of knowledge characteristically thrive or are lost in this process of percolating from research to school practice. Lombard and Weiss, report that metacognitive attributes that characterise scientific understanding, such as methodology, social practice, social norms, and worldviews risk being lost in such a transposition process. One example of where wonder might be lost in the transposition process is when national standards for school science are developed. According to Fortus et al. (2022), many national science education standards focus almost entirely on prescribing the conceptual knowledge and science practices, and do only include little, if any, reference to the affective characteristics that need to be fostered in parallel. The above-mentioned studies hint at wonder being lost during different stages of the transposition process. However, no studies have yet focused on describing and comparing the perceptions of wonder in science among stakeholders within science practices involved in the process to reveal if, and where, wonder is lost. Hence, a Delphi study is performed to examine views on the role of wonder in science practices, and science education from a range of important stakeholders of different areas of science and science education: scientists, science curriculum developers, and science teacher educators.

3 Research methods

The Delphi Study

Delphi studies have been used in science education research to advise curriculum developers, textbook authors, and teachers about how to renew content to align with contemporary science research (Hallström, et al., 2023; Kvello & Gericke, 2021) and to identify key ideas about the nature of science (Osborne et al., 2003). A key characteristic of the method is that it avoids direct confrontation of the experts allowing them to make independent judgments and gradually form an opinion. In this project, we construct our Delphi study following the set-up of Osborne et al. (2003). We include participants selected from the communities of experts involved in the transposition process. We approached a) 32 senior researchers in biology, chemistry or physics, b) 10 science curriculum developers with experience from science curriculum development, and c) 24 science teacher educators and researchers in science education with experience of teaching student teachers (grade 4-6).

Avella (2016) discusses the number of participants and note that panels typically seem to be between 10-100 participants within two or three expert groups. The response rates of the two rounds are presented in table below, even though the numbers decreased, the total number of participants is still in line with Avella (2016).

	Approached	**Round 1**	**Round 2**
Scientists	32	5	2
Curriculum developers	10	4	4
Science teacher educators and researchers in science education	24	14	9
	66	23	15

In Round 1 we used a 'brainstorming' open ended questionnaire were we briefly introduce how wonder is hypothesised to be a driving force for the scientific process as well as for students' learning and then ask the respondents about a) their experiences of wonder in relation to their work and engagement with science and scientific questions, b) their views on the role for wonder in science teaching and learning and c) their recommendations for teachers who wish to make room for wonder in school science. The analysis process started after Round 1 where answers to the six open questions were analysed through an inductive thematic analysis to identify main themes and sub-themes capturing different ideas and perceptions of wonder in science activities. The sub-themes were used to construct statements for a new questionnaire, which was used to collect data in round 2. In the second phase of the analysis, we looked for similarities and differences in the responses regarding the statements.

4 Results

All responding participants were in favour of making room for wonder in school science. Their associations to the term wonder were described through 1) synonyms, 2) examples of what arouses wonder, and 3) what effects it can lead to. All participants could relate wonder to their own professional practice, seeing wonder as an enthusiastic driving force and/or as a direction setter. Some researchers, both in science and in science education, also added that wonder is embedded in the research process. All participants considered wonder as an important part of students' learning. However, they emphasised the importance of a balance between building knowledge and wondering through experience.

When participants were asked to describe how to design teaching for wonder, practical, non-assessment elements were high on the list. Additional descriptions included providing space in the form of time and opening to questions, communication, and reflection. All three stakeholder groups agreed with the categories formed in round 1. Participants were also asked to give examples of what teaching that evokes wonder could include, which provided a variety of concrete examples categorised under three main categories 1) breath-taking facts 2) the unexpected and undiscovered and 3) aesthetic and affective experiences. Highlighted potential challenges of including wonder in science education were:

- The planned lesson not unfolding as intended, potentially resulting in insufficient time for the key content.
- School demands for assessing student's performance can hinder the realization of wonder.
- Teacher subject knowledge stands as a crucial prerequisite for fostering wonder in science teaching.

In round 2, however, most participants emphasized that these issues can be resolved with careful planning and that the curriculum offers possibilities to make room for wonder.

4 Discussion and conclusion

Our findings do not indicate that wonder is lost in transposition. There were no major differences in views between the three stakeholder groups. All respondents were positive towards including wonder in teaching and their suggestions for content and work forms to arouse wonder in science education were very similar. Further research is needed to explore how wonder is embedded in the research process and introduced to the students, and hence inspire a renewal of science teaching.

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PÆDAGOGISK PERSONALES VURDERING AF SCIENCEPRAKSISSER OG LEGESTEMNINGER I PRAKSISSITUATIONER I DANSKE DAGTILBUD

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Abstract

Science in Early Childhood Education and Care (ECEC) is drawing more attention in these years. Especially in the methodological approach to inquiry in ECEC. In the project Science and Technology in Child height we aim to combine an inquiry approach to science with a focus on children's play.

In an in-service professional development course, the ECEC personnel is introduced to science practices and play qualities. This study present results two science activities analyzed by ECEC personnel using science practices and play qualities.

The results show that ECEC personnel is capable of distinguishing between science practices and play qualities from the two contexts and thereby use these analytical tolls. However, results also show that despite agreement on the most common science practices, the ECEC personnel recognize very different numbers of science practices. There is an indication in the results that more science practices recognized is equal to more play qualities recognized. This calls for further analyses of the connection between science practices and play qualities and for more clarification of the usage of science practices as analytical tool for practice.

1 Introduktion

Der har været meget fokus på den undersøgende tilgang til science for børn i dagtilbud. Ofte har disse undersøgende tilgange taget udgangspunkt i Inquiry Based Science Education (IBSE) (se f.eks. Minner et al., 2010). Der findes mange forskellige modeller for IBSE, men fælles er at de ofte beskriver undersøgelserne i generelle termer, der kan være vanskelige at omsætte til praksis. I den internationale litteratur ses et skift i retning af at tale om praksisser frem for undersøgende (Crawford, 2014; Furtak, Seidel, Iverson, & Briggs, 2012; Haug, Sørborg, Mork, Frøyland, 2021; Rönnebeck, Bernholt, & Ropohl, 2016). Således er praksisserne en udspecificering af de centrale handlinger, der kendetegner en undersøgende tilgang. På denne måde bliver undersøgelserne omsat til konkrete handlinger.

Ligeledes står leg centralt i det fællespædagogiske grundlag i Den styrkede pædagogiske læreplan (Børne- og Socialministeriet, 2018) for de danske dagtilbud. Det er således et mål, at der etableres pædagogiske læringsmiljøer med legende og undersøgende tilgange til natur og naturfænomener. Begrebet legestemninger (Skovbjerg & Jørgensen, 2021) kan hjælpe med at identificere, hvad det legende kan være.

Forsknings- og udviklingsprojektet *Science og teknologi i børnehøjde* er organiseret omkring kompetenceudviklingsforløb for pædagogisk personale i dagtilbud, således de understøttes i at alle børn i en dansk kommunes dagtilbud (børn i alderen 0-6 år) udvikler en legende, undersøgende tilgang til natur og naturfænomener, herunder også teknologi.

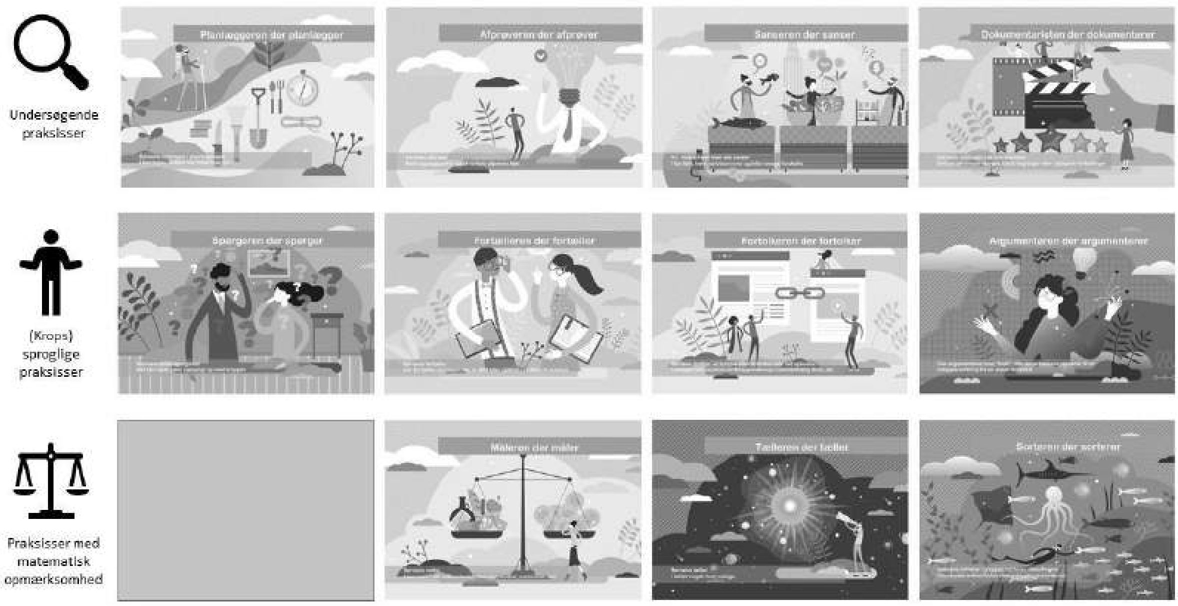
Som en del af det pædagogiske personales kompetenceudvikling bliver de introduceret til sciencepraksisser (Forfattere, 2023) og legestemninger (Skovbjerg & Jørgensen, 2021).

I projektet ser vi bl.a. på det pædagogiske personales vurderinger af tilstedeværelsen af sciencepraksisser og legekvaliteter i praksissituationer og søger at besvare forskningsspørgsmålet

Hvilke sciencepraksisser og legestemninger vurderer det pædagogisk personale som tilstedeværende i to praksissituationer?

2 Sciencepraksisser og legestemninger

De omtalte tilgange til science beskriver alle sciencepraksisser i en skolekontekst. Dette er ikke den samme kontekst som for børn i 0-6-årsalderen og der er derfor brug for endnu en konkretisering af sciencepraksisserne og for at sammenholde dem med legestemninger. Johnston (2013) kommer med et bud på en omskrivning af sciencepraksisser fra skolekontekst til en dagtilbudskontekst. Dette bliver dog stadig ikke helt konkretiseret og det fremkommer afkoblet fra legen. I projektet Science og Teknologi i Børnehøjde tager vi udgangspunkt i et sciencepraksssisser, der er udviklet i samarbejde med pædagogisk personale i dagtilbud (forfatter, 2023) og med inspiration fra legestemninger (Skovbjerg & Jørgensen, 2021). I alt indeholder denne tilgang til science 11 sciencepraksisser i tre forskellige dimensioner (se figur 1).



Figur 1: De 11 sciencepraksisser inddelt i 3 katergorier (Efter forfattere, 2023)

Begrebet sciencepraksisser bruges om de handlinger, som udøves i forbindelse med en sciencesituation.

Hver af disse sciencepraksisser er et redskab til at få blik for, hvilke handlinger der kan styrke en undersøgende tilgang til natur og naturfænomener.

Begrebet legestemninger (Skovbjerg & Jørgensen, 2021) kan hjælpe med at identificere, hvad det legende kan være. Legekvaliteter er teoretisk forankret i Skovbjergs (2021) stemningsperspektiv på leg.

I projektet Science og Teknologi i Børnehøjde fokuseres på de fire legestemninger hengiven, euroforisk, højspændt og opspændt med henblik på at etablerer science-orienterede læringsmiljøer, hvor leg er grundlæggende. Det er vigtigt at have blik for hvilke legemedier, der er til rådighed, og hvilke legestemninger der understøttes eller udgrænses i science situationer med science praksisser.

Legestemninger er et redskab til blandt andet at få blik for, hvilke handlinger der kan styrke legens position i en undersøgende i en tilgang til natur og naturfænomener.

Det er det pædagogiske personales forståelse og anvendelse af disse sciencepraksisser og legestemninger i forhold til deres egen praksis, der undersøges i projektet.

3 Undersøgelsesmetode

I projektet er der udviklet en online platform, der bliver anvendt af det pædagogiske personale som en e-læringsressource. Via tekst, videoer og billeder introduceres man til projektet og dets forskellige tematikker. Tema 1 omhandler undersøgende tilgange i hverdagssituationer, med fokus på sciencepraksisser, mens tema 2 har fokus på de fire legestemninger. Som en del af materialet indgår to korte videoer, som viser hver deres praksissituation.

Video 1 indeholderen praksissituation, hvor ét vuggestuebarn og én pædagog leger med forstørrelsesglas og ser på frugt og blomster i forstørrelsesglasset.

Video 2 indeholder en praksissituation fra en legeplads, hvor mange børnehavebørn og pædagogiske personale leger med rør og bolde, som de bl.a. laver kuglebaner af. Desuden sidder et par børn og det pædagogiske personale ved et bord og undersøger magneter.

Der er således forskel på kompleksitet i den kontekst, der vises i videoerne.

Det pædagogiske personale tilkendegiver digitalt hvilke af de 11 sciencepraksisser og fire legestemninger de vurderer som tilstedeværende i hver af de to praksissituationer.

4 Foreløbige resultater

Der er stor enighed blandt det pædagogiske personale ift. hvilke sciencepraksisser, de vurderer tilstedeværende i video 1, idet 93% (n=193) angiver *Afprøveren der afprøver* og 90% også angiver *Sanseren der sanser,* som tilstedeværende. Enigheden blandt det pædagogiske personale forsætter endvidere, ift. angivelsen af hvilke legestemninger, der er til stede i praksissituationen, idet 98% (N= 111) angiver den *Hengiven* legestemning, som tilstedeværende.

Ved praksissituationen som vises i video 2, er der ikke lige så stor enighed blandt det pædagogiske personale om, hvilke sciencepraksisser, som er til stede. Her er hele 7 sciencepraksisser blevet vurderet af over 100 af de i alt 181 respondenter. Tydeligst er igen *Afprøveren der afprøver* med 92% tilkendegivelser, dernæst *Sanseren der sanser* med 76%

tilkendegivelser, *Spørgeren der spørger* blev set af 70%, derefter ligger *Måleren der måler* og *Planlæggeren der planlægger* nogenlunde ens med henholdsvis 64% og 63% tilkendegivelser, *Fortolkeren der fortolker* identificeres af 61% og slutteligt har *Fortælleren der fortæller* fået 53% tilkendegivelser.

På samme måde er der også stor spredning ift. hvilke legestemninger, som er til stede i praksissituationen, som vises i video 2. Ud afbesvarelserne (n=103), har 72% tilkendegivet den *Hengiven* legestemning, 51% har tilkendegivet den *Opspændte* legestemning, 47% har tilkendegivet den *Højspændte*, mens den *Euroforiske* legestemning er vurderet tilstedeværende af 37% respondenter.

Der viser sig således et større spænd i antallet af identificerede sciencepraksisser legestemninger fra den mindre komplekse kontekst i video 1 til den mere komplekse kontekst i video 2.

4 Diskussion

Resultaterne viser, at det pædagogiske personale kan bruge siencepraksisser og legestemninger som analyseværktøj. Men resultaterne viser også at der er en spredning på hvorledes sciencepraksisserne og legestemningerne bliver brugt. Der er således sket en genfortolkning fra dét som det pædagogiske personale er blevet introduceret til på workshops og det som de tilkendegiver at se i praksis.

På tværs af de to praksissituationer, er det interessant at det pædagogiske personale både vurderer at der er færre sciencepraksisser og færre legestemninger ved praksissituationen i video nr. 1 end praksissituation i video 2. Årsagen kan ikke identificeres i dette studie, men kan undersøges nærmere.

Hvad end, der er tilfældet giver resultaternes spredning anledning til at understøtte det pædagogiske personales forståelse af begreberne og på baggrund af dette kunne spotte deres tilstedeværelse i forskellige praksissituationer, samt kunne handle på dem. Dette er noget, der bør øves.

De oftest vurderede legestemninger er den *Hengivne* og derefter den *Opspændte* legestemning og den *Højspændte*. Den *Euforiske* legestemning vurderes mindst tilstede i praksissituationen. Undersøgelser viser at pædagogisk personale typisk foretrækker og tilrettelægger situationer der er dommiret af den Hengivne legestemning (Skovbjerg et al. 2022) mens den Euroforiske legestemning udgrænses. Det pædagogiske personales vurdering af legestemninger i praksissituationer afspejler således hvad der ses i praksisfeltet (Skovbjerg et al. 2022) og peger samtidig på et udviklingspotentiale hvor endnu flere legestemninger får omgang med bl.a. sciencesituationer

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READING NONFICTION PICTUREBOOKS IN SCIENCE AS PART OF EDUCATION FOR SUSTAINABLE DEVELOPMENT

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Abstract

Reading is a ubiquitous part of education for sustainable development (ESD) in science, and this study investigates the use of nonfiction picturebooks for young learners in primary school with an emergent understanding of biodiversity. The study is the first part of a collaborative project involving an interdisciplinary approach to literature and science. This part of the study presents a framework and shows an example of an analysis of a nonfiction picturebook (Thin of an Eel). The framework aims to provide a tool for teacher educators, teachers and teacher students to analyse, discuss and develop a collaborative understanding of the potential of nonfiction picturebooks in science classrooms. The framework is based on one analysis tool for nonfiction picturebooks, and a combination of core ideas and learning progression in biology. Based on three categories from our framework (organising knowledge, presenting knowledge, and positioning the reader) we illustrate how qualities of nonfiction picturebooks can facilitate meaning-making in science and reading engagement as part of ESD. Our analysis reveals that the framework has the potential to help teachers, teacher educators and teacher students create awareness about how to understand and evaluate nonfiction picturebooks integrated into reading and science.

1 Introduction

The notion of sustainability highlights the need for interdisciplinary knowledge, aiming to foster active students with different competencies, such as the ability to read about complex environmental challenges. However, interdisciplinary teaching is challenging, because of the need to cross boundaries for pedagogical content knowledge (Leung, 2020). The discipline of Literature and Natural Science has separate epistemic practices that cannot be combined easily, but also, the disciplines complement each other. The mutual dependence is particularly prominent in reading activities for students in primary school. Reading is a ubiquitous part of science, communicating knowledge, creating opportunities to experience wonder and engagement about nature, and constituting one of several skills in inquiry-based learning. However, less attention has been drawn towards the various qualities in picturebooks, and how they can facilitate reading skills and meaning-making in science synchronously. This study is a contribution to the discussion about how to use literature in science education.

Interdisciplinary approaches involving language and science in teaching for sustainable development (SD) encompass various activities and situations revolving around complex problems. In this study, we delineate our investigations into how reading and science can be intertwined for the youngest students in school when reading nonfiction picturebooks involving biodiversity. Our contribution to the field involves two dimensions. First, we propose a framework for interdisciplinary reading as part of teaching about biodiversity. The framework aims to maintain both disciplinary and interdisciplinary skills. We experience a need for such a framework to evaluate, analyse and create a common understanding of picturebooks integrated in science and reading. Second, we exemplify how the framework can be utilised in an analysis of the nonfiction picturebook *Think of an Eel* (1993) by Karen Wallace and Mike Bostock. The chosen book includes various visual and textual strategies to describe the life of the European Eel (*Anguilla anguilla*), its metamorphoses and surrounding ecosystems. As a catadromous fish, the eel is vulnerable to environmental changes. We investigate the following research questions:

1. How can a boundary-crossing framework emphasise qualities for interpreting and utilising nonfiction picturebooks in biology?
2. How can a picture book for children be understood and interpreted in science (biology) and the teaching of nonfiction literature, with an interdisciplinary approach?

2 Theoretical backgrounds

Interdisciplinary teaching is rooted in the ideas of unity and synthesis, evoking a common epistemology on convergence" (Klein, 1990, p. 11). A transition between the multi-, inter- and transdisciplinary entrances to teaching is fluid, and different approaches can facilitate engagement, critical thinking and professional development among students (Drake & Reid, 2020).

Nonfiction picturebooks have become important sources of information, expanding the child reader´s interest. Such books implicate a close relationship between visual and textual modalities and the reader (Hallberg, 1982), and reality. The content of the book is expected to be perceived as true, or at least likely to be true. Reading nonfiction may help students to improve their vocabulary within the academic content areas, and to relate to complex interdisciplinary projects demanding knowledge of various content areas and use multiple ways of thinking (Job & Coleman, 2016).

Science combines various representations as young learners explore and solve problems through reading, writing, talking and practical work (Cervetti et al., 2007). Wonder and creativity are ubiquitous for young learners who are in the process of creating meaning about complex processes (Glăveanu, 2019). Wonder and imagination are stimulated by various experiences, and constructing science knowledge depends upon how children use experiences to negotiate and intertwine them with school topics (Jewitt et al., 2001). Learning biology involves engagement and meaning-making within seven domains; basic needs, growth/lifecycles, classification, living and non-living, plants and animals, structure and function, and offspring/reproduction and inherited traits (Elmesky, 2013). For the youngest learners in school, classification often dominates in activities revolving around exploring plants and animals, and what is living and non-living. Literature plays a prominent role in all parts of this work.

3 Research methods

Our study consists of two parts; first, we propose a framework, aiming to provide a tool for teacher educators and researchers to analyse, discuss and develop collaborative understanding about the potential of nonfiction picturebooks. Also, the framework has the potential to help teachers and teacher students create awareness about how to understand and evaluate nonfiction picturebooks integrated into reading and science. The framework is based upon one analysis tool of nonfiction picturebooks (Goga, 2019), and a combination of core ideas and learning progression in biology (Elmesky, 2013; NGSS, 2020) (figure. 1).

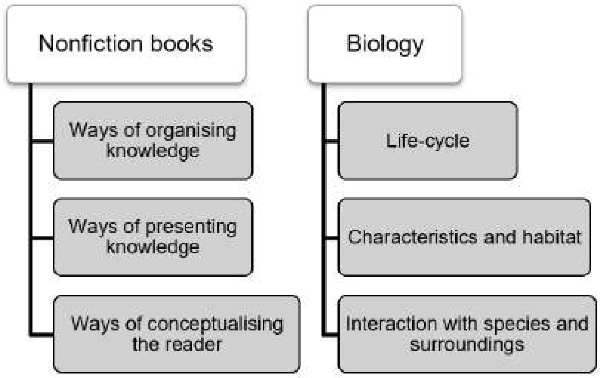

Figure. 1. *Categories from the two disciplines (nonfiction literature and biology) included in the framework developed in the study*

We use our framework in an integrated analysis of the picturebook Think of an Eel. The analysis aims to reveal an example of how the framework can facilitate an integrative understanding of how nonfiction books and meaning-making in science can complement each other.

4 Results and Discussion

The framework developed in the study is presented as a methodological tool, as part of the method chapter. The results include our elaboration of the framework. Based on three of the categories from our framework (organising knowledge, presenting knowledge, and positioning the reader) we illustrate how qualities of nonfiction picturebooks can facilitate meaning-making in science and reading engagement. This can contribute to an awareness of the use of nonfiction literature in science education for teachers, teacher students and teacher educators.

The analysis of the book's organisation of knowledge emphasizes chronological and circular presentation. For example, the lifecycle, movement and transformation of the eel is presented chronologically; from birth to reproduction and death. When it comes to circular organisation, the picturebook encourages the reader to create an emerging understanding of natural science processes without beginning and ending.

The presentation for engagement about the animal includes the dynamics between words and pictures. For example, the pictures demonstrate the appearance of the eel, what it eats and the characteristics of its environment in saltwater and freshwater. The textual descriptions involve combinations of unexpected comparisons (“he slides like a snake”, “he eats like a horse”), aiming to make something less known (the life and characteristics of the eel) more understandable.

The analysis of the book´s potential to position the reader as an active participator focuses on how the combination of various texts and pictures contributes to bridge between scientific and artistic representation. It unites scientific concepts with aesthetic choices. Also, the book constitutes an ecocentric representation, where the ecosystems involving the eel are in the centre, and the human being - the reader - becomes a wondering and interested observer. By studying the eel's way of life as a catadromous fish, the reader is provided an opportunity to be curious about parts of nature. The book calls for a respectful explorer attitude.

Our conclusion emphasizes the need for an interdisciplinary approach based on a dynamic movement between the borders of the disciplines and between a limited focus on subject-specific knowledge and complex issues associated with SD. Anchoring the interdisciplinary work in a nonfiction picturebook that concentrates on something very specific, can enhance opportunities to develop transdisciplinary teaching. While the book about the eel primarily concentrates on a single animal and its life, the conversations revolving around the book must involve a wider sustainable perspective.

Making students engage critically and aesthetically with nonfiction picturebooks may create environmental consciousness. It encourages them to reflect on one´s perceptions and values and take a position in the sustainability discourse. Awareness about how to utilise literature in disciplinary and interdisciplinary situations is important for teachers collaborating on education for SD.

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EXPLORING PRE-SERVICE TEACHERS' VIEWS OF SCIENCE AND SCIENTISTS USING SCIENCE-COMICS

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Abstract

In today's society it is essential to understand and be able to make use of scientific and technological information. This includes knowledge about the nature of science. Learning about the nature of science is a critical component of students' scientific literacy. Teachers attitudes and views about science and scientists is found to affect the student's perception of science. This study, therefore, investigates how pre-service teachers view science and scientists, and how their view reflects their understanding of nature of science. Collected data are science comics drawn by 27 pre-service teachers attending a nature of science course. The data is analyzed with the use of abductive content analysis. The results from this study coincide with previous research on pre-service teachers view of science and scientists, as the comics reflect mostly a stereotypical view. However, the comics also illustrate several aspects of nature of science from how science is conducted, how science is a human and social endeavor and how science impacts and is impacted by the society.

1 Introduction

Science and technology are present in almost every aspect of our life. This means that it is essential to understand and make use of scientific and technological information to make informed decisions (Karisan & Zeidler, 2017). This includes insight into how this knowledge is developed, including the cultural and social context, knowledge about the scientific methods and processes, and the norms and values that underlie it. In other words, knowledge about the nature of science (NOS) (Christidou, Bonoti & Hatzinikita, 2021).

Learning about the nature of science is a critical component in developing students' scientific literacy and how students perceive science and scientists affect their development of scientific literacy (Chionas & Emvalotis, 2021). Abd-El-Khalick and Lederman (2000) emphasizes that it is necessary for teachers to have informed views of NOS to promote it in the classroom. Attitudes about science that teachers bring into their teaching have an important impact on the students' perceptions of science (Reinisch & Krell, 2022).

This study investigates how pre-service teachers view science and scientists, and how their view reflects their understanding of nature of science.

2 Theoretical backgrounds

Nature of science (NOS) describe how the scientific enterprise works, including what science is, how questions are answered, how scientists work, and how science impact and is impacted by the society (McComas & Clough, 2020). Several models present different elements of NOS. Erduran & Dagher (2014) argue for a holistic approach to NOS, focusing on three levels: (1) the knowledge, methods, practice, and aims and values of science, (2) the social aspects of science (how scientists evaluate and work together, and follow the same values and ethos), and (3) how society is impacted by and impacts science through politics, finance and interactions. McComas (2020) presents a set of important NOS-aspects within three main domains: (I) tools, processes, and products of science, (II) the science domain and its limitations and (III) human elements of science.

Despite limited research on pre-service teachers' conception of NOS, studies show that pre-service teachers hold inadequate views about several NOS-aspects (Dorsah, 2020). Drawings are often used to assess perception of science and scientists, often focusing on the scientists' appearance, activities and location (Lamminpää et al., 2023). Although recent studies show that male and female scientists are drawn more equally, studies show that drawings often include stereotypes like male scientists with lab coat and glasses, doing experiments in the laboratory alone surrounded by laboratory equipment, symbols of knowledge (e.g., books) and technology (Reinisch & Krell, 2022). Comics, instead of single pictures, allow the participants to tell multimodal stories, add more information and illustrate different processes (Lamminpää et al., 2023)

3 Research methods

This study employed drawings as it is a useful tool for new insight and for eliciting participants' emotions and attitudes (Hsieh & Tsai, 2018). 27 pre-service teachers attending a nature of science course were purposely selected as research participants. Before the research, they were familiarized with different models of NOS. The research participants were then asked to draw a comic about science. They were told that there is no right or wrong way to draw their comic and that artistic quality was not considered a factor in the study. To ensure anonymity, the comics were not signed and handed in without the researcher watching.

Abductive content analysis method (Jacobsen, 2022) was used to analyze the science comics. The comics were converted into codes which were grouped under categories by the researcher. The categories were then compared with relevant literature and evaluated accordingly.

4 Preliminary results

This section will report some of the preliminary results of the study. 24 of 27 comics illustrate the process of doing scientific research. Most comics illustrate scientific method as linear step-by-step method, but several illustrate it as more complex and cyclical. 4 comics include the process of consulting with colleagues and peer-review. Reviewers are displayed as a group of scientists discussing the scientists' work together. 4 comics include the process of getting finance and how politicians, interest groups and the media affect the money flow.

Several illustrative elements recur in the comics. In 8 comics, a light bulb is used to illustrate an idea or sudden insight. In 2 of the comics the idea comes from reading a book. In 3 comics, explosion is used to illustrate experiments going wrong. Explosions make the researcher either give up in frustration or start again. In fact, several comics show that scientific efforts take time and work. Emotions are displayed to show how failure and rejection is frustrating, but also to show that doing science is fun.

8 comics are located in a laboratory with elements such as test tubes and flasks. 5 comics are located outside in nature, with field equipment and telescopes, or other venues. In the comics that have main characters, 7 comics present teacher and student(s), 3 comics present children, and 15 comics present scientists. Of the scientists, there is only 3 female scientists and 6 of the scientists work alone. The overall image of a scientist is white male with glasses and wearing a lab coat. However, the lab coat is often used inside the laboratory. 9 comics include other characters, such as reviewers and colleagues.

4 Discussion and conclusion

The results from this study coincide with previous research on pre-service teachers views on science and scientists when it comes to the stereotypical appearance of the scientists, how and where they conduct their work (Lamminpää et al., 2023; Reinisch & Krell, 2022). The participants also include several important NOS-aspects in their comics, where most is related to the methods and practices of doing research (Erduran & Dagher, 2014) and the tools, processes, and products of science (McComas, 2020). It seems like the comics are suitable for illustrating such processes.

The comics also illustrate how science knowledge is tentative, self-correcting, and a human and social endeavor (Erduran & Dagher, 2014; McComas, 2020) as several include the process of building new knowledge on existing knowledge, peer-review, and collaboration with colleagues. Even a misconception regarding peer-review is shown, as reviewers sit together and discuss instead of being anonymous. The comics also illustrate aspect related to how science impacts and is impacted by the society (Erduran & Dagher, 2014), when showing the process of financing and societies power to decide what to research.

This study provides novel input that can be used for the design of curriculum materials aimed to support pre-service teachers in developing a more sophisticated understanding of NOS, and the results deliver useful insight for further studies. The study implies that comics can be used as basis for reflection about relevant aspects of NOS. There’s a need for further research on such implementation.

There are some limitations regarding the use of drawing to elicit participants’ conceptions as the graphic abilities may influence the outcome or the participants may draw in alignment with known stereotypes even if their view is more nuanced. Further studies should therefore include other data collection techniques.

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UTRYMME FÖR FLERSPRÅKIGHET? PEDAGOGISKA MÖJLIGHETER OCH BEGRÄNSNINGAR FÖR FLERSPRÅKIGA FÖRHÅLLNINGSSÄTT OCH AKTIVITETER I NO-UNDERVISNINGEN

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Abstract

This paper is a part of the project Spaces for multilingualism (Swedish Research Council, 2021-04155). The aim of the project is to generate knowledge about the pedagogical potentials and limitations of multilingual practices in mathematics and science education. We specifically aim to explore and problematise how multilingual approaches and activities may promote mathematics and science teaching and learning in school years 4–9. The qualitative project is conducted by an interdisciplinary research team that integrates theories from educational research in didactics, sociology and linguistics, including translanguaging theories. The project's four-year period comprises initial exploration of existing pedagogical practices, in four culturally and linguistically diverse schools. The explorative phase is followed by a two-year period of pedagogical interventions.

The presentation will focus on the exploratory phase of the study and the preliminary findings from interviews with students and teachers, workshops where teachers and researchers worked together, and classroom observations, and focus on teachers' and students' use of meaning-making resources in science education, and how students' prior experiences and communicative repertoires are acknowledged as resources in multilingual classroom activities.

Introduktion

Det övergripande syftet med projektet Utrymme för flerspråkighet är att bidra med kunskap om pedagogiska möjligheter och begränsningar för flerspråkiga förhållningssätt och arbetssätt i undervisning och lärande i matematik och naturvetenskap. Både internationellt och nationellt pågår processer av socialt och diskursivt utanförskap inom utbildning som riskerar leda till segregation och motverka inkludering för elever med flerspråkig bakgrund. Därav sker en ständig utveckling av inkluderande, kritiska och transformativa pedagogiska förhållningssätt som bygger på en demokratisk syn på undervisning för flerspråkiga elever. Dessa förhållningssätt är en del av ett paradigmskifte inom forskning om flerspråkighet och utbildning som utmanar enspråkiga ideologier, och ser språket som en rättighet och en resurs som ger röst och handlingskraft åt flerspråkiga elever (t.ex. Alisaari et al., 2019; Cummins & Persad, 2014). I synnerhet har teorier om transspråkande (García & Wei, 2014) resulterat i en betoning av det pedagogiska värdet av att engagera elevers flerspråkiga repertoarer i alla skolämnen. En viktig utgångspunkt i projektet är att vi ser undervisning och lärande som processer för meningsskapande och identitetsutveckling i sociala praktiker. I dessa praktiker spelar läraren en avgörande roll för att främja elevers utveckling av disciplinära kunskaper inom matematik och naturvetenskap samt elevers lärandeidentiteter (Karlsson et al. 2020; Nygård Larsson, 2018; Svensson Källberg, 2018). I flerspråkiga klassrum finns ett komplext samspel mellan olika språk (vardagliga, akademiska och disciplinära/ämnesspråk) samt mellan olika modaliteter. Projektet fokuserar på att tydliggöra detta samspel, både i teori och praktik, och kommer därigenom att ge värdefulla bidrag angående komplexiteten i att utveckla och använda flerspråkiga förhållningssätt och aktiviteter i matematik- och NO-klassrum.

I det här konferensbidraget fokuseras NO-klassrummet och preliminära resultat från den explorativa fasen av studien som belyser elevers och lärares användning av meningsskapande resurser i flerspråkiga NO-klassrum samt på vilka sätt elevers bakgrund, tidigare erfarenheter, språk och kunskaper bekräftas och används som resurser i NO-undervisningen.

Syfte

Det specifika syftet med det här konferensbidraget är att generera fördjupad kunskap om hur meningsskapande resurser används i flerspråkiga NO-klassrum samt tydliggöra på vilka sätt elevers bakgrund, tidigare erfarenheter, språk och kunskaper bekräftas och används i NO-undervisningen.

Teoretiska utgångspunkter

För att öka möjligheterna att skapa mångfasetterad och fördjupad kunskap om pedagogiska möjligheter och begränsningar i flerspråkiga NO-klassrum kombinerar vi teorier från utbildningsvetenskaplig och didaktisk forskning (ämnesdidaktik och språkdidaktik), sociologi och språkvetenskap. Främst använder vi begrepp som härrör från teorier om transspråkande och andraspråk, Legitimation Code Theory (LCT) och social semiotik (García & Wei, 2014; Gibbons, 2009; Halliday & Matthiessen, 2004; Kress & van Leeuwen, 2021; Maton, 2014) för att utforska komplexiteten som uppstår i flerspråkiga klassrum.

Metod

Metodologiskt är projektet utformat som en interventionsstudie utifrån ett designforskningsperspektiv (Educational Design Research, EDR) (McKenney & Reeves, 2019). EDR:s dubbla fokus på teori och praktik gör den lämplig för att sätta komplexa utbildningsproblem i ett reflekterande ljus, och utforska nya teoretiska och praktiska utrymmen (t.ex. Bakker & Smit, 2017). Den explorativa fasen i projektet ger viktig kunskap i sig, samt utgör ett värdefullt underlag för projektets andra fas. Den andra fasen utgörs främst av pedagogiska klassrumsinterventioner i kombination med elevintervjuer. Studien har inletts med ett noggrant utforskande av praktikerna ur ett emiskt perspektiv, vilket innebär att ge röst åt deltagarnas erfarenheter och uppfattningar. Det handlar om att observera pedagogiska praktiker, samt att förstå lärares och elevers reflektioner kring möjligheter och utmaningar i undervisningen. Data, i denna fas, har samlats in genom semistrukturerade intervjuer med 22 lärare och 20 elever vid fyra olika skolor. Dessutom har data samlats in från fyra utforskande och kritisk-reflexiva workshoppar där lärare och forskare möts samt genom klassrumsobservationer på de fyra skolorna. Det insamlade materialet i den explorativa fasen utgör underlaget för det här konferensbidraget. I analysen (som är pågående vid inlämningen av konferensbidraget) kodas materialet först i teman inom flerspråkig NO-undervisning med hjälp av en tematisk analys (Braun & Clarke, 2006). För att vidare utforska på vilka sätt meningsskapande resurser används och hur lärare inkluderar och bekräftar elevers bakgrund, tidigare erfarenheter, språk och kunskaper som resurser i NO-undervisningen analyseras temana med hjälp av begrepp som hänvisar till meningsskapande, multimodalitet, flerspråkighet som resurs, undervisningsstrategier samt vardagligt och ämnesspecifikt språkbruk. Eftersom all data inte transkriberats vid tidpunkten för inlämning av konferensbidraget och därför inte analyserats fullständigt, presenteras endast preliminära fynd i korthet i detta dokument.

Preliminära resultat

Både elever och lärare tar upp det ämnesspecifika språket som en utmaning i NO-undervisningen. Lärare upplever att ämnesspecifika ord och begrepp ofta är främmande för eleverna och att de därför inte är vana att använda dessa, vilket leder till att ”det är svårare att få orden att bli deras, det hamnar i deras arbetsminne så länge man pratar om det, men det blir inte riktigt deras ordentligt” (Lärare D). Flera av eleverna tar upp undervisningens betydelse för att utveckla förståelse för ämnesinnehållet och de ämnesspecifika begreppen. En elev uttrycker det på följande sätt, ”I NO är det många svåra begrepp men det kan vara enkelt om man har en bra lärare” (Elev). I analysen framkommer det att en NO-undervisning som tar sin utgångspunkt i vardagliga erfarenheter och laborativa aktiviteter och succesivt introducerar det ämnesspecifika språket genom att sätt ”ord” på det som görs ofta engagerar eleverna och främjar elevernas utveckling av ämneslitteracitet. Den undervisning som däremot inleds med, och i högre grad fokuserar, ämnesspecifika begrepp och skriftspråkliga uttryckssätt leder vanligtvis till att eleverna upplever NO som svårt. För att förtydliga ämnesinnehållet för eleverna använder lärare ofta visuella resurser och olika typer av bildstöd såsom föremål, teckningar, foton, skisser på tavlan och filmer. En del filmer finns på flera språk och flera av lärarna berättar att flerspråkiga elever ibland väljer att lyssna eller läsa undertexterna på sitt modersmål. Det förekommer även att elever använder översättningsappar och att elever som delar modersmål översätter och hjälper varandra på sitt modersmål. Dock finns det även lärare som menar att eleverna inte har behov av att använda sina modersmål och i deras undervisning är det mycket sällsynt att eleverna använder sina modersmål. Dessa lärare är tveksamma till att använda flerspråkighet som resurs i undervisningen (transspråkande) eftersom de menar att elevernas språkkunskaper i modersmålet är otillräckliga. Däremot pekar samtliga lärare på vikten av att bekräfta elevernas modersmål i NO-undervisningen för att stärka elevernas lärandeidentiteter. Detta visar på att lärare ofta förstår värdet av ett flerspråkigt förhållningssätt, men saknar metoder och konkreta strategier för en transspråkande NO-undervisning. I analysen blir det tydligt att lärare har lättare för att resonera om språk- och kunskapsutvecklande undervisning, än att resonera om en flerspråkig NO-undervisning utifrån transspråkande perspektiv.

Diskussion och slutsats

Det framförs ofta att resursbaserade strategier minskar risken för bristtänkande och kan underlätta elevers ämneslärande, språkutveckling och identitetsutveckling samt minska prestationsgapen mellan olika elevgrupper. Men forskning som på ett mer fördjupat sätt undersöker undervisning och lärande i NO-klassrum där flerspråkighet används som en pedagogisk resurs är begränsad. En stor del av forskningen har dessutom fokuserat NO-klassrum där lärare och elever kan kommunicera på två gemensamma språk. De svenska klassrummen ser däremot ofta annorlunda ut. I ett klassrum kan elevernas språkbakgrunder omfatta en mängd olika språk. Frågor som lärare ställer sig i sådana klassrum är exempelvis hur flerspråkiga förhållningssätt och arbetssätt ändå kan utgöra en resurs för lärande. Detta praktiknära forskningsprojekt kan därför ge ett unikt internationellt och nationellt bidrag till utforskandet av elevers språk-, kunskaps- och identitetsutveckling i flerspråkiga NO-klassrum.

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SUSTAINABILITY CONTENT AND COMPETENCES IN TEACHER EDUCATION

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Abstract

In this study, we wanted to gain insight into the potential for interdisciplinary teaching about sustainable development (SD) -issues in teacher education by investigating different course plans and one ESD teaching program including reflections from pre-service teachers taking this course. Document analysis was used to gain insight into how sustainability competences, central perspectives related to sustainability are taken care of in the modules, and we have also analysed student assignments about sustainability issues and competences. Based on an interdisciplinary framework of teacher's pedagogical capacity, three main themes seem to emerge from the data, including (1) interdisciplinary and disciplinary content knowledge in SD including sustainability issues (2), general interdisciplinary ESD teaching approaches, including green competencies; and (3) interdisciplinary content pedagogical knowledge; connecting perspectives in interdisciplinary ESD teaching. For instance, we find find that some of the sustainability competences (for example critical and scientific thinking) are well taken care of in the various course plans, while others are hardly mentioned (for example creativity and future thinking). To a certain extent, the course plans mention similar content elements relevant for SD. Moreover, the pre-service teachers referred to several relevant perspectives in the content of SD.

Introduction

Education for sustainable development (ESD) has been implemented more strongly in the Norwegian teaching curriculum the recent years (Ministry of Education and Research, 2017). When implementing sustainability, teachers are in a key position (Munkebye & Gericke, 2022), and teacher education is crucial (Arneback & Blåsjö, 2017). Sustainability issues are often complex and can be seen from various perspectives. Interdisciplinary teaching in teacher training provides many opportunities to engage future teachers in teaching related to societal challenges and sustainability issues. In addition, all teachers are responsible of promoting sustainability competences such as critical thinking, problem solving, creativity, reflection, and argumentation (Sinnes, 2015).

However, there has been little focus on and cooperation across subjects in teacher education, and there is a need for restructuring and change of work habits in how teaching is carried out (Biseth et al., 2022). Effective elementary generalist teachers who teach multiple subjects are required to be competent at motivating students to learn, sustaining students' engagement, planning, and implementing lessons with clear objectives, presenting content through multiple methods, and helping students make meaningful connections within and across subject areas. In an intervention at a Norwegian teacher education program, student teachers had to deal with authenticity and complexity when it comes to interdisciplinarity and sustainability (Ødegaard et. al., 2021). Results from the study indicate that if teacher education programs are to accommodate both interdisciplinary and sustainability perspectives, structural changes are necessary. Hammerness and Klette (2015) point out that there is a growing consensus that high-quality teacher education is developed around a clear and shared vision of good teaching. Teaching interdisciplinary about sustainable development by incorporating both social, economic, and environmental perspectives can be said to be such a common vision, and in this study, we assume that this should be visible in course plans and teaching program based on these course plans. We investigate how course plans in one teacher education program attend to sustainability content and to sustainability competences, and how pre-service teachers reflect on such competences. In addition to investigation of different subject course plans.

We aim to address the following research questions:

- What content from SD (sustainable development) is emphasised in various course plans in teacher education?
- Which interdisciplinary competences and sustainability competences are emphasised in the course plans and how do pre-service teachers majoring in natural science reflect on which competences they have developed?

Theoretical background

Sustainable development is a term that is usually defined as an interaction between ecological, economic and social conditions (Giddings et al., 2002). These perspectives are also expressed through the Sustainable Development Goals (SDGs), which are based on five basic pillars (United Nations, 2015). The SDGS can be seen as a universal call to action. The holistic perspective is central because sustainable development is a common goal for people and the planet and emphasizes the connections between these perspectives (McKenzie & Abdulkadri, 2018). Higher education must contribute to achieving the SDGs, and this will require renewal of curricula with an emphasis on

competences that are clearly linked to the content of these goals (see e.g. Sustainable Development Goals and Institutions of Higher Education, 2019). A study of the different course plans from different departments at a major university in Taiwan (Chan & Lien, 2020) shows that the number of sustainability goals covered by a course reflects the diversity of perspectives related to SD. They found that the university as a whole emphasised the goals that dealt with the social dimension, and that several sustainability goals were not represented in all departments. Regarding teacher training in Norway, Jónsson et al. (2021) show that SD is not strongly integrated into the framework and guidelines for teacher education, where it is mentioned only once. However, these guidelines point out that plans for teacher education should be in line with and relevant to the national curriculum for basic education.

There is growing recognition of the important role ESD plays in supporting the development of competence and the abilities for lifelong learning. Several studies have specifically worked to examine and identify key sustainability competencies, especially in the context of higher education (for instance Rieckmann, 2018; Wiek et al., 2011, 2016). As part of the European Green Deal, there was a mandate to prepare a European sustainability competence framework as a key policy action to further promote sustainability learning within the European Union. GreenComp: The European sustainability competence framework reports on this work and presents this new framework to “foster a sustainability mindset by helping users develop the knowledge, skills and attitudes to think, plan and act with empathy, responsibility, and care for our planet” (Bianchi et al., 2022: 2). The GreenComp framework presents twelve different competencies divided evenly across four interrelated competence areas: ‘embodying sustainability values', 'embracing complexity in sustainability', 'envisioning sustainable futures' and 'acting for sustainability'.

Methods

In this study, we have looked more closely at the potential for interdisciplinary teaching about SD in teacher education by examining different subject modules, and by analysing written reflections from student teachers. We examined the course plans in pedagogical knowledge (PEL), Norwegian, mathematics, natural sciences, and various elective subjects of 30 credits. Document analysis was used to gain insight into how SD content and sustainability competences are taken care of in the course plans. In addition, written reflections were obtained from 17 students with natural science as their master's subject.

Results and discussion

A key finding is that no single plan mentions all three perspectives in sustainable development. Reference is also made to very few explicit sustainability competences, and only in certain subjects. Thus, it is unlikely that student teachers will gain a sufficient holistic insight into SD. However, the student teachers feel that they have gained an insight into some of the sustainability competences, for example critical thinking and future thinking. This suggests that regardless of subject combination, all student teachers will have the opportunity to develop a certain competence in ESD. However, there will be great variation in the opportunity the individual student has to develop competence in this. The challenge seems to be to create links between content and interdisciplinary competences in order to create sustainability competences.

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WHAT MAKES TEAHER PRACTICES EFFECTIVE AND EQUITABLE IN PRIMARY MATH AND SCIENCE CLASSROMMS?

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Abstract

Research on teacher practices in primary school, particularly in mathematics and science education is scarce, making studies that use representative samples from large-scale international assessments crucial for offering valid insights into these educational domains. This present study addresses this gap by examining teacher practices by focusing on what teachers teach (*content coverage*) and how teachers teach (*teaching quality*) in Norway, Sweden, Denmark, and Finland. With data from the Trends in Mathematics and Science Study (TIMSS) cycles between 2011 and 2019, the analyses show that higher teaching quality and content coverage were associated with higher subjects' learning outcomes. It also was found that teaching quality declined, and limitations to teaching (such as students lacking prerequisite skills or not understanding the language instruction) increased over time in the Nordic classrooms. These negative trends were associated with decreased achievement overtime. Teaching quality and content coverage also played a vital role in educational equality. High-quality teachers tended to teach advantaged students and cover more of the content than disadvantaged students, especially in Denmark. Yet, teachers also had the potential to decrease the achievement gap between advantaged and disadvantaged students, such as in Norway, where teaching quality reduced this gap.

Introduction

At the heart of student learning are teachers' practices, which are about, among others,what they teach (*content coverage*) and how they teach (*teaching quality*). For teachers,school owners, researchers, and policymakers, there is a need to understand how these practices are related to students' achievement, how they have changed over time, and whether the changes in teacher practices are related to the changes in students' achievement. In challenging times of war, pandemic, energy crisis, economic instability, andgrowing social inequality, it becomes further important to know how teacher practices are related to academic equality in the Nordic countries.

Additionally, there is a notable lack of research on teacher practices in primary schools, particularly in the areas of mathematics and science education. This scarcity underscores the need for studies utilizing representative samples from international large-scale assessments to provide meaningful and accurate insights into these critical domains. Hence, the present study draws on data from Trends in Mathematics and Science Study (TIMSS), the only international large-scale assessment with a nationally representative sample that includes primary schools and samples of whole classrooms and their teachers, to address the following research questions (RQs):

1. how have teacher practices changed over time?
2. how are teacher practices related to student outcomes?
3. how are changes in teacher practices related to changes in achievement over time?
4. how are teacher practices related to equity?

Theoretical backgrounds

Content coverage refers to what teachers teach and is one of the key indicators of students' opportunities to learn (OTL; Schmidt et al., 1997, 2014). The OTL framework distinguishes between (1) *the prescribed curriculum*, specified at the system level, (2) *the taught curriculum*, what is actually delivered in the classrooms, (3) *the assessed curriculum*, involving content and tasks from achievement tests, and (4) *the achieved curriculum*, reflecting to what students have learnt as shown in the assessment. In this context, teachers'content coverage is measured based on the degree to which teachers cover the intended curriculum as agreed by the participating countries in TIMSS, which forms the framework forthe test.

Teaching quality describes how teachers teach and includes key aspects of classroom teaching identified by previous research as promoting student learning (Senden et.al, 2021).The most commonly used and validated theoretical framework of teaching quality (see e.g., Klieme et al., 2009, Praetorius et al., 2018) outlines three critical aspects, as shown in Figure1.

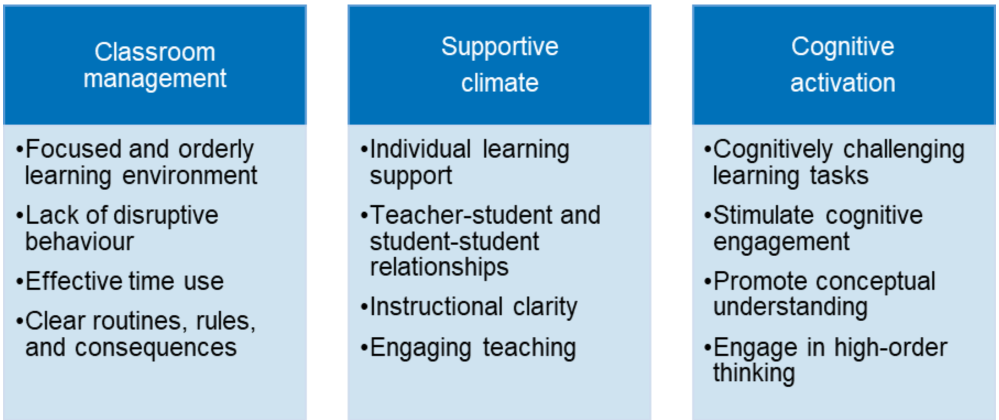

Figure 1. Various aspects of teaching quality, adopted from Klieme et al. (2009).

Teachers' content coverage and teaching quality may be limited by various challenges caused by, for instance, the composition of the classroom (Gustafsson, et al., 2016). For instance, teaching becomes more challenging in classrooms with many students who struggle with the language of instruction, disrupt lessons, lack necessary prior knowledge, orattend school hungry or sleepy (e.g., Vik et.al., 2022). Understanding these challenges is crucial for facilitating effective teaching in diverse classroom settings.

Research methods

Data from fourth graders participating in TIMSS cycles between 2011 and 2019 from Sweden, Denmark, Norway, and Finland were analyzed. ***Content coverage*** was assessed primarily through teachers' responses to the coverage of the topics taught in mathematics and science. In mathematics, this entails assessing the coverage across three domains: Number, Measurement and Geometry, and Data; and in science: Life Science, Physical Science, and

Earth Science. ***Teaching quality*** was measured by students' responses to theirteachers' instruction and included the three aspects of teaching quality (Figure 1).

All analyses employed two-level structural equation modeling allowing for simultaneous estimations at both student and classroom levels and accounts for the cluster effects in the sample (e.g., students are clustered in the same classrooms and schools). This approach was also used to evaluate the reliability and validity of the measures and findings.

Results and Discussion

Teachers' content coverage

No clear trend across the Nordic countries and over time can be identified. The only exception was found in the content domain Number in mathematics. Significantly fewerstudents had teachers who covered Number topics in 2011 compared to 2019 in all the Nordic countries. The content domain Number also was found the strongest and most robust relation to achievement in all countries, except Sweden.

In general, content coverage was positively related to achievement, and this relationship was stronger in mathematics than science. The findings further indicated that changes in content coverage in Number, Measurement and Geometry, and Data, were related to thechanges in mathematics achievement in all countries, except Sweden.

Content coverage was also related to equality and was particularly evident in Denmark. Here, students in high-SES classrooms had better opportunities to learn than those in low- SES classrooms, increasing the gap between these students. In contrast, in Norway and Sweden, a reverse trend was observed; low-SES students were more often exposed to Datatopics (Norway) and Number topics (Sweden) than students from higher SES backgrounds.

Teaching quality and limitations to teaching.

Teachers' support and instructional clarity decreased from 2011 to 2019 in both subjects in all Nordic countries, except Finland, while there were no clear patterns for cognitive activation. Teachers reported more challenges or factors that limited their teaching in 2019, as opposed to 2011. These challenges include students lacking prerequisite knowledge, being hungry, sleepy, or absent, disrupting lessons, suffering from psychological impairment,or struggling with the language of the instruction.

Teaching quality was positively associated with student achievement, particularly in mathematics. Classroom management showed the strongest relationship, while cognitive activation was the weakest, except for the positive relationship between inquiry-based science teaching (e.g., conducting experiments) and student achievement. Cognitive activation seems to be more important in secondary than in primary school, except for inquiry-based teaching in science (Nilsen et al., 2018). Nevertheless, longitudinal studies arerequired to support these findings.

The findings revealed significant relations between changes in teacher support and clarity of instruction with the changes in student achievement, especially in mathematics. The same pattern was found for inquiry in science.

The strongest and most persistent pattern across countries and subjects was the limitations to teaching, such as students feeling tired or lacking prerequisite knowledge. The limitationsto teaching increased over time, and this was associated with a significant decrease in student achievement. These findings are supported by many previous studies (e.g. Vik et al.,2022), and point to a change in the student composition and characteristics in the Nordic countries.

Regarding educational equality, the findings indicate an unequal distribution of high-quality teachers, in that high-quality teachers tend to teach in high SES schools. This finding was similar across the Nordic countries, except Norway. Here, teaching quality compensated the gap between advantaged and disadvantaged students, highlighting the role of teaching quality in promoting educational equity.

Conclusion

Taken together, the study highlights the important values of teacher practices for student learning outcomes. Yet, the decline in teaching quality and increased limitations to teaching since 2011 send alarming signals about the future of educational quality and equity in Nordic countries. Teachers today indeed face more challenges, as teaching has become more complex and demanding, especially in heterogeneous classrooms compared to more homogeneous settings. Additionally, the research unveils an uneven distribution of high-quality teachers across different socioeconomic classrooms. Despite these challenges, there is potential for teacher practices to reduce the educational disparities between advantaged and disadvantaged students.

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WHAT ROLE DO TEACHERS PLAY IN FOSTERING ACADEMIC RESILIENCE? GLOBAL INSIGHT ACROSS 58 COUNTRIES

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Abstract

For children in poverty, accessing a quality education often represents the only chance to reach their full potential. This study investigates the academic resilience of disadvantaged students, drawing on data from 58 education systems, including the Americas, Europe, Africa, Asia, and the Middle East. Utilizing Grade 4 assessment and survey data from the Trends in Mathematics and Science Study (TIMSS) 2015, it aims to (1) examine the prevalence of resilient students and (2) identify the characteristics of teaching quality between resilient and non-resilient disadvantaged students. The results of the study highlight that the proportion of academically resilient students, those excelling despite socio-economic disadvantages, differs notably across education systems. Additionally, it was found that resilient and non-resilient students experienced different levels of teaching quality, particularly in their perceptions of instructional clarity and cognitive activation in science. These variations suggest that certain teaching methods and classroom environments are more effective in supporting disadvantaged students to achieve academic success. The study underscores the role of teaching quality in reducing educational inequality and suggests the importance of supportive learning environments in helping disadvantaged students succeed. These insights are crucial for educational policies and practices focusing on equity and quality.

1 Introduction

Students from low-income families are at exceptional risk of underachieving and dropping out (Kim et al., 2019). Three out of four socioeconomically disadvantaged students across OECD countries lacked mathematics and science proficiency (OECD, 2016). Nonetheless, despite having limited educational resources and disadvantaged home backgrounds, some students manage to succeed against the odds. These students are considered to be *academically resilient*. They excel academically, despite experiencing adversity that puts them at heightened risk of school failure (Martin & Marsh, 2006). However, it is yet unclear what makes some disadvantaged students perform better than their background predicts. This knowledge is crucial for informing educational policy and practice to support all students in realizing their full potential, thus contributing to equity and social justice initiatives.

Teaching matters in mitigating inequality in education. Yet, few studies have examined the extent to which teaching quality is related to students' capacity to be resilient, especially in science learning. No coherent understanding of teaching quality factors contributing to academic resilience exists, especially in primary education. Primary school is a critical period for children to develop resilience and interest in STEM (Charlesworth, 2015).

To address these knowledge gaps in education worldwide, this current study draws upon nationally representative data from the Trends in International Mathematics and Science Study (TIMSS). This study utilizes multilevel data from students and teachers across 58 countries to address the following research questions (RQs):

1. *How prevalent are academically resilient students in science across the 58 countries?*
2. *What are the characteristics of teaching quality that differentiate resilient and non-resilient disadvantaged students?*

2 Theoretical backgrounds

Academic resilience

Academic resilience is concerned primarily with the increased likelihood of success in school despite experiencing adversity (Rudd et al., 2021). It refers to students' capacity to accomplish successful educational outcomes despite conditions that put them at risk of failure (Martin & Marsh, 2006; Rudd et al., 2021). They have the capacity to deal with adversity and succeed, while others who experience similar conditions demonstrate poor academic outcomes and fail. They are willing to struggle through mistakes and able to overcome negative emotions and challenging situations to achieve better learning outcomes despite their unfavourable circumstances (Masten, 2015).

Teaching quality

Teaching quality is a multifaceted construct that is related to student outcomes. This study uses the three basic dimensions of teaching quality: classroom management, supportive climate, and cognitive activation (Klieme et al., 2009). *Classroom management* involves organizing a focused learning environment with minimal disruptions. A *supportive climate* relates to the quality of classroom interactions, encompassing teacher support and instructional clarity to meet student needs and enhance understanding. *Cognitive activation* refers to strategies that promote deep thinking and understanding through challenging tasks. This study delves into the last two dimensions by examining their importance in fostering the academic resilience of disadvantaged students.

The impact of teaching quality on disadvantaged students' academic success is profound. Poor teaching quality can be particularly detrimental for disadvantaged students who may already face other barriers to learning, such as limited access to resources, family instability, language barriers, and lack of positive role models (Charalambous, 2015). If their teachers are not competent at engaging students and fostering a supportive learning environment, disadvantaged students may be more likely to disengage from the subject, leading to lower academic achievement and a lack of interest in pursuing STEM-related careers. Teachers who do not provide adequate support or resources for these students may exacerbate these challenges and create additional barriers to academic success (Goldhaber et al., 2022).

3 Research methods

Data from fourth graders and their teachers participating in TIMSS 2019 across 58 countries were analyzed (*N* = 101, 173 socioeconomically students in Grade 4).

To address **RQ1**, the measure of students' socioeconomic status (SES) and achievement was used to estimate the proportion of resilient students. SES was measured using six items about home educational resources, including the number of books at home, owning a computer, and the availability of a study desk. Student achievement was assessed with a standardized test that covered three content areas: life science (45%), physical science (35%), and Earth science (20%). Students are academically resilient if they are among the bottom 1/3 of the SES distribution in their countries but demonstrate mathematics or science performance above the TIMSS Intermediate International Benchmark (i.e., above 475 points). This fixed threshold stresses an international perspective in order to compare countries.

To explore **RQ2**, we compared the levels of teaching quality, specifically instructional clarity and cognitive activation, between resilient and non-resilient disadvantaged students. This comparison was made using descriptive statistics and the Mann-Whitney U test to determine differences in means.

4 Results and Discussion

RQ1: The proportion of resilient students

Not all disadvantaged students are equally vulnerable; some students are able to beat the odds and succeed. As shown in Figure 1, the three countries with the lowest proportion of academically resilient students were the Philippines (0.3%), South Africa (2.1%), and Pakistan (3.5%). In contrast, the highest proportions of academically resilient students were found in Russia (30.6%), South Korea (30%), and Taiwan (27.6%).

When it comes to Nordic countries, Finland had the highest proportion of academically resilient students (26.4%), followed by Norway (23.4%), Sweden (19.8%), and Denmark (19.5%).

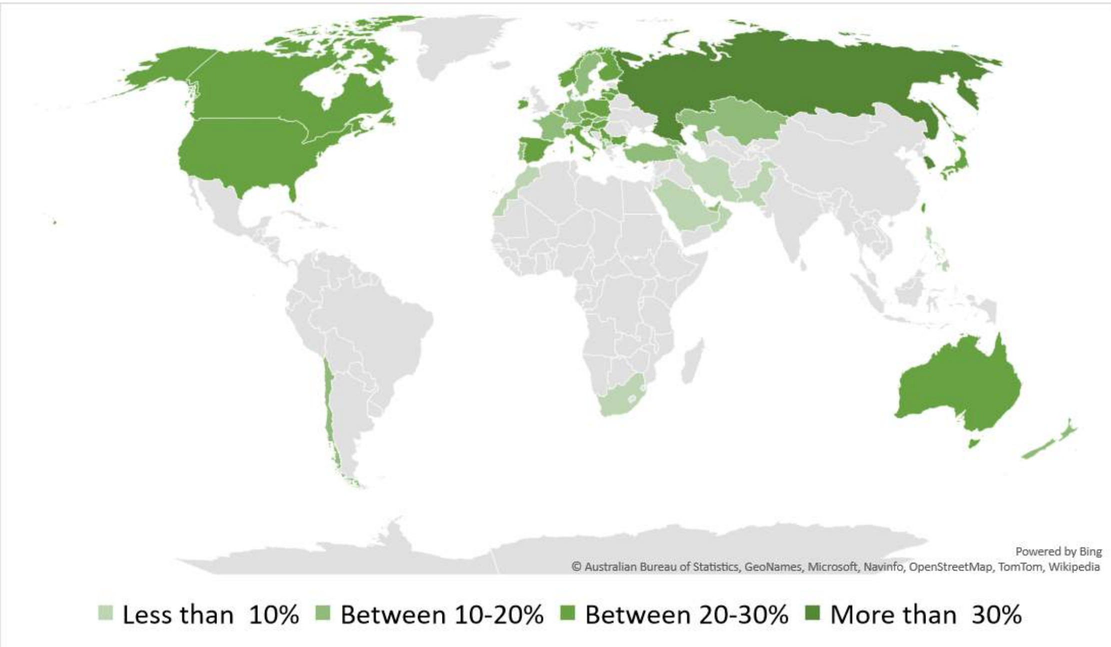

Figure 1. The share of academically resilient students in science across 558 education systems.

Although it may appear that wealthier countries have a higher percentage of resilient students than developing countries, the pattern is more complex. For instance, Latvia had a higher percentage than Denmark and Sweden. Further research is required to understand these variations.

RQ2: Teaching quality between resilient and non-resilient students

The findings highlighted that resilient students typically have teachers who provide strong support and instructional clarity. Supportive teachers foster positive relationships, trust, and motivation, which is particularly vital for socioeconomically disadvantaged students facing additional challenges (Goldhaber et al., 2022; Teig & Nilsen, 2022). In an environment where students feel valued and respected, they may engage more and persist through difficulties.

Moreover, clear and relatable instruction is crucial, especially for students who may lack background knowledge or face language barriers (Teig & Nilsen, 2022). Teachers who effectively explain content and connect it to real-life contexts can significantly enhance student engagement and motivation (Klieme et al., 2009).

Unlike other aspects of teaching quality, more frequent cognitive activation in science, especially activities related to science investigation, does not necessarily lead to better outcomes (Teig et al., 2018). The findings show that the proportion of resilient students was higher when students engaged in science investigation in less than half the lessons, but it was lower in about half the lessons or more. Science experiments often require considerable time and effort, both for teachers to plan an elaborate, well-thought lesson and for students to pursue a variety of science activities (Teig et al., 2018). As such, a high quality, rather than quantity of science investigation is likely to be more beneficial to promote student learning.

4 Conclusion

The overall message from this study is encouraging. Disadvantaged students, with the right support, can succeed academically, and teachers play a critical role in this process. Disadvantaged students may require learning experiences that go above and beyond the average to overcome their challenges and achieve academic success. Thus, ensuring they have access to ample teaching and learning resources is essential for schools to foster social mobility and offer high-quality education.

High-quality instruction, including teacher support and instructional clarity, is key to fostering academic resilience among disadvantaged students. Consequently, teacher education and professional development need to equip teachers with the necessary knowledge, skills, and strategies to meet the specific needs of these students effectively.

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RESEARCH-BASED RECOMMENTATIONS FOR ADDRESSING STUDENTS´ FUTURES THINKING IN SCIENCE EDUCATION

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Abstract

Fostering transformative agency has been taken up as an important aim of science education. Such agency is deeply connected to how one orients towards the future. We investigated young people's perceptions of the future, agency and technology, and suggest how science education can provide students with tools for connecting with, and finding agency within, their personal and global futures. Almost 300 students' writings about their desirable futures were analysed from various perspectives within the EU-project "FEDORA", employing qualitative content analysis and narrative inquiry. Several issues in students' futures thinking were identified: simplistic and non-problematised narratives of sociotechnical development, polarised attitudes, and a lack of imagination for alternatives and opportunities for agency. Besides the studies on students' perceptions, an analysis of secondary school science curricula from five European countries showed that curricula do not provide explicit support for students' perception of time and the future. On the basis of these empirical results and extant literature on young people's futures thinking, we propose recommendations for 'futurizing' science education by revising curricular contents, contexts and pedagogical methods. We conclude by discussing the relevance of the findings and recommendations for further development of science education fostering students' imagination and transformative agency towards the future.

1 Introduction

Global sustainability crises and accelerating societal and technological developments are posing new demands for science education research and practice. A lack of stable future horizons can lead young people to regard the future with hopelessness, to take directionless actions and to exhibit inabilities to project themselves into the future (Carter & Smith, 2003; Cook, 2016). Meanwhile, the United Nations' Agenda 2030 programme calls for societal transformations that cannot be achieved without transgenerational thinking, responsibility and transformative agency of the young (UNESCO, 2017).

The present paper addresses these concerns by reporting research carried out in an EU-funded project "FEDORA" (2020-2023) on students' perceptions and curricula, and suggesting how science education can provide students with tools for connecting with, and finding agency within, their personal and global futures. The aim is to address the following broad questions: *How do students perceive the future and their agency in it? What is the role of science and technology in students' futures thinking? What is the role of futures thinking in European science curricula? How can science education foster students' futures thinking and sense of agency?*

2 Theoretical backgrounds

This research draws on some earlier initiatives to adapt futures thinking in science education (e.g. Carter & Smith, 2003; Paige & Lloyd, 2016). The approach interconnects earlier research on people's perceptions carried out in a variety of domains: futures studies, youth studies, science and technology studies, and educational studies on agency, as well as societally oriented approaches to science education, such as the SSI (socioscientific issues) and STSE (science, technology, society, environment) movements (Bencze, 2020).

In the extant literature analysing young people's perceptions of the future, "two-track thinking" has been a typical finding: personal futures may be seen as positive and in one's own hands, but the national and especially the global futures as gloomy and out of one's influence (e.g. Cook, 2016). Research in the field of futures studies has also shown how positive images of the future and a perspective of hope connect to seeing new possibilities for action (e.g. Ahvenharju et al., 2018). Thereby, futures thinking is intertwined with the concept of agency. In social science, agency is commonly defined as the capacity for autonomous social action during which people intentionally transform their social and material worlds (Biesta & Tedder, 2007).

Research has shown that science and technology connect to young people's fears and deterministic future views (Carter & Smith, 2003), and also to their hopes about sustainable futures (Cook, 2016). Both deterministic and constructivist views of technology (Bauchspies et al., 2006) can be recognised in students' future thinking, deeply influencing their sense of future and agency and, thereby, having important implications for future-oriented science education.

3 Research methods

This paper summarises the results and outcomes of four part-studies analysing students' writings on the future, and one part-study analysing upper secondary school science curricula from five European countries.

The main corpus of the data on students' perceptions consisted of 16-19 year old upper secondary school students' essays on a desirable future, collected in Finland (n=58) and Italy (n=223). Additional data from the Netherlands was analysed to expand the research into younger, 8-14 years old children. Students' narratives were analysed by qualitative content analysis and narrative inquiry, also used in earlier research on youth's agency and views of the future (e.g. Angheloiu et al., 2020).

For the curriculum analysis, a subset of European secondary-level science curricula (i.e. Dutch, English, Finnish, Italian and Lithuanian) was selected. The qualitative content analysis combined inductive and deductive coding, latter basing on the model of Futures Conciousness (Ahvenharju et al., 2018).

4. Results

The empirical results are reported in detail elsewhere (Laherto & Rasa, 2022; Rasa & Laherto, 2022; Rasa, Laherto & Lavonen, 2023; Barelli, 2022; Barelli et al., 2022; Rasa et al., 2022). Here only the key findings are summarised in order to justify the research-based recommendations for future-oriented science education, presented in the next section.

Part-studies analysing students' writings on the future showed students lacking imagination and alternatives in their future narratives; their scenarios were mostly constrained by the present-day currents and assumptions (Laherto & Rasa, 2022; Rasa & Laherto, 2022; Rasa, Laherto & Lavonen, 2023; Barelli, 2022). Furthermore, a part-study (Barelli et al., 2022) analysing writings on the future pointed out a general dichotomy in students' thinking: they tend to either focus on very concrete, personal actions and challenges, or to see the issues so big that only political top-down actions can make the difference ("polarization effect"). To manage the anxiety toward the future, students tend to search for comfort zones by focusing on personal and social routines ("bubble effect").

Part-studies on students' writings also showed the central position of technology in students' hopes, fears and uncertainties for the future (Rasa, Laherto & Lavonen, 2023; Barelli, 2022). Technology was given various highly different roles in transforming our world: building sustainability, saving time from mundane tasks, accelerating inequality, making jobs obsolete, reducing privacy and providing interesting career opportunities. Some students saw more transformative potential in technological development, while some expected only incremental, or almost static trajectories. Sociotechnical changes were often discussed in unproblematised or even deterministic terms. Agency was discussed somewhat vaguely; students struggle with understanding or integrating in their futures thinking the issue of who will act on these changes.

The curriculum analysis (Rasa et al., 2022) revealed that European science curricula for secondary level provide little support for students' perception of time or futures thinking. Although all analysed national curricula state that education has to prepare and develop students for their further lifetime, they only rarely use specific futures terminology for this.

5. Discussion and conclusion

Figure 1 summarises the above-described issues pointed out by our empirical research, and connects those issues to 14 implications for science education research and practice. Those implications – our recommendations for *futurizing* science education – are outlined in the following.

The first five recommendations (Fig. 1) relate to the need to realign the aims of science education with the need to provide future-oriented competencies in the rapidly transforming world. We argue that incorporating explicit futures thinking into science curricula and teacher education would address the identified challenges in students' sense of the future and agency.

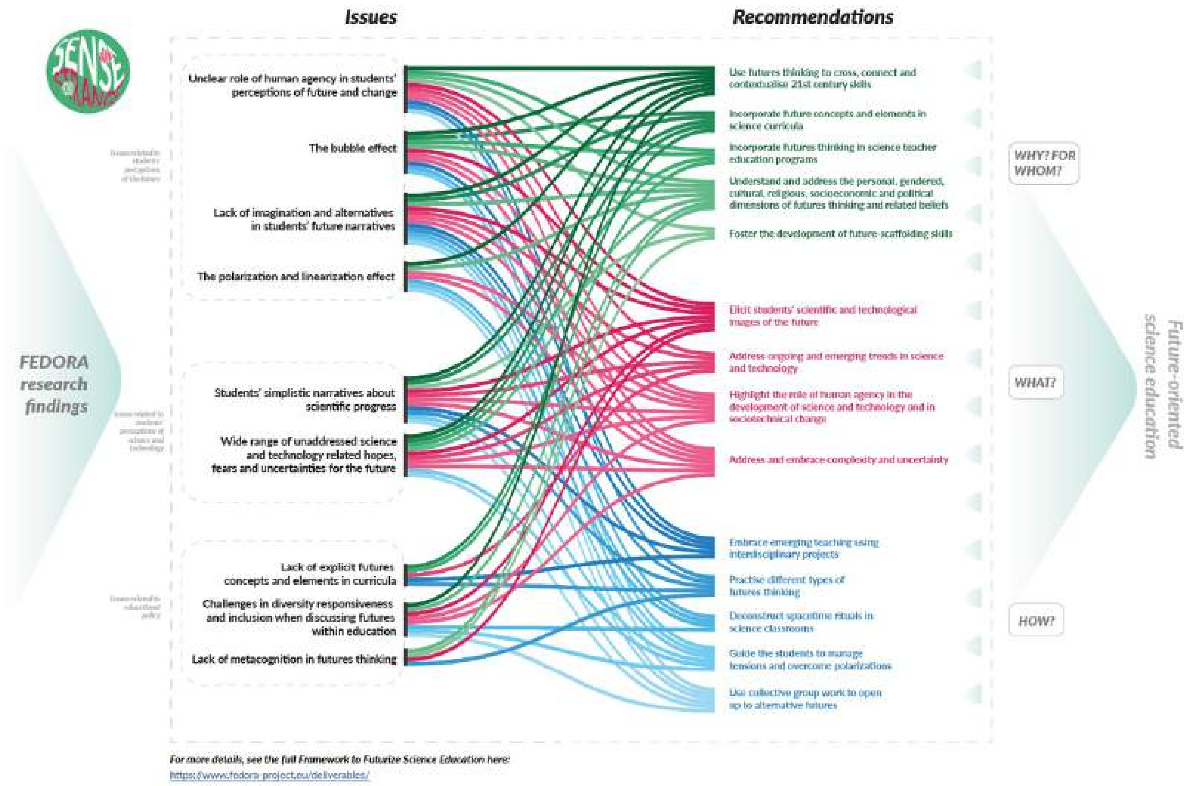

Figure 1. *Research-based issues and recommendations for future-oriented science education.*

The next four recommendations (Fig. 1) relate to how science and technology are contextualised in school. Due to the issues pointed out by our research and earlier literature (see Theoretical background), science lessons should elicit students' scientific and technological images of the future, address ongoing and emerging currents in science and technology, highlight the role of human agency in sociotechnical change, and embrace complexity and uncertainty of the future.

In the last five recommendations we suggest concrete pedagogical methods for future-oriented science teaching. Our research indicates that, e.g., interdisciplinary projects, group work and scenario building exercises can be effective for fostering students' imagination and transformative agency towards the future.

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LÆRERES HOLDNINGAR TIL PRAKTISKE OG SKAPENDE ERBEIDSFORMER SOM GRUNNLAG FOR PRAKSISENDRING

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Abstract

This study explores the attitude of Norwegian teachers towards practical and creative teaching methods. Skaperskolen, a resource collection, supports teachers in using an interdisciplinary, practical, and creative teaching approach. Using Skaperskolen, a two-year competence enhancement program seeks to reshape teachers' attitudes and practices. Pre-tests indicate that participating teachers possess attitudes conducive to competence enhancement. Among them 57 % incorporate practical and creative methods in their practice regularly, citing students' engagement, mastery and development of collaboration skills as key motivators. This aligns with the underlying values for Skaperskolen. The 43 %, who infrequently use such methods, mainly attribute this to external factors such as lack of competence, and the time and equipment demands associated with planning and implementation. Importantly, teachers do not doubt enhanced student learning outcomes through these methods. Continued collaboration and post-intervention investigations will track how teacher attitudes evolve, contributing to a development in practice based on Skaperskolen's teaching resources.

1 Introduksjon

Den norske læreplanen, LK20 (Kunnskapsdepartementet, 2019), framhever behovet for at elevene skal erfare skaperglede og mestring og at de skal tilegne seg teknologisk kompetanse. Dette innebærer fokus på kreativitet og problemløsningsferdigheter og mer praktisk og skapende arbeid i skolen.

For å støtte lærere i dette arbeidet har Naturfagsenteret ved UiO sammen med norske regionale vitensentre utviklet Skaperskolen som inneholder en samling undervisningsressurser sammen med en didaktisk modell for bruk av praktiske og skapende arbeidsformer (skaperskolen.no). Målet med denne modellen er å bidra til mestring og deltakelse for flere elever, samt ruste elever med ferdigheter for fremtidens utfordringer.

Denne studien er del av en større studie der formålet er å undersøke i hvilken grad kompetanseheving i Skaperskolens didaktiske modell og undervisningsressurser fører til endring i læreres holdninger og undervisningspraksis. I studien deltar tre skoler i et to-årig kompetanseutviklingstiltak basert på Skaperskolens ressurser. I starten av kompetanseutviklingstiltak gjennomførte vi en pretest for å undersøke følgende forskningsspørsmål:

1. *I hvor stor grad praktiserer lærere praktiske og skapende arbeidsformer?*
2. *I* hvor stor grad *legger eksisterende holdninger til rette for praksisendring?*

2 Teoretisk bakgrunn

Mange norske elever opplever skolen som teoritung og kjedelig (Bakken, 2021). Skolen får kritikk for å være for teoretisk og legger for liten vekt på bruk av flere sanser og læring gjennom praktisk arbeid. Sentrale mål for Skaperskolen er at elevene skal oppleve mening og mestring, at de skal trene grunnleggende ferdigheter som er nødvendig for kreativt, problemløsende og skapende arbeid, bidra til et kreative klima i klassen og bidra til at flere elever «blir koblet på» og deltar i undervisningen (Voll, 2024). Skaperskolens filosofi bygger på at det som skal læres må oppleves som meningsfullt, det som Voll & Holt (2019) omtaler som at «læringsdøra må være åpen».

Intensjonen med Skaperskolens ressurser er å støtte lærere og øke bruk av praktiske og skapende arbeidsformer. Skaperkulturen bygger på fagområdene STEM eller STEAM (Johnston et al., 2022) og bidrar til å utvikle teknologisk kompetanse samtidig som den kjennetegnes av fire sentrale elementer: glede, dynamisk tankesett, fantastiske feil og samarbeid og delingskultur (Martin, 2015).

Målet med kompetansehevingstiltak basert på Skaperskolen er endring av eksisterende praksis og å bidra til en mer praktisk og engasjerende skole. Men holdninger spiller en sentral rolle for om tiltakene faktisk bidrar til praksisendring (Kennedy, 2016). En viktig faktor for praksisendring er at det er samsvar mellom innholdet i kompetanseutviklingen og lærernes kunnskap og holdninger (Korsager et al., 2023).

Ytre faktorer vil også ha betydning for praksisendring. Utdanningsforbundets rapport (Wedde, 2023) presenterer læreres erfaringer og synspunkter om hvordan skolen kan bli mer praktisk og variert. Lærerne hevder at dette er en målsetning de jobber mot og som de opplever at læreplanen bidrar til å fremme. Rapporten trekker også fram at mer tid til planlegging og samarbeid, tydelig prioritering fra ledelse, kompetanseheving og egnede lokaler og utstyr er nødvendige faktorer for å lykkes med realisering av målsettingene.

3 Metode

Datagrunnlaget for denne studien er de kvantitative dataene fra pretesten som ble gjennomført før kompetansehevingstiltaket der lærerne fikk innføring i Skaperskolens undervisningsressurser og didaktikk. Utvalget består av 93 (N=93) lærere som underviser på barne- og ungdomstrinnet.

Lærere svarte på spørsmål om hvor ofte de tar i bruk skapende og praktisk arbeidsformer med vekt på følgende kjennetegn:

- være kreative, ta valg og finne egne løsninger
- oppleve engasjement og mestring
- arbeide praktisk og være aktive

Videre fikk lærerne velge mellom ulike påstander for å begrunne hvorfor de bruker/ikke bruker skapende og praktiske arbeidsformer. Påstandene som begrunner bruk av praktiske og skapende arbeidsformer tok utgangspunkt i grunnlaget for Skaperskolen og ble inndelt i kategoriene følelser og opplevelser, trening av ferdigheter, klassemiljø og elevmedvirkning (Voll, 2024). Påstandene som begrunner manglende bruk av praktiske og skapende arbeidsformer tok utgangspunkt i begrunnelsene fra Utdanningsforbundets rapport (Wedde, 2023).

4 Resultater

Tabell 1 viser hyppigheten av bruk av skapende arbeidsformer i undervisningen blant lærerne. Dataene viser at 43% av respondentene benytter skapende arbeidsformer aldri eller iblant, mens 57% gjennomfører undervisning med skapende arbeidsformer én til to ganger i måneden eller mer.

Tabell 1: *Oversikt over hvor ofte lærere tar i bruk skapende arbeidsformer.*

Spørsmål: Hvor ofte tar du i bruk skapende arbeidsformer i undervisningen? N= 93		
Svaralternativ	**Antall**	**% av svar**
Aldri	2	2%
Iblant (noen få ganger i løpet av skoleåret)	38	41%
En til to ganger i måneden	29	31%
En gang i uken	12	13%
Flere ganger i uken	12	13%

Tabell 2 viser hva lærere som inkluderer skapende arbeidsformer i sin undervisning en til to ganger i måneden eller mer peker på som årsaker til denne praksisen. Resultatene viser at flere av årsakene går igjen blant lærerne. Blant de viktigste faktorene peker elevenes opplevelse av mestring og engasjement, samt muligheten til å trene samarbeidsferdigheter seg ut som sentrale.

Tabell 2: *Årsaker til at lærere gjennomfører undervisning med skapende arbeidsformer to ganger i måneden eller mer.*

Spørsmål: Hva er årsaken til at du gjennomfører undervisning med skapende arbeidsformer to ganger i måneden eller mer? N=50		
Svaralternativ	**Antall**	**% av svar**
Følelser og opplevelser		
Elevene blir engasjerte	39	78%
Elevene opplever mestring	36	72%
Ferdigheter		
Elevene trener samarbeidsferdigheter	37	74%
Elevene tilegner seg problemløsende og kreative ferdigheter	31	62%
Ytre faktorer		
Elevene møter faglig læring på en ny/annerledes måte	34	68%
Bidrar til et inkluderende klassemiljø	26	52%
Adferd		
Flere elever deltar, også de som vanligvis ikke deltar i undervisningen	28	56%

Tabell 3 viser hvilke årsaker lærere som aldri eller iblant tar i bruk skapende arbeidsformer peker ut som grunnlag for sin praksis. At en slik form for undervisning er utstyrskrevende og krever forberedelse som tar mye tid, pekes ut som særlig viktige årsaker. Tidkrevende gjennomføring og manglende kunnskap om undervisning med skapende arbeidsformer peker seg også ut.

Tabell 3: *Årsaker til at lærere aldri eller iblant gjennomfører undervisning med skapende arbeidsformer.*

Spørsmål: Hva er årsaken til at du aldri eller kun iblant gjennomfører undervisning med skapende arbeidsformer? N=36		
Svaralternativ	**Antall**	**% av svar**
tid- og utstyrskrevende		
Forberedelse tar mye tid	19	53%
Utstyrskrevende	18	50%
Gjennomføring krever mye tid	11	31%
Manglende kunnskap om skapende arbeidsformer hos læreren		
Jeg mangler kunnskap om undervisning med skapende arbeidsformer	11	31%
Jeg føler meg usikker	8	22%
Læring og vurdering		
Vanskelig å vurdere læring	1	3%
Lite læring for elevene	1	3%
Klasseledelse		
Undervisningen blir kaotisk	13	36%
Elevene blir urolige	9	25%

4 Diskusjon og konklusjon

Resultatene gir et bilde av at lærerne i hovedsak har en positiv holdning til bruk av praktiske og skapende arbeidsformer. Funnet av at 57% av lærerne som deltok i undersøkelsen tar i bruk slike arbeidsformer mer enn en til to ganger i måneden tyder på at flertallet av lærerne har positive holdninger og anvender praktiske og skapende arbeidsformer i relativt stor grad. Noe som legger godt til rette for kompetanseutvikling (Kennedy, 2016; Korsager et al., 2023).

Som begrunnelse for å anvende praktiske og skapende arbeidsformer trekker lærerne særlig fram engasjement, mestring og trening av samarbeidsferdigheter. Dette er i tråd med intensjonene med bruk av skaperverksted i skolen og utvikling av skaperkultur. Det faktum at lærerne vektlegger sentrale elementer som ligger til grunn for Skaperskolens undervisningsressurser, viser at det er samsvar mellom lærernes holdninger og Skaperskolens verdier. Dette vil kunne legge et godt grunnlag for videre samarbeid og utvikling. Holdningene til lærerne indikerer at de kan være åpne for å la seg inspirere og berike sin praksis med Skaperskolens didaktiske prinsipper, verktøy, grep og metoder.

Den resterende gruppen lærere på 43% som svarer at de sjelden bruker skapende arbeidsformer begrunner dette hovedsakelig i ytre faktorer som manglende kompetanse samt at planlegging og gjennomføring er tid- og utstyrskrevende. Lærerne gir ikke uttrykk for manglende tro på elevenes læringsutbytte ved bruk av slike arbeidsformer. Studien tyder på at lærerne har positive holdninger til bruk av praktiske og skapende arbeidsformer, men blir begrenset av ytre faktorer og rammevilkår. Dette samsvarer med funnene til Wedde (2023).

Intensjonen med kompetansehevingstiltaket og bruk av ressurser hentet fra Skaperskolen er å gi lærere den nødvendige støtten de trenger for å overkomme ytre hindringer og mestre undervisning med skapende og praktiske arbeidsformer. Resultatene tyder på at disse lærerne har holdninger som legger til rette for å lære mer om didaktiske grep, verktøy og metoder som kan bidra til praksisendring.

Videre undersøkelser i løpet av og etter tiltaksperioden vil avdekke i hvilken grad lærernes holdninger endres, og bidrar til praksisutvikling etter hvert som de får støtte og erfaring med undervisningsressursene som er utviklet gjennom Skaperskolen.

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AQUACULTURE ON DISPLAY – DILEMMAS ARISING IN A SPONSOREDEXHIBITION

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Abstract

Over the two last decades the number of salmon farming exhibitions have increased in Norway. This study examines one of these exhibitions, which is displayed in a museum andsponsored by a salmon farming company. The aim of this study is to examine the intentionsof the curators (a sponsor representative and the exhibition manager at the museum) regarding the salmon farming exhibition and contrast them with the actual manifestation inthe exhibition. Preliminary results from analysing the interviews with the curators show thatthe sponsor's objectives were to show advantages and disadvantages of the salmon farming industry, recruit competent labour to their industry striving to solve the industry's challenges, improve their public image and correct misconceptions about the industry. Theexhibition manager conveyed that certain objectives of the sponsor clashed with the museum's purpose and acknowledged the practice of self-censorship. The findings will bediscussed against an analysis of how the exhibition addresses sustainable development related to salmon farming. The results shed light on the role and motivation of museums to collaborate with industrial sponsors.

Introduction

Many museums claim to be neutral, and this has abstained them from addressing societal issues (Janes, 2009, p. 59), but "…the museum is not, nor has it ever been, neutral" (Evans et al., 2020, p. 19). The International Council of Museums emphasise the role of museums in shaping a sustainable future and recommend incorporation of sustainability into museums' practices (ICOM, 2019).

Given the museums' expectations to integrate sustainability and the criticism towards their'neutral' approach, we find it interesting and important to investigate a sponsored exhibitionabout a controversial sustainability issue like salmon farming. Hence, the aim of this study isto examine the curators' intentions behind the salmon farming exhibition and discuss this against an analysis of how the exhibition addresses sustainable development in relation to the salmon farming industry.

Theoretical background

Museums and sponsorship

A study by Davidsson and Sørensen (2010) shows that Nordic science centres and science museums heavily rely on external economic support. Sponsors have a direct influence on how science is constituted in the exhibitions, and pressure to be visible in the exhibitions. Indirectly, sponsors can also impact the exhibition content through self-censorship of staff-members and involvement in the creation of the exhibition. Additionally, the study highlightsthe shortage of studies on the experiences of sponsors who support new exhibitions at museums/science centres.

Andrée and Hansson (2020) found that when commercial interests merge with educational institutions, conflicts between private and public interest become apparent. Industrial actors engage in such collaborations for various reasons, including enhancing their public image, marketing and ensuring access to competent labour. However, critical perspectives aremissing in the industrial actors' discursive repertoires. This presents a tension with thedemocratic purposes of education (ibid.). These studies underline the importance of investigating the impact of industrial actors' engagement in informal education.

Sustainability education

Within sustainability education there are three approaches, referred to as *selective traditions* (Öhman & Östman, 2019). This study is grounded in the *critical pluralistic approach* which is characterised by a strive to explore and recognise different perspectives and ethical and political values. The aim is to develop students' ability to critically evaluate and take a stand in sustainability issues, in contrast to *the normative approach* where students are taught preconceived environmentally friendly and sustainable values, norms, and lifestyles. In the *fact-based approach* students receive knowledge about sustainability problems by learningof scientific facts.

Research methods

Context

The salmon farming exhibition explored in this study is a collaboration between a salmon farming company, who provided the funding, and the museum, responsible for the dissemination. The exhibition manager and a sponsor representative decided the content and design of the exhibition. The exhibition was observed by all authors and conceptualised as primarily *fact-based* regarding the *selective traditions* of sustainability education (Öhman & Östman, 2019). This interpretation is formed, in part, by noting that the exhibition conveys the idea that increased research and information are keys to addressing the challenges in the salmon farming industry. The exhibition also highlights the potential for diverse job opportunities for young people in a growing industry and emphasises the importance of wise minds in driving the development of a sustainable salmon farming sector. Some *normative* elements are also present in the exhibition by the use of specific, value laden words trying to influence visitors' attitudes. *Pluralistic approaches* are absent.

Data collection and analysis

Semi-structured, individual interviews with the sponsor and the exhibition manager were carried out. The interview transcripts were analysed using constructivist grounded theory (Charmaz, 2006, p. 130).

Results

The sponsor's perspective

Regarding the collaboration with the museum, the sponsor expressed that disagreements with staff who were salmon fishermen were expected. And the sponsor further commented:

> "However, it is so pleasing to hear that the staff have expressed their positive opinion about theexhibition. The depiction is not an idealized version of reality".

The sponsor said that one of the conditions set by the museum for their collaboration was to also highlight the challenges of the salmon farming industry. The sponsor agreed on that, because:

> "Excluding the challenges… of course you have to showcase them as well. By concealing the challenges,they may remain unsolved. And I think we have done a good job in addressing them".

The sponsor expressed the belief that during the making of the exhibition, the exhibition manager did not engage in self-censorship. In fact, they actually agreed upon the exhibition manager to be highly critical.

The results of the analysis reveal that the sponsor's aims of the exhibition were to show advantages and disadvantages of the salmon farming industry, to enhance their reputation,to correct misconceptions about the industry, and to recruit competent labour to the company and the industry. The sponsor articulates the challenges in the industry and the need for wise minds to solve these challenges:

> "Maybe we should consider eliminating the use of soy and instead use other raw materials. But forthat, we need wise minds".

When questioned about the integration of various interest groups and diverse perspectives on the salmon farming industry in the exhibition, the sponsor emphasised that they carefully assessed websites of environmental and animal protection organisations. Their objective wasto acknowledge the concerns expressed by these organisations and offer comprehensive responses to their allegations. The sponsor states that the exhibition successfully debunkedthe majority of these claims.

The exhibition manager's perspective

According to the exhibition manager, the staff were solicited for their opinion regarding the collaboration with the salmon farming industry:

> "Uh… and it was actually a joint no, then, amongst all the employees, that we did not want a cooperation with the aquaculture industry".

But the management continued with the collaboration and the making of the exhibition. The exhibition manager further highlights that without the support of the sponsor, an exhibition solely dedicated to salmon farming would not have come to fruition. The exhibition manager expressed that the museum had been inadequate in describing their own role in the collaboration with the sponsor, and indicated that the museum's intentions were in conflict with the sponsor's and the salmon farming industry's intentions.

The exhibition manager would ideally have made an honest and neutral exhibition on the premises of the museum. However, a dilemma occurred:

> "If you had made an honest exhibition then the sponsor would not be interested in investing such a significant amount of money in it".

This demonstrates the difficulty the exhibition manager faced in being overly critical.According to the exhibition manager several compromises was made:

> "It was a question of give and take. You had to pick your battles and although there were certain matters I wanted to include, but…".

In relation to the issue of self-censorship the following response was:

> "Yes, I've had to do that [censor myself]. Absolutely. It is not an ideal exhibition for me to create, but when I am first assigned a job, I do it".

According to the exhibition manager one of the aims of the exhibition were to:

> "… provide visitors with a nuanced picture of …. The most nuanced depiction of the salmon farming industry as possible".

Furthermore, the exhibition manager mentions goals as for example recruitment of wiseminds to solve the challenges in the industry:

> "If you make it inviting and exciting, and present the problem and… that you don't pretend that it is anindustry without problems and challenges. And openly states, "We need help". In the long run, I believe this approach can be effective".

Discussion and conclusion

This study examines the motives of the sponsor and the museum regarding a salmon farming exhibition. The preliminary findings shed light on specific challenges and dilemmas that can emerge in the making of exhibitions supported by corporate sponsors. These challenges are particularly linked to discrepancies between the sponsor's objectives for the exhibition and the museum's dual role as a science educator and a platform for promoting sustainability education. The preliminary findings indicates that the sponsor's main goals for the exhibition were to attract skilled individuals to the industry to solve their challenges, improve the public image of the industry, and correct misconceptions about the industry. On the other hand, the exhibition manager aimed to create a nuanced exhibition. Thus, there are potential conflicts and tensions between private and public interests when corporate sponsors are involved in public science education initiatives. These findings align with those presented in Andrée and Hansson (2020)'s study, which highlight potential conflicts and tensions between private interests and the public good when industrial actors engage in public science education initiatives. The effects of sponsorship manifests in the exhibition manager's self-censorship. This may hinder the promotion of critical pluralistic sustainability education, which strives to highlight different perspectives and to develop students ability to critically evaluate and takea stand in sustainability issues (Öhman & Östman, 2019). The findings will be discussed against an analysis of how the exhibition addresses sustainable development related to salmon farming and shed light on the purpose and motivation of museums to collaborate with corporate sponsors.

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UNIVERSITY STUDENTS' CONSIDERATIONS OF THE USEFULNESS OG MODELS OF CHEMICAL BONDING

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Abstract

Teaching of chemical bonding is generally done using several models, which represent chemical bonding in different ways. Out of eight models of a hydrogen molecule, most first-semester students at a Norwegian university (N = 200) prefer the octet (duet) model or the Lewis structure. As reliance on the octet rule is shown to be associated with several alternative conceptions, the popularity of the octet model could hinder future learning. Comparing students who prefer a model with students choosing another model as their favourite, the first group rates the model as more useful than the other does. When asked about what it means to them that a model is useful, students (N = 20) tend to mention how a model can increase their understanding, is useful for visualisation or conveys information. None of the students mentioned exams or grades. This focus on understanding could imply that the students have an intrinsic motivation to learn and understand chemistry, but it could also be caused by students being accustomed to models being introduced and used as teaching models, rather than scientific models.

1 Introduction

Models play an important part of science education, and chemistry is by no means an exception. Chemistry as a science aims to explain perceptible phenomena and changes by use of the imperceptible, such as atoms, electrons, molecules, and orbitals. Models are a valuable tool for describing, teaching, and understanding such phenomena. Chemical bonding is what makes atoms and molecules stick together and build the structures our world is made of. This is one of the most fundamental concepts in chemistry (Gillespie, 1997), and the teaching of chemical bonding is heavily reliant on use of models.

Several models of chemical bonding are used, both at school and university level. These models may be physical models made of clay, simple drawings on a blackboard, or take the more abstract form of a mathematical equation. Models can be categorised by ontological status (Gilbert et al., 2000). It can be a personal *mental model*, a *scientific model* used by a community of scientists, or a *teaching model* used mainly to improve understanding of other models. The four models of chemical bonding used in this study are shown in *Figure 6*. These models are frequently found in textbooks used in Norwegian secondary schools.

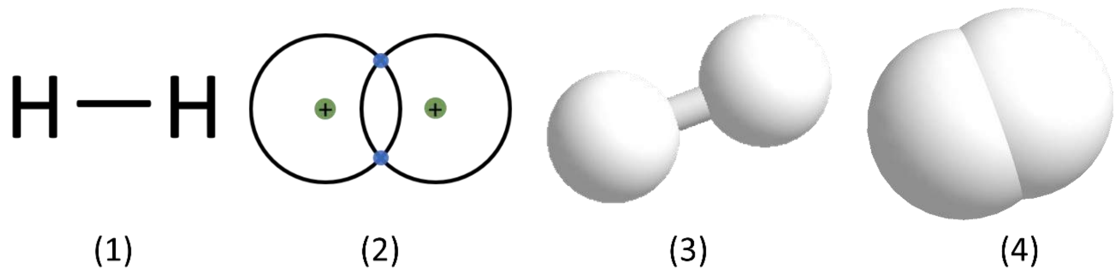

Figure 6: Four models envisioning chemical bonding in the hydrogen molecule (H_2). From left to right: (1) Lewis structure, (2) octet model, (3) stick-and-balls model, (4) space-filling model

The Lewis structure (model 1) shows chemical bonds as lines between atoms represented by their symbols. The octet model (model 2) visualises electron shells as rings around the nuclei, and the chemical bond is shown as overlapping electron shells. The name reflects that the compounds formed are expected to follow the *octet rule*, that is, atoms get eight electrons in their outer shell. Hydrogen, however, will never have more than two electrons in its first shell, and this model could thus be called a *duet* model. The stick-and-balls model (model 3) and the space-filling model (model 4) both try to visualise the 3D structure of the molecule.

2 Research methods

First-semester students at a Norwegian university answered a short survey during one of their first chemistry lectures. The response rates were 46-88 % of the students enrolled in the courses. The students were shown eight different models of chemical bonding and given questions about these models. This paper will discuss the answers to the following selection of questions:

- Multiple select: "Which of these representations have you seen before?"[3]
- Lickert scale question given for 4 of the 8 models: "To what degree do you think this representation is useful? very small degree – rather small degree – neutral – rather large degree – very large degree"[4]
- Open question (textbox) given to a random selection of students: "What does it mean for you that a representation is useful?"[5]
- Multiple choice: "Which of these representations do you like the best?"[6]

Students' written answers were coded using the constant comparison method, with each student answer coded into one or more categories.

3 Results

Almost all students claim to be familiar with the Lewis structure and the stick-and-balls model, see *Table 1*. The octet model and the space-filling model are also recognized by more than 80 % of the students. The four other models of chemical bonding included in the survey, are only recognized by 5.0-16.5 % of the students, and are not discussed further here. More than 90 % of the students prefer either the octet model or the Lewis structure.

***Table 7**: Percentages of students claiming familiarity with a model, and choosing a model as their favourite model*

Model		Students familiar with the model	Students choosing this model as their favourite
1	**Lewis structure**	198/200 = 99 %	71/200 = 35.5 %
2	**Octet model**	164/200 = 82 %	111/200 = 55.5 %
3	**Stick-and-balls model**	189/200 = 94.5 %	7/200 = 3.5 %
4	**Space-filling model**	161/200 = 80.5 %	4/200 = 2.0 %
Other models		5.0-16.5 %	0-2.0 %

[3] In Norwegian: "Hvilke av disse representasjonene har du sett før?"
[4] In Norwegian: "I hvor stor grad mener du at denne representasjonen er nyttig? (i veldig liten grad – i ganske liten grad – nøytral – i ganske stor grad – i veldig stor grad)"
[5] In Norwegian: "Hva vil det si for deg at en representasjon er nyttig?"
[6] In Norwegian: "Hvilken av disse representasjonene liker du best?"

Error! Reference source not found. compares how students choosing a model as their favourite model and how the students choosing *another* model as their favourite model rate the usefulness of the model. This is shown for the Lewis structure and the octet model. To calculate the average usefulness, the Lickert scale is converted to numbers 1 through 5, with 5 representing *a very large degree*.

Table 8: Comparison of how students' choosing the model as their favourite model and students choosing another model as their favourite model rate the usefulness of the Lewis model and the octet model

	Lewis structure		Octet model	
	Lewis structure as favourite model	Other models as favourite model	Octet model as favourite model	Other models as favourite model
Average usefulness	4.24	3.78	4.40	3.97
Number of students	71	129	111	89

Table 9 summarizes the categories in the students answers to the open question "What does it mean for you that a representation is useful?" 20 students were given this question.

Table 9: *Main categories in students' answers to the question "What does it mean for you that a representation is useful?"*

Category	**Frequency**	**Example quote**
Easy to understand, improves understanding or learning	$\frac{12}{20} = 60\ \%$	"That one can use it to better understand the topic."[7]
Shows, visualises, represents	$\frac{6}{20} = 30\ \%$	"That it is easy to see which atoms are in the bond (…)"[8]
Gives information	$\frac{5}{20} = 25\ \%$	"That it gives meaningful information that can explain a complex system in a simple way."[9]
Simplifies, not too complex	$\frac{4}{20} = 20\ \%$	
It's important	$\frac{3}{20} = 15\ \%$	"It's very important because representations and models influence our understanding of the topic we learn. So, to be useful, they must be possible to understand, while as scientifically correct as possible so that we don't misunderstand the information."[10]
Is correct, scientific	$\frac{2}{20} = 10\ \%$	
Can be used for solving exercises, calculations, nomenclature	$\frac{2}{20} = 10\ \%$	"That it shows something I can (…) use for calculations, nomenclature, etc."[11]
Can be used for something unspecified	$\frac{1}{20} = 5\ \%$	"Whether I can use it effectively or not"[12]

[7] In Norwegian: "At man kan bruke den for å forstå stoffet bedre."

[8] In Norwegian: "At det er lett å se hvilke atomer som er med i bindingen (…)."

[9] In Norwegian: "At den gir meningsfull informasjon som kan forklare et kompleks system på en enkel måte."

[10] In Norwegian: "Det er veldig viktig etter som representasjoner og modeller påvirker forståelsen vår av stoffet vi lærer. Så for å være nyttige må de være mulige å forstå samtidig som å være så vitenskapelig korrekt som mulig slik at vi ikke oppfatter informasjonen feil."

[11] In Norwegian: "At den viser noe jeg kan (…) ha bruk for ved regning, navnsetting osv."

[12] In Norwegian: "Hvorvidt jeg kan bruke den effektivt eller ikke"

No codes	$\frac{1}{20} = 5\ \%$	"Yes"

4 Discussion and conclusion

All four models are familiar to most of the students, which reflects that all four models are much used in Norwegian schools. Students who choose the Lewis structure or the octet model as their favourite, tend to rate it as more useful than other students do. But what do students mean by useful? In their written answers, many students (60 %) mention how use of models increases understanding, is useful for visualisation (30 %) or conveys information (25 %). Only a few students (10 %) mention usefulness in relation to solving exercises, and no one mentions exams or grades. This could imply that students think of models of chemical bonding mainly as tools for learning, and that they are not used to *using* them, except as illustrations. It could also mean that the students have an intrinsic motivation for learning and understanding chemistry, which would be a very good thing – and perhaps not surprising for first-year science students.

The Lewis structure and the octet model, while both popular among students, are of a different ontological status. While the Lewis structure is used by scientists, the octet model can be classified as a teaching model that visualises how atoms form covalent bonds by sharing electrons. It is well-documented that the octet model can lead to students developing multiple alternative conceptions, and that students tend to overuse the octet rule as an explanation (Taber, 2013).

The students answered the question "What does it mean to you that a representation is useful?" Based on their answers, they might just as well have answered the question "What does it mean that a representation is useful to *you*?" The student perspective is prominent in their answers. They might write *we*, but the focus appears to be on *we* as *students* or *learners*, not *we* as *scientists* or *chemists*. This could simply be a natural consequence of how the question is formulated, but it could also indicate that students are used to models being teaching models, and not scientific models. Does this reflect how teachers and textbooks present the models? It would be interesting to investigate if their focus shifts from the student perspective to the perspective of a professional chemist during their chemistry studies.

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TEACHING IS NOT FOR LIFE – STUDENT TEACHERS' REFLECTIONS ON CAREERSHIP AND THEIR POSSIBLE FUTURE SELVES

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Abstract

A shortage of qualified teachers in general and science teachers in particular is a well recognised problem across Europe. Part of this teacher shortage derives from student teachers who choose not to enter the teaching profession upon graduation. In order to understand and in turn alleviate teacher shortage in general, it is important to understand how experiences during teacher education affect student teachers' career reflections. In this study I have explored how five student teachers' reflections on their future career interacted with the opportunity to sign up for an honours programme with an emphasis on science teaching. The study is longitudinal and qualitative and inspired by Constructivist Grounded Theory. Common for the student teachers' reflections is that they see teaching as a profession with limited opportunities for personal and professional development and reflect on the choice to sign up for the honours programme as a means to expand their opportunities upon graduation. These insights are important contributions to understand teacher shortage.

1 Introduction

Teacher shortage is a global problem which has been recognised for decades (Bruinsma & Jansen, 2010; Carver-Thomas & Darling-Hammond, 2019; Hong, 2010; Rots et al., 2014) and Denmark is no exception (Rinne et al., 2023). This study adds to a growing research interest in an otherwise overlooked area of exploring how teacher education affects preservice teachers' decision to either drop out or enter the teaching profession and how long they intend to stay in the profession (Horvath et al., 2018; Rots et al., 2014).

Previous research in this field has found that student teachers are more likely to enter the profession if they feel well prepared to teach from the teacher education (Bruinsma & Jansen, 2010; Horvath et al., 2018; Klassen et al., 2021; Lavrenteva & Orland-Barak, 2019; Rots et al., 2014).

At a University College in Denmark, a talent programme in the form of an Honours College (HC) was introduced in 2018 as an add-on to the ordinary science teacher education. The HC offers participating students a favourable teacher:student ratio, personal mentorship among the student teachers, connections with partnering schools and extra science-teaching coursework.

As feeling well prepared to teach is considered an important factor in the decision to enter the teaching profession, the level of support and relation to praxis provided by the HC suggests that the programme could be an ideal add-on to the teacher education for increasing rates of transition from teacher education to the teaching profession.

In the present study I combine the careership model developed by Hodkinson and Sparkes (1997) and the Possible Selves theory developed by Markus and Nurius (1984) to answer the question: Why do preservice science teachers choose an honours programme and how do Possible Selves and career plans evolve during participation? The findings in the study provide insights to student teachers' career plans and how experiences during education such as the option to choose a HC interacts with these career plans. Such insights are important to consider in order to understand and alleviate teacher shortage.

2 Theoretical backgrounds

2.1 Careership Model

Students' reflections on prospective career and whether the choice of education was the right choice does not end with entrance to an education (Holmegaard et al., 2014; Vulperhorst et al., 2020). For this reason, it is relevant to understand influencing factors behind career decisions of student teachers, which in my case includes the opportunity to participate in an honours programme.

To aid the understanding of my respondents' career reflections and choices I use Hodkinson and Sparkes' (1997) Careership Model. The Careership Model is inspired by the concepts of "habitus" (how a person views the world based on their background) and "field" (a social or institutional arena) developed by Bourdieu and a study on young people's career decisions to leave full-time study. The main point in the Careership Model is that career choices are based on a person's background but continuously reevaluated as a consequence of interactions with others in the field and the experience of contexts related to the career choice.

2.2 Possible Selves

To further support the analysis of why the student teachers in my study chose an honours programme and how their Possible Selves and career plans evolved during the last two years of their education I have chosen to supplement the Careership Model with the Possible Selves theory developed by Markus and Nurius (1986). Where Hodkinson and Sparkes (1997) took a sociological approach to decision making, Markus and Nurius (1986) take a cognitive approach in which they argue that the Possible Selves of a person works as an incentive for present and future behavior. Similarly, they also affect decision making. In this study, the Possible Selves Theory will be used to understand how past experiences affect how student teachers see themselves in the future and how their thoughts for the future affect their choices both during education and on the brink of graduation.

3 Methods and Methodology

This study is inspired by Constructivist Grounded Theory as described by Charmaz (2006).

The main source of data is intensive interviews, which "…permits an in-depth exploration of a particular topic or experience…" (Charmaz, 2006, p. 25). In this case, student participation in the HC is the experience explored.

The open-ended interviews asked questions around:

- why the respondents chose to study to become teachers

- their experience of teacher education

- why they chose to apply for HC

- the experience of HC

- their thoughts for the future.

Data was coded and categorised with initial theoretical conjectures refined and checked through a constant comparison between data analysis and literature.

The data analysed in this study consists of three rounds of interviews with students from the second cohort of student teachers who participated in the HC, which initially consisted of 19 students of which 17 had agreed to participate in the study. I chose five respondents randomly for the project out of the 17 students who agreed to be invited for interviews. However, the HC experienced high dropout rates, which affected the data collection. Two of the student teachers interviewed in the first round had dropped out by the time of the second round of interviews and were replaced by two new respondents as a result of an open call to participate.

A	***B***	***C***	***D***	***E***
F	G	H	I	J
K	L	M	N	O
P	Q	R	S	

Respondents/cohort, round 1, January 2020.

A	***B***	***C***		
F	***G***	H		
K	L	M		
P				

Respondents/cohort, round 2, September 2020 (cohort estimated).

A	***B***	***C***		
F	***G***	H		
K				

Respondents /cohort, round 3, June 2021

Figure 7 *Overview of respondents relative to cohort, respondents in bold italics*

4 Results

In each interview, students reflected on their thoughts for the future. Generally, they felt more certain about one plan for the future than others and they narrowed down their options as they came closer to graduation. With the exception of one student, respondents did not think teaching was going to be fulfilling enough for them for more than a couple of years. Before or just after graduating, they were already thinking about what they would do after teaching, or in one case while still being a teacher.

When reflecting on the choices they have made regarding career and their plans for the future, the respondents refer to their background such as working in schools or daycare after graduating from high school or having parents who are teachers. Their reflections on alternatives to a career in teaching revolve around a concern for career opportunities – they are worried about a lack of opportunities for professional development within the teaching profession. The respondents argue for the choice of signing up to the HC as something that "opens doors" and thus as a means to expand their opportunities to include more than the teaching profession.

5. Discussion and conclusion

The stories of the respondents illustrate how context and experience are important when considering a future career as argued by Hodkinson and Sparkes (1997). The stories are also examples of the ongoing process of this choice; the students do not see themselves in the same position for a very long time but consider the teacher education vocational BA as a starting point and the HC as an addition to this education which has the potential to expand their options. None of the respondents consider dropping out of teacher education, but their Possible Selves reveal concerns for what life is like as a teacher. The concern about the teaching profession as a career with limited opportunities can be viewed as a reflection on feared Possible Self, i.e. a possible self "stuck" as a teacher. To a large extent, the respondents argue for their choice to sign up for HC through their Possible Selves. The fear of being stuck and ending up in the wrong workplace is countered with the hope of having other opportunities besides teaching in a public school when graduating. This finding indicates that although the opportunity to sign up for a HC was appreciated by the respondents, it did not appear to be a means to alleviate teacher shortage. However, the insights about the respondents concerns about the teaching profession can are valuable to understand why new teachers choose not to enter the profession.

By exploring why student teachers chose an HC and how this choice affected their career plans I found that the respondents perceived the teaching profession as a profession with limited opportunities for development. The respondents who intended to enter the profession upon graduation were considering their next career move while still at teacher education. The choice of signing up to the HC was mainly considered a means to expand career opportunities beyond the teaching profession and not as a means to be better prepared for the teaching profession.

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PRE- AND IN-SERVICE SCIENCE TEACHERS' CONCERNS FOCUSSING ON THE REQUIREMENT TO ENHANCE BOTH STUDENTS' ACADEMIC LANGUAGE COMPETENCES AND THEIR SCIENTIFIC LITERACY IN EVERYDAY SCHOOLING

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Abstract

Teachers all over Europe have to deal with the challenge to foster *both students' academic language and their subject-relevant literacy* in times of cultural, ethnical and language diversity in classrooms. However, these challenges seem to be the source of serious difficulties for teachers – especially for prospective science teachers. Therefore, reconstructing science teachers' professional concerns regarding the requirement to enhance both their students' academic language skills *and* subject-specific learning progression in science classes is crucial. Hence, we ask: *How do pre- and in-service science teachers assess the challenges to enhance both their students' academic language competences* <u>*and*</u> *scientific literacy?* To pursue this question, we use the "Stages-of-Concern-Model" (SoC) by Hall and Hord (2011) to analyse teachers' concerns regarding professional challenges. Following these objectives, we applied existing SoC-Questionnaires to our subject, adapted items to optimise the scientific quality of its scales regarding language, semantics, and a stronger connection to pedagogically sound assumptions, and reduced the number of items per SoC-Scale. The study consisted of pre- and in-service science teachers (N=98). The analyses prove an increase of the scientific quality of the revised SoC-Scales, and indicate different theoretically sound SoC-Profiles describing pre- and in-service science teachers' concerns based on statistically significant evidence.

1 Introduction

The first PISA assessments already attested the German educational system a (too) low educational performance; particularly for students with a migration background and/or from households with a low socio-economic status (Deutsches PISA-Konsortium, 2001). These disappointing results have not improved substantially during the past two decades (OECD, 2023). For many years scholars have called for an integration of academic language and subject-matter instruction in all subjects (KMK, 2005), i.e., also in science education. In the light of Germany's once again poor performance in PISA 2022 (Lewalter et al., 2023), it becomes obvious, that the realization of this educational requirement is still a source of serious difficulties for pupils regarding their learning development. As teachers are the most important factor regarding the implementation of educational reforms, the question arises: *How do (pre- and in-service) science teachers assess the professional challenges they anticipate concerning the requirement to enhance both their students' educational language competences and their students' scientific literacy?*

2 Theoretical Framework

To pursue this general research question, we use the "Stages-of-Concern-Model" (SoC) by Hall and Hord (2011). The SoC-model is a proven model for analyzing the concerns of professionals when they reflect challenges and chances of the implementation of educational innovations. According to Hall and Hord (2011), a successful adoption of an innovation runs through seven different development stages (the so-called “Stages-of-Concern” (SoC); see fig. 1).

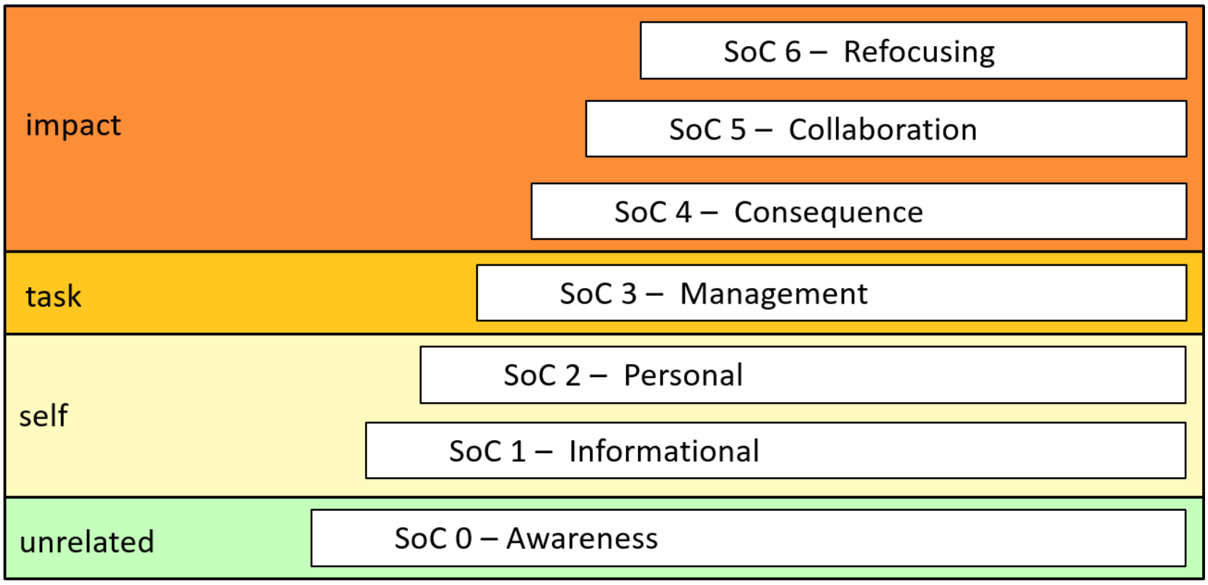

Figure 1. *Stages-of-Concern-Model according to Hall and Hord (2011).*

The SoC-Model of Hall and Hord (2011) has already been successfully used in various 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; Schneider, Bolte & Krischer 2015; Bolte & Dreßler, 2021), finally leading to the identification of typical “SoC-Profiles” (Bitan-Friedlander et al., 2004), which help to explain professional believes and concerns of specific teacher prototypes who support or impede educational innovation. While Pant et al. (2008) applied the SoC-model to investigate the implementation of national educational standards in general, the implementation of the two specific educational standards (namely, to foster students’ academic language competences *and* to enhance their scientific literacy) has not yet been investigated.

Hence, we decided to adapt existing SoC-questionnaires including the applied scales and corresponding items to our research subject. In the frame of this adaptation we decided to shorten the length of the original questionnaires in terms of the number of items per scale, and to semantically optimize the combinations of the SoC-scales and their corresponding items based on pedagogical conclusions.

Research Question

These considerations finally led to the following research questions:

1st To what extent does our revised SoC-questionnaire fulfill the criteria of scientific quality?

If the revised version of the SoC-questionnaire provides satisfying psychometric features compared to those in other studies, we focus on the questions:

2nd To what extent do pre- and in-service science teachers show one or more proto-typical SoC-Profiles?

3rd To what extent do the SoC-Profiles of pre- and in-service science teachers differ?

3 Method

To identify typical SoC-Profiles in general and to test differences between pre- and in-service science teachers, we involve pre- and in-service science teachers and ask them to complete the 28 SoC-items (four items per SoC-scale) of the revised SoC-questionnaire-version. Each item has a 7-point Likert scale from "not true for me now" (1) to "very true for me now" (7). Furthermore, if the subject of an item is absolutely irrelevant for the participant at the moment he/she could choose the option "irrelevant for me at the moment" (0).

To test the scientific quality of the revised SoC-questionnaire we calculate reliability coefficients for each scale and check the construct validity using factor analysis (Eid & Schmidt 2014). Finally, we calculate mean-scores per scale and sub-sample and use Mann-Whitney-U-Tests and t-Tests to identify – if possible – statistically significant differences between the two sub-samples.

4 Results

The sample in total includes 98 participants; 50 in-service science teachers and 48 pre-service science teachers.

The reliability analyses indicate a satisfying level of reliability for all SoC-scales (Cronbach's alpha: $.721 < \alpha < .945$). The factor analyses using principal component analysis and varimax rotation show that the 28 SoC-items load high on factors of the SoC-model to which they should theoretically belong.

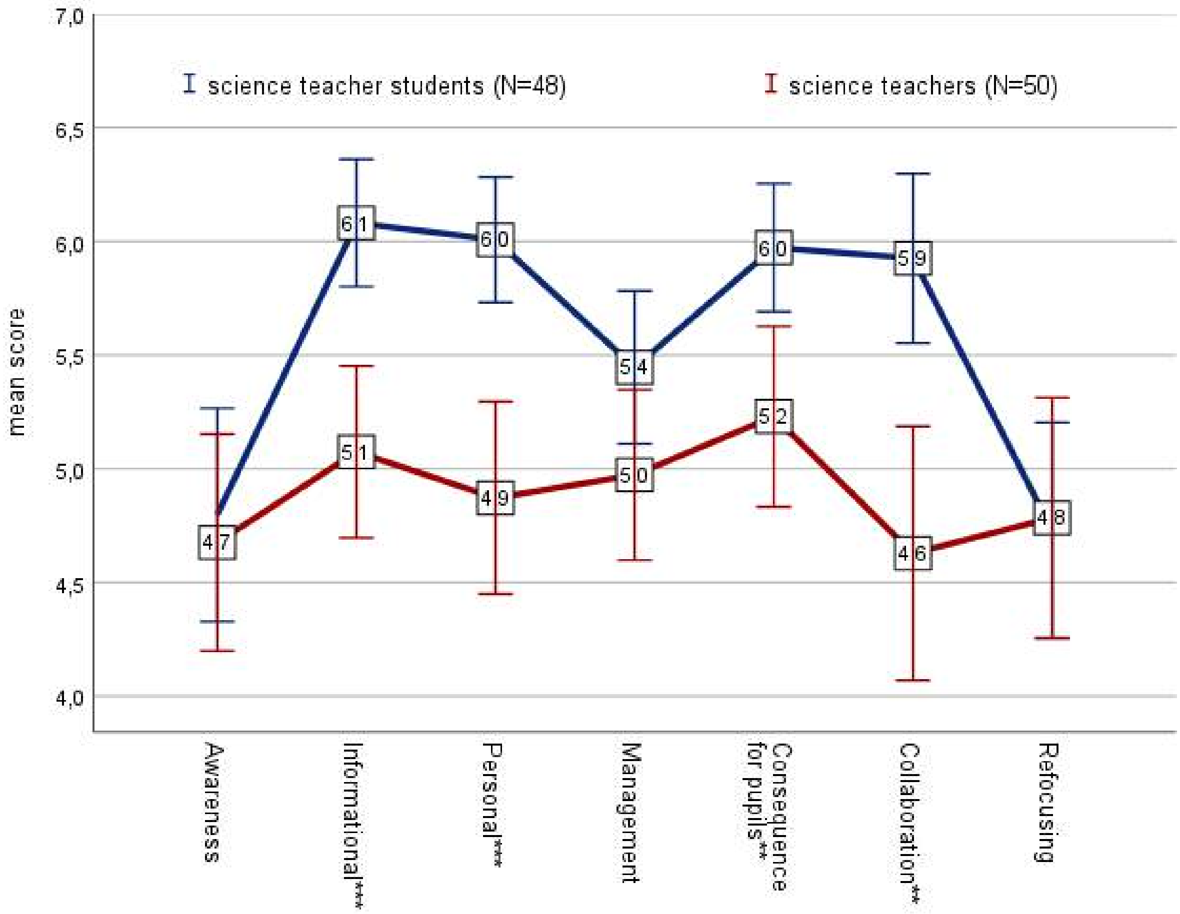

Figure 2. *SoC-Profiles of pre- and in-service science teachers focusing on the requirement to foster their students' academic language skills and their scientific literacy (in everyday science schooling classes) [* p < .05; ** p < .01; *** p < .001]*

Looking at the calculated SoC-Profiles of both sub-samples we discover two typical SoC-profiles. Focusing on the results of the science teacher students, we identify the SoC-Profile of the "Cooperator" (according to Bitan-Friedlander et al., 2004). The profile of in-service science teachers shows more similarities to the SoC-Profile of a "moderately motivated Implementer" (as introduced by Böse et al., 2018). Furthermore, the results of the Mann-Whitney-U-test show statistically significant differences between the two sub-samples' mean-scores in five of seven cases (see fig. 2).

5 Discussion and conclusion

Our study shows that the adapted questionnaire version is theoretically sound and the scales based on the revised items are reliable. The data analyses of the science teacher students identify the SoC-Profile of the "Cooperator" (Bitan-Friedlander et al. 2004), while the profile of the in-service science teachers exhibit the profile of a "moderately motivated Implementer" (Böse et al., 2018). The good news of these findings is: If teacher students develop the willingness to cooperate in fostering their students' academic language skills *and* their scientific literacy in the frame of their professional university education, there should be opportunities to convince undecided in-service teachers to tackle this contemporary educational objective as well. However, the challenge for school administration and science teacher education is now/would be to develop and offer attractive (long-term) CPD courses to convince and motivate those teachers to make progress concerning their continuous professional development and their teaching practice.

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“WHAT IS MY RESPOSIBILITY”? EDUCATION ON CLIMATE CHANGE IN UPPER SECONDARY SCHOOLS

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Abstract

What is the current knowledge on climate change of students at upper secondary level in Iceland? From where do students get their knowledge on climate change? Are they ready to act and to actively address environmental challenges in general? And what is the role of education? These questions are among those who were addressed in a survey taken by students at two upper secondary schools in Akureyri, Iceland. The main goal was to get an insight into the scientific knowledge and skills on climate change of students and to better understand their willingness to act and behave. Results indicate that students’ knowledge, mostly comes from the internet and only 10% of students claimed that school was the main source of knowledge. Up to 80% of students said they were aware of methods to reduce the effect of climate change but only 10% of them were willing to act to reduce CO2 emissions. The results highlight the fact that knowledge on climate change only comes to a small extend from the Education system. It is therefore clear that formal education on climate change at both compulsory and secondary level in Iceland needs to be redefined, to some extent.

1 Introduction

The world demands action to meet the global effect of climate change. Young people will experience the consequences of climate change more directly during their lifetime than any previous generation in recent history. Education plays a critical role in preparing new generations for a greener future. What students learn may directly affect their actions and behavior in the future and therefore education should help students to build up a sustainable future. But what is the current knowledge on climate change of students at upper secondary level? From where do students get their knowledge on climate change? Are they aware of the consequences of climate change? Are they ready to act and to actively address environmental challenges in general? And what is the role of education? These questions are among those who were addressed in a survey taken by students at two upper secondary schools in Akureyri, Iceland. The main goal was to get an insight into the scientific knowledge and skills on climate change of students and to better understand their willingness to act and behave to build up a sustainable future. The results provide important information on how to approach climate change education.

2 Theoretical backgrounds

Iceland, like other OECD countries has participated in PISA (Programme for International Student Assessment) for several years. PISA measures 15-year-olds’ ability to use their reading, mathematics and science knowledge and skills to meet real-life challenges. In Iceland, science knowledge has been declining since 2006 and latest results show substantially lower science skills than the average of OECD counties (Menntamálastofnun, 2023). This fact brings up questions on the knowledge, skills, attitude, and action that students at upper secondary schools have on important environmental challenges, like climate change. It also wakes up questions on the role of science education, both at compulsory and upper secondary level. In a recent review paper, authors point out four themes related to climate change education; engaging in deliberative discussion, interacting with scientists, addressing misconceptions and implementing school or community projects (Monore et al, 2019). In another review paper, where a qualitative analysis was made on climate change education at secondary level, the most frequently addressed topics focused on knowledge, behavior, actions, experiences, and attitudes (Nepraš et al, 2022). A number of climate change education studies have, furthermore, repeatedly highlighted the limitations of scientific knowledge approaches in their ability to influence the attitudes and behaviors of children and young people. Therefore, it is of high importance to try to understand the unclear relationship between knowledge and behavior. Sufficient knowledge has an impact on climate change concerns, which further influences students' willingness to act in favor of the climate (Nepraš et al, 2022). Current survey aims to get an insight into the status of science knowledge and willingness to act by students at secondary level and should, in the future, help to design a meaningful climate change education in Iceland.

3 Research methods

In 2017 a survey with 30 questions was sent to all students at age 18-20 in two upper secondary schools in Akureyri, North-Iceland. The response rate was 35% and 30% of the participants where male and the rest (70%) females. 55% of the participants claimed that they had been involved in courses in school where there was a special focus on climate change. The questions were divided into 3 sets. The first one addressed the knowledge and awareness of climate change, the second set focused on the consequences of climate change and the third one aimed at action and behaviour of students.

4 Results

Results indicate that the knowledge on climate change of students mostly comes from the internet and only 10% of students claimed that school was the main source of knowledge on climate change (Fig. 1). Up to 80% of students said they were aware of methods to reduce the effect of climate change but only 10% of them were willing to act to reduce CO2 emissions.

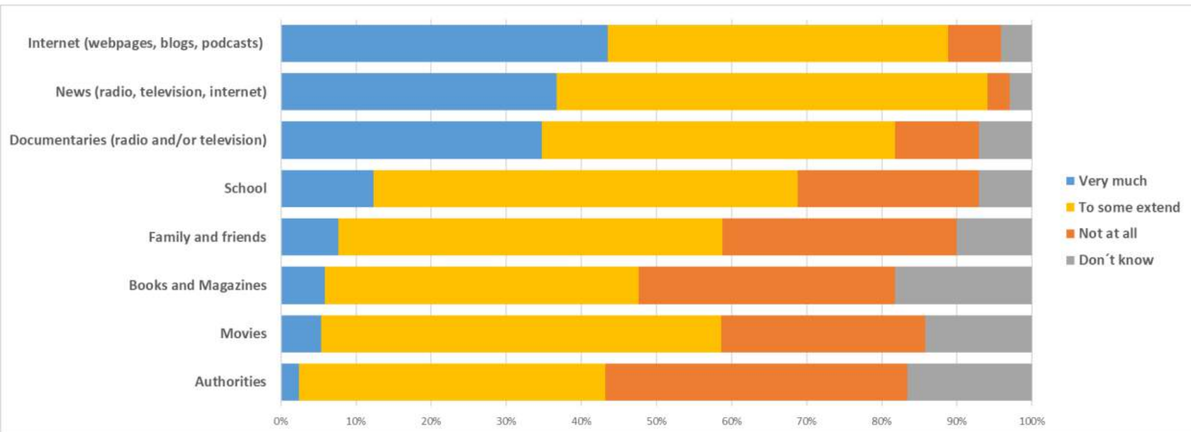

***Figure 3**. Answers on the question: From where do you get your knowledge on climate change?*

Most of the students (2/3) claimed that the responsibility of fighting against climate change was in hands of the international community and Icelandic authorities. Less than half of the group felt that individuals needed to show some responsibility and only 1/3 of the group showed some concern regarding climate change in general. This could be further seen in the following questions where students were asked if they were willing to change their lifestyle to reduce the effect of climate change (1/3 again). Despite this, quite many students were willing to make some specific changes, like recycling trash, decrease food waste exc. Other actions, like stop traveling by air, were less popular.

4 Discussion and conclusion

Climate change education is a relatively new discipline of education and find its roots primarily in environmental and sustainability education and science education. It is designed to equip students with the knowledge, skills and competencies that will make them the agents of change much needed to deal with the climate change crisis. The survey results highlight the fact that knowledge on climate change only comes to small extend from the Education system. It also shows that Icelandic students are not willing to make a dramatic change in their lifestyle, showing responsibility by acting. It is therefore clear that formal education on climate change at both compulsory and secondary level in Iceland needs to be redefined, to some extent. The focus should be on effective, well-tested education methods of experiential activities around relevant and meaningful impacts of climate change. Effective climate change education can help build problem-solving skills by engaging students in classroom and community projects to increase awareness. Finally, students learn more if they are encouraged to assess their own ideas, talk through the evidence, and explain their thinking. Understanding and applying some or all these strategies for climate change education can help teachers improve their practice and deepen their students' learning. Based on the results of this survey, it is obvious that teachers in Iceland need more support and retraining. They need to be more empowered to inspire their students.

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WORKSHOP: TRANSDICIPLINARITY IN HIGHER EDUCATION USING THE STEAM+ TRAIL-TOOL

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Indented audience: Educators and policymakers wishing to implement transdisciplinarity in higher education.
Educational context: Higher education. Transdiciplinarity. Talentprograms.
Language: English
What to bring to the workshop: (computer, smartphone ...) PC, pencil and notepaper

Abstract

Transdisciplinarity in higher education is crucial for addressing complex, real-world problems (Bain, Griffith & Varney, 2019). The globalized world requires a generation of change makers that are not only equipped with STEM subjects (Science, Technology, Engineering, Mathematics), but also with skills and knowledge from all other subjects that are needed to create STEAM solutions.

In the first part of the workshop we present the STEAM+ project (2020-2023) funded by the ERASMUS+ program KA3. Two main tools were co-created during the project: “The Menu for Policy inspiration” aimed to inspire policymakers to support transdiciplinarity in higher education, and “The Trail Map” – an instrument for designing transdisciplinary learning experiences for higher education students.

The second part of the workshop invites participants into an active and interactive transdisciplinary experience. Participants will work in groups and co-create solutions for a complex challenge. Their experience, questions and insights will be discussed with the whole audience.

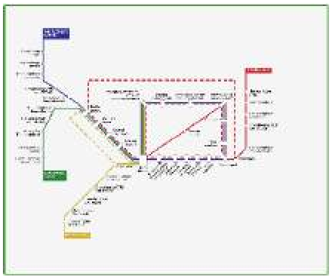
Introduction

The global society faces complex issues that require economically and socially viable solutions; our students are impatient and express their need to act upon it, to get the opportunity to be involved in creating a sustainable future. Transdisciplinarity in higher education becomes an emergent need, a need to create new ways of knowing by widening participation, by implementing new models of partnerships, including lifelong learning, public and private sector, and student partnerships.

The STEAM+ EU project – **Innovating STE(A)M in Higher Education through Transdisciplinary Talent Programs** is a collaboration between partners from nine European higher institutions and additional policy makers. Our goal was to co-create together with students and policy makers two main products. One is aimed at supporting higher education institutions to implement transdisciplinary talent programs “The Trail Map”, and the other at inspiring policy makers at different levels to support and recognize such programs “The Menu for Policy inspiration”.

Workshop structure

In the present workshop we focus on the first STEAM+ instrument: "The Trail Map" (Transdisciplinary Innovation Lab Map). https://steam-plus.vercel.app/trail. This instrument describes and offers scaffolding to a specific approach to working with transdiciplinarity in higher education. The Trail Map is developed through weeklong workshops with students and educators from talentprograms from HEIs in all nine partner countries. The intent was to develop the transdiciplinary approach to working with wicked problems while working with a specific wicked problem; an intentional collaborative ambition of paving the way as we go/learning by doing.



The STEAM+ Trail Map

In this workshop, we will invite the audience to join us on the trail, be part of a transdisciplinarian team and try to find potential solutions to a real challenge. Participants will have to build their team, get different roles in the team, they will have to discuss the challenge, align their understanding of the problem, build a common goal, think about activities needed to address the problem in collaboration with others and finally discuss the best potential solutions.

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Project website www.steamtalent.eu

STEM-EXPERTS VISITING SCHOOL CLASSES IN SCIENCE

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University Collage Absalon

Abstract

´The Danish Society of Engineers´ has made a program for STEM-employees where they visit school classes. The program is called ´Book an expert´. The experts are joining the program as volunteers and visit in a school class for 1-2 hours.

The program offers the STEM-workers a short didactical course (2x4 hours) where they learn about science concepts in school curriculum, how to meet the students level of knowledge, ask open questions, how to start scientific debates in class, and learn how to make small scale scientific experiments with the students. In short, experts learn how to motivate students and how they can become role models for students to learn science and work in STEM fields.

In this study, we investigate which elements the STEM workers use from the course and which learning outcomes the students get from the visit.

Based on the study, it can be concluded that the 'Book an expert' visit scheme in the primary school works extremely well and is experienced as interesting and rewarding by pupils, experts and teachers alike. Furthermore, it is assessed that the scheme fulfills many of the development project's short-term and long-term goal.

Theoretical backgrounds

The theoretical framework used in this study is part of the learning in a context of Socioscientific Issues (SSI) (Zeidler & Nichols, 2009) mixed with learning outputs from ´out-of-school´ settings (Braund & Reiss, 2006).

In their article 'Towards a More Authentic Science Curriculum: The contribution of out-of-school learning' they state that science education is boring and old-fashioned, but that science is interesting outside of school and that teaching can be made much more interesting and rewarding, if the natural sciences were practiced to a greater extent in school, as natural sciences are practiced outside school. They argue that this can be done by students working with more problem-oriented and open-ended issues, and by having them solve problems that science does in reality. Among other things they pointers:

> ”…that authentic school science should provide experiences that are more in line with the sort of activities that scientists and technologists do in the real world of science…” (p. 1375).

Research in Out-of-school learning has pointed out, that social and cultural factors are important, when we want to know more about what is happening when students meet the real-world context. Leonie Rennie et al. have shown us, how important these social and cultural aspects are:

“Out-of-school learning is strongly socioculturally mediated, so research designs need to offer opportunities to explore social and cultural mediating factors including the role of conversations, social learning networks, cultural dimensions, and the use of groups as well as individuals as the unit of analysis” (Rennie et al., 2003, p. 115).

Research question

“What kind of learning outcomes can we see from a 1-2 hours visit from a STEM-expert in a school class?”

Research methods

The evaluation consists of a qualitative and quantitative evaluation. The qualitative evaluation is based on classroom observations of 13 visits to 13 schools, 18 focus group interviews with a total of 67 students as well as individual interviews with 11 teachers and 13 experts. The quantitative part consists of answers to questionnaires from 271 students divided into 4th - 10th grade and answers from 19 teachers and 8 experts.

The evaluation design is based on impact evaluation (Dahler-Larsen, 2018), and is based on a mixed-methods design with a view to achieving a deeper and more holistic investigation of how the Book an expert scheme works and fulfills some of the central objectives. The evaluation consists of a qualitative and quantitative evaluation. The qualitative evaluation is based on 1) classroom observations and 2) semi-structured focus group interviews with students and 3) individual interviews with teachers and experts. The quantitative part consists of questionnaires sent to students, teachers and experts. All data has been anonymized.

In the questionnaire, the pupils have been asked to answer a number of statements, and have also had the opportunity in open answer categories to elaborate on what they think was good about the visit and what could be better. The questions investigate whether the students think that the visit has given them a good idea of what science can be used for, as well as how science is relevant in their everyday life. They are also asked whether the visit has given them an idea of what you can work with if you have a science/technology education, and whether after the visit they have become more interested in working with science, technology and/or mathematics at school or when they become adults. In addition, they are asked about their views on the connection of the visit with their teaching in science, how the exercises/activities/questions of the visit work, and whether the visit has given them new knowledge about science.

Results

The study indicates that the visit can have a positive impact on students' interest in or perceptions of STEM jobs and educations. The experts' presentation of their own education and career path seems to inspire some of the students, so that after the visit several students have wanted to investigate the STEM path when they have to consider possible educational paths. This may be due to the experts' concrete examples of how professional knowledge is used 'in reality' with their personal stories about education and jobs. In interviews, some of the students stated that their STEM education and career plans have been strengthened, while others, who are still undecided, see it as a good inspiration.

Discussion and conclusion

On the basis of the study, it can be concluded that the 'Book an expert' visit scheme in the primary school works extremely well and is experienced as interesting and rewarding by pupils, experts and teachers alike. Furthermore, it is assessed that the scheme fulfills many of the development project's short-term and long-term goals.

Apprentices also express that they find it exciting to hear about different education and job opportunities. The gender perspective that emerges in the data collection indicates that there are more than twice as many boys as girls who had plans for jobs and education in natural science and technology before the expert came. On the other hand, there is a larger percentage of girls compared to boys who change their attitude based on the visit. Overall, there is an increase in students' interest in working with STEM because of the expert visits - both among boys and girls. Although the study cannot unequivocally conclude that more students change their educational and job plans as a result of the visit or can say something about whether it will be important in the long term, it can be concluded that for some students the visit contributes to expanding their knowledge to STEM jobs and educations in a positive way.

Central topics for discussion could be:

- What could be the long-term effect of a school visit from a STEM-expert?
- Does it lower the authenticity if the experts learn a lot of didactics before visiting school classes?
- How short can a visit be, if you want to learn the students more about the culture in STEM-jobs and STEM-education?

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CAPTURING AND ANALYSING STUDENTS ENGINEERINGSPROCESSES USING VIDEOETNOGRAPHY

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Abstract

This paper presents the results from research done into developing a method for capturing and analysing student engineering processes. The focus of the study has been students in primary schools. Using a video-ethnographical approach for capturing individual and group engineering processes, it was possible to develop a coding scheme for capturing students engineering subprocesses. The main findings indicate that a meaningful analysis should both focus on distinguishing students´ physical activities and verbal communication. The study uses an engineering design model with seven subprocesses. The development of the coding scheme shows that these subprocesses are not as distinct as theory tells both in description and in order. Furthermore, our research indicates that some subprocesses of engineering may overlap. The study finds video-ethnographical analysis as a useful tool for exploring group engineering subprocesses from a student perspective. These findings may be valuable to researchers interested in student centred engineering-processes or teachers evaluating engineering teaching.

1 Introduction

In the last decade engineering has become a widely used didactical approach to science education. This can be attributed to a focus on the demand for engineering competencies like e.g. design skills and prototyping. However, it also affords a more student-centred approach to science education where students can experience science education as more relevant. In Danish science education this is visible with the increase in funding of engineering- or STEM-grounded projects and the presence of engineering in the national curriculum.

Engineering learning processes are in comparison to traditional science teaching most often both problem-based and student-centred and relies ideally on the students' ability to autonomously work on open ended problems (Cunningham & Carlsen, 2014; Brophy et al., 2008). To truly capture and understand students' engagement in engineering processes this requires methods for capturing students *in situ* with minimum interference from teachers and researchers, as well as a valid method for analysing student engineering activities. The current study addresses the following research questions:

1. How can we collect empirical data from the students engineering groupwork with minimal intrusion in a teacher-student context?
2. How can we analyse such data to gather meaningful coverage of students' autonomous work?

Findings may further the methodology of capturing student engagement in engineering processes or may provide suggestions for evaluating didactical models of student-centred learning

2 Theoretical backgrounds

The engineering design process model (EDP model) used in the study, is developed through the large-scale implementation project *Engineering in the school.*

A project with the purpose of developing and implementing engineering as a student-centred method in schools and engineering teaching activities (engineerthefuture.dk).

Student groups are engaged in open ended problem-based learning, facilitated through seven subprocesses (Auner et al., 2022) (see Figure 1):

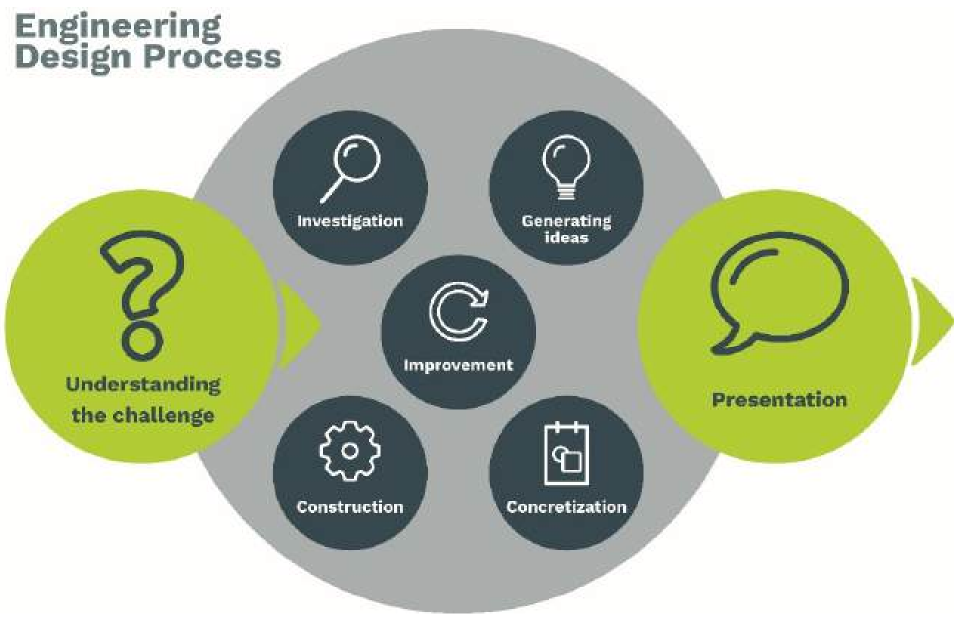

Figure 1. *The Danish EDP-Model, showing 7 subprocesses in a didactical framework.*

1. *Understanding the Challenge*: The teacher presents a challenge. Student groups and the teacher agree on the goals and requirements for the upcoming work. The groups describe the challenge in their own words.
2. *Investigation*: Student groups map out relevant necessary knowledge. The students acquire and gather information.
3. *Generating Ideas*: Student groups develop, negotiate and select ideas to proceed with.
4. *Concretization*: Student groups specify, sketch, and select materials for the concrete idea. They plan the next steps and allocate tasks.
5. *Construction*: Student groups realize their idea into a prototype using chosen materials and tools.
6. *Improvement*: Student groups test, evaluate, and enhance the prototype, developing it into their solution.
7. *Presentation*: Student groups present their solution and disseminate considerations concerning the design process, and choices made along the way.

Students work in engineering processes has a high level of complexity. Observing student learning in engineering subprocesses can be an arduous and extensive task. Students are both engaged in groupwork, and they are moving around to collect materials and make investigations. Video-ethnography used in this study presents a method capable of collecting many such details from the perspective of the student and the collected data may be analysed repeatedly (Heath and Hindmarsh, 2002).

3 Research methods

A head-mounted camera is used on a single student in each group to be able to capture while the students are moving around. This is a choice of student perspective and closeness (Blikstad-Balas, 2017), to observe, what the student is doing, however at an angle so to observe all group members.

The videos were coded using the seven engineering subprocesses in the EDP-model. To develop upon the predefined codes, we chose two cases, each with a student group working in an engineering process. The cases were selected for information-orientation in relation to their expected maximum variation (Flyvbjerg, 2006). The cases were selected to comprise all the engineering subprocess and two different age groups (grade 5 and 8).

The video-etnographical data was analysed by two researchers in one-minute intervals using the original scheme of subprocesses. The coding was done in 2 consecutive sessions for each video (approximately 1 hour each), where the second session was used as a code refinement process. Intercoder reliability by Cohens kappa was used as a reliability measure (final Cohens Kappa 0,77).

4 Results

In *Table 1*, the developed coding scheme from the initially described EDP-model is presented. In general, our results show an overlap in several of the subprocesses. The development of the subprocess codes has a focus on the observed activities, which the students engage themselves in and how some subprocesses appear themselves during the entire process.

Table 1: *Showing development of codes in the study*

	Initial subprocess description	Appearance of the subprocess in the study
Understandingthe Challenge	The teacher presents a challenge. Student groups and the teacher agree on the goals and requirements for the upcoming work. The groups describe the challenge in their own words.	In theory this subprocess was only occurring at the beginning of the overall engineering process. However, this subprocess presents itself also during other subprocesses, where the students need to revisit and understand the challenge, they are working on, in order to continue their work.
Investigation	Student groups map out relevant necessary knowledge. The students acquire and gather information.	This subprocess covers a broad area, including searching on internet, test, experiments, mental simulations and sharing information already available between members of the same group. The validity of the information gathered should not be accounted for.
Generating Ideas	Student groups develop, negotiate and select ideas to proceed with.	This subprocess is challenging to code since ideas rely on the novelty and influence, the idea has on the design. It is decided that any idea which the students generate, should be coded as generating idea if it relates to the problem.
Concretization	Student groups specify, sketch, and select materials for the concrete idea. They plan the next steps and allocate tasks.	This subprocess occurs mostly between the subprocesses *Generating Ideas* and *Construction*. If the changes are only concerned with practical matters, e.g. shortage of some materials it is considered *Concretization*.
Construction	Student groups realize their idea into a prototype using chosen materials and tools.	This subprocess separates simple task distribution from the concretization task distribution subprocess. When the task distribution only concerns smaller things e.g. who holds a scissor or a screwdriver it is considered *Construction*
Improvement	Student groups test, evaluate, and enhance the prototype, developing it into their solution.	This subprocess occurs only after the first prototype is made and does not present itself without another subprocess present.
Presentation	Student groups present their solution and disseminate considerations concerning the design process, and choices made along the way.	In theory this was considered the last subprocess. However, it turns out, that students may present their product many times in interaction either with other students or the teacher.

This study suggests the necessity to code the subprocess for both spoken and physical activities. Sometimes students communicate verbally in one subprocess and work physically in another subprocess simultaneously. Some subprocesses present themselves as more verbal e.g. presentation, while others are more physical such as *Construction*. With the distinction between the physical and verbal activities it becomes possible to capture other overlaps between the subprocesses and how they interact.

5 Discussion and conclusion

Our study suggests the possibility to collect empirical data from student engineering processes without inflicting with a teacher-student context, using a head-mounted camera during engineering processes. This clarifies when noting the student teacher interaction during the video-ethnographical analysis and observing a distinct change in the student behaviour with or without the presence of a teacher during some of the subprocesses. Interaction between students and teacher has a significant influence on the students' autonomy, after the teacher leaves the interaction. It may be relevant to investigate and study the teacher influence.

Findings suggest that, when coding and analysing engineering activities, the overlap in subprocesses and the difference in physical and verbal activities may be an important feature when capturing meaningful data concerning students autonomous group work. Further investigations into the patterns of overlap during subprocesses may provide insight into student workflow during engineering processes.

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A TEACHER-RESEARCHER COLLABORATION IN PRIMARY SCIENCE

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Abstract

This poster presentation will present findings from a study of collaboration between a researcher and primary teachers working together to develop a tentative didactic model through didactic modelling. The study is part of an ongoing doctoral project in science education. The theoretical framework and central concepts in the study are mainly grounded in Dewey's pragmatic philosophy. The study involved teachers from two primary schools in Sweden. The empirical material consisted of audio- and video recordings of conversations with teachers (grades 1-6) and from lessons in two classes (grade 3). Preliminary findings indicated that creativity was an important factor in the modelling process. The joint teacher-researcher collaboration led to distinct changes to the model and several suggestions on how it could be modified and developed further. The organisation of the mangling phase and the creative activities during the meetings generated new versions of the model's illustrations, which in turn generated ideas for new applications.

Introduction

This presentation will describe some preliminary findings from an ongoing doctoral project in science education in primary school. The project as a whole consists of two parts, and the presentation will focus on the second, where teachers collaborate to further modify the tentative model from the first part (Weiland, 2019). In order to make the model functional as a didactic tool for teachers in early grades, a researcher and primary school teachers worked together to develop the model through didactic modelling. The definition of didactic modelling used in this study, is described in Wickman, Hamza and Lundegård (2018; 2020) and Ingerman and Wickman (2015).

Teachers make many didactic considerations and need to have a solid professional base on which to ground their choices. In order to distinguish, manage and reflect on a complex content, teachers need a variety of tools. For this purpose, several types of didactic models and conceptual schemes have been created (cf. Jank & Meyer, 2006; Sjöström, Eilks & Talanquer, 2020; Wickman, Hamza & Lundegård, 2018; 2020).

Didactic models are helpful in analysing, organizing, and planning teaching in a systematic way. They can also be used for arguing and reasoning about different didactic choices. Didactic models can be said to function as didactic tools that, by providing teachers with concepts and principles, can increase the teachers' possibilities to make relevant distinctions and judgments of certain features of teaching (cf. Joffredo-Le Brun et al., 2018; Wickman, Hamza & Lundegård, 2018). Working with didactic models is an essential part of the discipline of didactics (Arnold, 2012; Jank & Meyer, 2006).

Didactic models are designed through didactic modelling, where modelling involves both the application and production of didactic models. The production of a didactic model has three integrated phases - extraction, mangling and exemplifying - and is carried out in interaction between theory and practice (Wickman, Hamza & Lundegård, 2018; 2020). Generating and modifying didactic models requires a close and reciprocal exchange between teachers and researchers.

Aim and research questions

The study aims to explore how the second phase of didactic modelling can be organised to incorporate and take advantage of teachers' experience and expertise in the process. An extracted didactic model, called Didactic Score, forms the basis of the study and thus served as a starting point for the mangling process. The research questions are as follows:

1: How can a mangling of a didactic model be organised where teachers' experience and expertise are taken into account and utilised in the modelling process?

2: What do teachers contribute to the model when their experience and expertise are taken advantage of and used in the mangling process?

Theoretical background

The study is based on the pragmatic approach and Dewey's philosophy, where the concepts *experience* and *transaction* are of central importance. Experience is encompassing both the process and the content of the interaction between the individual and the environment (Dewey 1938/1997). The transactional approach describes how meaning-making occurs in encounters where individuals interact with each other and the environment, in a mutual and simultaneous process. Transaction is significant in relation to the study, where meetings and interactions between teachers, the model and the school environment are studied.

To analyse how relations were established between the model and the teachers' new proposals for modifications of the model, we used Practical Epistemology Analysis (Wickman & Östman, 2002). The terms *encounter* and *relation* were employed in the analysis, which encompassed empirical material derived from both transcripts, collages and sketches of the model's illustrations. The analysis of the data considered both linguistic and non-linguistic relations constructed regarding the potential contributions of teachers during the modelling phase. This involved discussions and other activities related to the work on the model.

Methodological approach

The study was conducted in two different schools in Stockholm County, Sweden. A small group of teachers (2-7 persons depending on the meetings) and students from two classes in grade 3 participated in the project. The empirical material comprises conversations and lessons from a total of 12 different types of sessions. Data consists of field notes, video and audio recordings, collages/sketches of the model, photos and copies of students' work.

The mangling was designed to generate new ideas about the model and its function. To encourage creativity, the process included hands-on aesthetic activities. These were motivated by a movement towards possibilities, where imagination also played a role in creating new combinations.

Results

The mangling generated a large number of suggestions on how to modify and develop the model. The organisation and creative activities generated new versions of the model's illustrations, which in turn generated ideas for new applications. In this way, the collaborative mangling process led to modifications of both the illustration and the model's range of applicability.

To cut and reassembled the model and make new illustrations in the form of sketches was a useful approach to introduce a model that was intended to change. The creative elements also helped generate ideas for something that might not have been thought of before. Furthermore, the diversity of activities enabled participation in a multitude of ways, establishing both non-linguistic and linguistic relations as the model was modified.

- The illustrations were modified in four basic ways, through assembly, completion, clarification, and expansion. For example, the illustration was proposed to be modified to clarify the model's components, purposes and how the three content areas alternate between primary and secondary. Proposals were also made to expand the model for additional content.
- Suggestions that broadened the model's application range included: the model for both planning and reflection, for both students and teachers, to clarify lesson content, and to be used in several school subjects, not just in primary science. To make comparisons between school years or to use it in lesson observations, both individually or in collaboration with colleagues. To use it as a tool for reflection, to evaluate lesson outcome and whether it turned out as intended - or whether a certain content had ended up in the background.
- The teachers also described the benefits of using the model and perceived it as a potentially functional tool that could be helpful in their teaching of primary science.

The joint mangling led to distinct changes of the model. These have been incorporated into the model, which is further developed. For example, teachers contributions in relation to language support, extended communication and inclusion in primary science have led to the expansion of the content areas of the Didactic Score model.

Discussion and conclusion

A more detailed analysis and refined results will be presented at the poster presentation, together with a discussion of the implications of the results for teacher-researcher collaboration during the mangling phase of didactic modelling. The potential significance of the results for other teacher collaborations will also be discussed.

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A FRAMEWORK FOR GROUP DISCOURSE ANALYSIS AND ITS APPLICATION ON IBSE ACTIVITIES IN TEACHERS EDUCATION

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Abstract

As part of the TRELIS project we have developed inquiry-based science education activities (IBSE) that use explorative talk as a tool. To understand the efficacy of the activities for spurring explorative and productive talk, we have analysed the group dialogue with a two-step framework adapted and expanded from Mercer (2019) and (Bungum et al., 2018). In the first step we find that the IBSE activities do not spur explorative talk, with few of the conversational elements are directly coded as explorative talk. But in our second step, where conversational elements coded as individual statement, disputational talk, cumulative talk are re-evaluated in the light of later elements, and including data as the end product and student reflection notes, we show that the activities are closer to achieve the goals of the IBSE activities. We present here both the analytical framework and the results from its use on the transcripts from the IBSE activities to show how this second step is altering our perception of the dialogue and the efficacy of the activities.

1 Introduction

In the research project Teachers' research literacy for science teaching (TRELIS) led by Oslo Metropolitan University (OsloMet), teacher educators at both OsloMet and Western Norway University for Applied Sciences (HVL; Norwegian abbreviation) have been working on to develop the content, structure and work forms in the science teacher education. This study is part of work package four that especially is focusing on developing inquiry-based science education (IBSE) activities that supports explorative dialogue as a tool (Mercer, 2019; Mercer & Dawes, 2008, 2014).

Inspired by Frøyland et al. (2016) we developed an activity were the students should through explorative dialogue create a flowchart for rock specimen identification that they would try out in an un-supervised field trip. Later, we expanded the study by including a similar activity where the students should develop a tree of life in zoology. Both activities share the same underlaying motivation that by focusing on the systematics of classification instead of memorising details to identify a small selection of species, the students will gain a tool that will serve them better in their career (Frøyland et al., 2016; Palmberg et al., 2019; Stolpe & Björklund, 2013).

By using the presence of productive talk to be an indication of the fitness-for-purpose of the activity design, we analysed student discourse from the first run-throughs of the geology activity. From this analysis we iterated on both the structure for the student activity and the instructions that the teacher gave the students before and during lectures. We used this insight to develop the biology activity. In this initial analysis, and from Sæbø's work for his master thesis (Sæbø, 2021), we saw the need to modify our analytical framework that we present here.

In this study we use the analytical framework to investigate group-dialogue recorded during the student activity, supported by the student reflection notes and the end products, to address the following research questions:

1. *What characterises the student dialogue during the inquire-based activity?*
2. *What benefits does our new framework provide in terms of understanding the effectiveness of the activities?*

2 Theoretical backgrounds

Inquiry-based science education activities (IBSE) is long being promoted as a central part of science education in official policy and curriculum documents and in the science education research literature (Crawford, 2014; European Commission & Directorate-General for Research and Innovation, 2015; Furtak et al., 2012; Gericke et al., 2023; National Research Council, 1996, 2000; Rocard et al., 2007; Rönnebeck et al., 2016). A recent review by (Strat et al., 2023) found favourable outcomes of IBSE for science understanding, teaching competence and improved attitudes or self-efficacy when used in science teacher education. IBSE's widespread adoption are not without several caveats related to its use, also from the abovementioned references.

In the meta-analysis by Furtak et al. (2012) it is pointed out that while the overall results indicate a positive effect, secondary finding is that the teacher's role in actively guiding the students' activities are important for the learning outcome. They find that to help students learn science, the teacher must engage the students in "generating, developing, and justifying explanations as part of other science activities […]". Kolstø (2018) stress the need for the teacher to create a robust set of scaffoldings to help the participants through different phases of reflective thinking. Strat et al. (2023) found that the teacher students find it challenging to implement IBSE in school placement after having learned about it during teacher education.

3 Research methods

The study is based on the analysis of transcripts of sound recordings from student dialogue during group work, reflection notes written by the students, partly group and partly individual reflection notes, and the students' product created during the discussions.

We have a deductive two-step coding process. In the initial step we code the transcripts into six categories; non-relevant talk (NRT), destructive talk (DeT), individual statement (IS), disputational talk (DiT), cumulative talk (CT), and explorative talk (ET). This set has been adapted and expanded from (Mercer, 2019) and Bungum et al. (2018).

We keep all three categories of talks from Mercer (2019), disputational talk, cumulative talk, and explorative talk. In this we differ from Bungum et al. (2018) which replaced disputational talk with individual statements. We expand our set with non-relevant talk (Sæbø, 2021) that are conversational elements that is not relevant for the subject at hand. Destructive talk can despite being on topic be directly destructive for the educational activity and a productive dialogue. Both gives us a better insight in the dynamic among the participants but are not explored in this study. We do not include confirmatory talk to reduce the number of categories but acknowledge that elements that we code as IS and CT could have this label.

After the initial coding process, we are left with a series of conversational elements where only those directly coded as ET can be considered productive without further deliberations. But from the reflection notes we find that the student felt that the activity has been explorative and productive even though our first step finds few ET elements. Therefore, we analyse in step two the conversational elements in relation to the reflection notes and the end products, to reach an overall conclusion about productivity of the activity.

In step two elements coded as ET are considered as productive per definition, and likewise we directly disregard elements coded NRT and DeT as non-productive. Those elements that have been coded as IS, DiT and CT, are then subcoded to productive (P) or non-productive (NP). This is done by analysing these elements in relation to later conversational elements, the student product, or indications found in the student reflection notes. productive. The elements coded as non-productive are relevant enough to not be coded as NRT, e.g. talk about natural science, even geology or biology, but could have been removed from the dialogue without altering the outcome. They could still have had an influence on the participants, but we cannot detect it in our analysis.

We differ from the definition of productive/non-productive in Bungum et al. (2018) were they use productive dialogue related to the interactional aspects of the conversational elements within the dialogues, while we include more data to infer the productivity of the elements.

4 Results

Preliminary findings indicate that, subsequent to the initial coding of the first iteration, it was predominantly cumulative talk (CT). Additional elements were identified as non-relevant talk (NRT), a limited number as disputational talk (DiT), and only a few segments were categorized as exploratory talk (ET). Nonetheless, a discernible progression in how students addressed their assigned task was evident. Upon re-examination of the cumulative talk (CT), a substantial portion was deemed productive, with some segments subsequently reclassified as exploratory talk (ET) across separate elements. In contrast to the limited initial identification of exploratory talk (ET) segments, only one was conclusively categorized as true exploratory talk. It is noteworthy that certain segments initially labelled as productive cumulative talk (CT) were, upon closer scrutiny, interpretable as exploratory talk (ET), particularly when considering the final outcomes of the student activity and reflection notes.

5 Discussion and conclusion

The results presented here are from the first iteration of the student activity, revealing a prevalence of cumulative talk (CT), albeit notably productive. Despite of CT characterizing the activity, our observations indicate that both pre-service teachers and pupils effectively completed assignments. This success persisted even when preliminary results suggested that a considerable portion of the pre-teachers' discourse might have been initially deemed non-productive, as evidenced in prior studies such as (Bungum et al., 2018) since much of our CT resembles confirmatory talk. During our initial coding, certain segments of cumulative talk were subsequently reevaluated in successive coding phases, ultimately recognized as contributing productively. The second coding steps, conducted with a focus on the final products, unveiled instances where talk initially labelled as non-productive proved to be integral to the overall outcomes. We therefore argue that using a multi-step approach within a top-down deductive framework demonstrates efficacy, yielding nuanced insights into the effectiveness of student activities.

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CURIOSITY DRIVEN INQUIRY OF REAL-LIFE COMPLEX PROBLEMS IN PHYSICS; EXPERIENCES FROM SCIENCE TEACHER EDUCATION

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Abstract

Research shows that authentic context in science education may promote engagement and meaningfulness for learners. It has also been argued that student-centred approaches where students are engaged with a problem they can relate to, foster deeper learning. Physics teaching, however, has been known to be dominated by transmissive pedagogy and teacher-centred approaches. In our study, we combine authenticity with inquiry/project-based learning of physics where teacher students based on their curiosity chose physics problems from real-life as point of departure for inquiries. Our study investigates the experiences teacher students get when learning physics by using this approach for one semester. We analysed thematically their reflection notes at semester end. The results show that overall, the students have had positive experience in learning physics by this approach in their teacher formation. Though challenging, the combination between IBL/PBL and connection to real-life seems to be beneficial in making physics learning more interesting and motivating, engaging teacher students in active and in-depth ways, fostering deep learning & sense of mastery. Further investigation is needed into how their experience may influence their future career as science teachers. Our study contributes to the still lacking research on inquiry-based learning in teacher education context.

1 Introduction

Authenticity has been discussed in education for decades. The authenticity in science education not only concerns the design of educational activities, but also the content of what is being taught (Anker-Hansen & Andreé, 2019). The empirical studies by Crawford (2012, p.39) show that learning activities become meaningful for children who engage in real-world investigations. They connect their prior knowledge to new learning experiences and given appropriate support they will gain a deeper understanding of science. Arokoyu (2018) shows that chemistry and physics students that were taught using real-life phenomena performed better than those taught without. It was recommended to integrate real-life phenomena into the curriculum and teaching of the subject.

Research has shown that in practice there is still a dominance of transmissive pedagogy and teacher-centred instructions in physics teaching (Duit et al., 2014). It is argued meanwhile that student-centred approaches, such as Inquiry-Based Learning (IBL) or Project-Based Learning (PBL) – where students are engaged with a problem they can relate to – foster deeper learning and can lead to conceptual understanding (e.g. Odell & Pedersen, 2020). Besides, the students are more likely to succeed at applying what they learn when the IBL/PBL-approaches utilize contexts from real-life (Odell & Pedersen, 2020).

Although there has been much research on inquiry approaches in school contexts, to our knowledge little has been done in the context of teacher education (Strat et al., 2023). We investigate how the use of IBL/PBL on real-life problems can contribute to make physics learning interesting and motivating to teacher students. In this proposal, we focus the study on primary science teacher students who learn physics in their teacher education, and our research question is: *What experience do primary science teacher students get when learning physics by using inquiry-based approaches on real-life complex problems?*

2 Inquiry-Based and Project-Based Learning

Project-Based Learning (PBL) (Odell & Pedersen, 2020) is a model that organizes students' learning around projects done over a certain timeframe. PBL is associated with cooperative learning and Inquiry-based Learning (IBL) or scientific practices (Crawford, 2014). These approaches involve learners tackling processes like raising challenging questions, planning investigations, selecting scientific approaches, collecting data, seeking explanations, evaluating and communicating the results and proposed solutions. The subject of the investigations can be questions taken from authentic problems faced in real-life (Odell & Pedersen, 2020). Through IBL/PBL, students not only apply, analyze and evaluate their existing scientific knowledge, they are also encouraged to create new knowledge in terms of the solutions proposed. One approach proposed by The Norwegian Research Council is the Nysgjerrigper method (Forskningsrådet, 2023). ("Nysgjerrigper" is what we call a really curious person in Norwegian).

The Nysgjerrigper method is a representation of the hypothetical-deductive method adapted to primary school pupils (Forksningsrådet, 2023) where pupils research something they are curious about. It consists of 6 steps: *1) I wonder why,* find a research question from the pupils' everyday life. *2) make hypotheses,* based on prior knowledge and theory. *3) make a plan,* and design experiments to test the hypotheses. *4) test the hypotheses 5) discuss and summarize,* pupils are encouraged to use theory and other sources like experts in addition to experimental data to answer their questions. *6) Share with others.*

3 Research methods

Our study was conducted during a one semester physics course for teacher students at a Norwegian university. Nineteen teacher students in their 4th year of the 5-year Teacher-Education-programme for Year 1-7 participated in the course. They had previously completed two courses (45 ECTS in total) in natural science and science didactics that included modules in physics. The physics course was project-based using the Nysgjerrigper method as framework. The students were asked to use their curiosity to find research questions connected to a physics phenomenon from their everyday life (Arokoyu, 2018), and make those questions as point of departure for creating physics projects to be done groupwise for the whole semester; one project per group of 3-5 students.

The teacher students formulated hypotheses based on prior knowledge in physics, designed experiments, read up on theory and spoke to experts on the topic. Their research project was presented in a semester report and an oral presentation at the end of the term. They also submitted individual reflection notes where they answered to open-ended questions given by the researchers asking them to reflect over their experience doing the course and implications for their future work as teachers.

The students consented their reflection notes to be used in our study. The notes were analyzed using thematic analysis (Braun & Clarke, 2022); they were coded, and similar codes were combined to generate and develop themes (Fig.1). Direct quotes were translated and adapted into English preserving the students' meaning.

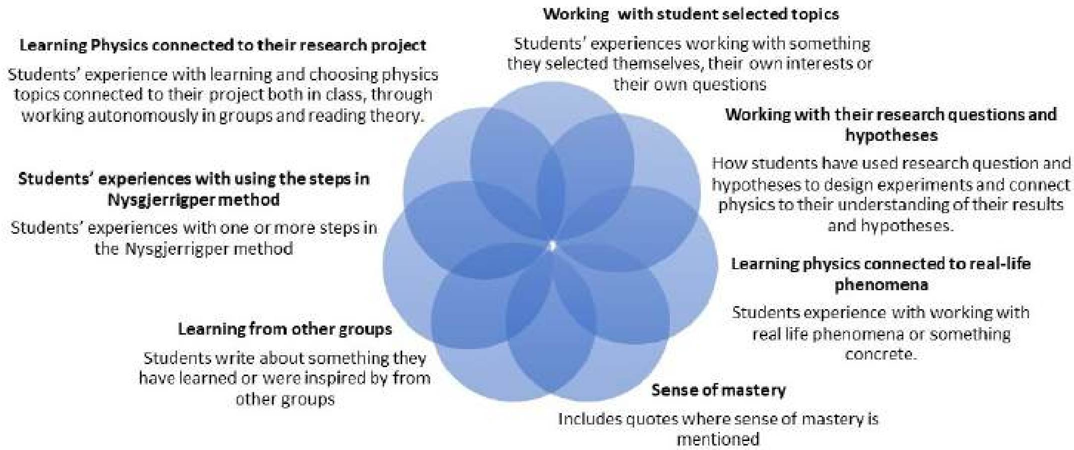

Figure 1. *The themes developed in the analysis of students' reflection notes.*

4 Results and discussion

Here preliminary results are presented and discussed. Firstly, students found it motivating and meaningful to work on a project that interested them and appreciated the possibility to decide topics and formulate research questions themselves. They experienced the physics contents as authentic (Anker-Hansen & Andreé, 2019), found it easier to learn physics and thought they will remember the theory longer, resonating with Crawford (2012), as a student wrote:

> *I have learnt to investigate questions I have. I have learned a lot from it because I have probably investigated more when I can answer my own questions and not something I have to learn or something others expect of me.*

Further, the groups used the research questions and hypotheses actively to find topics in physics to connect to their project. They found it interesting to plan the experiments and problem solve their work to test the hypotheses, suggesting the meaningfulness of the activities (e.g. Crawford, 2012).

The research questions connected to real-life phenomena helped them see connections between everyday life and physics, made it easier to understand physics theories, and to see connections between different theories in physics which they would probably not have succeeded had the teaching been done fragmentedly topic wise (e.g. Duit, 2014). It seems that implementing the IBL/PBL method this way has facilitated deep-learning and the sense of mastery (Odell & Pedersen, 2020). A student wrote: *The sense of mastery one feel when seeing connections and discover new things has been one of my favorite things.* They saw the need for learning more topics in physics to understand and discuss the results and describe their phenomenon.

Some students thought it was challenging to work on their own with theory for the project. It was useful to talk through the theory in groups or with teachers in these situations, underlining the value of cooperative learning (Odell & Pedersen, 2020).

Most students appreciated time to work in depth on their research topic which they found interesting, and it was less stressful to focus on a few topics in physics. Some saw the value in learning more topics in physics or want to spend less time on their project. One student saw the value of going in-depth and using the theory fully without simplifying physics, and recommended choosing research questions that limit the topics in physics.

5 Conclusions

Overall, the students have had positive experience in learning physics by this approach in their teacher formation. Though challenging, the combination between IBL/PBL and connection to real-life seems to be beneficial in making physics learning more interesting and motivating, engaging teacher students in active and in-depth ways, fostering deep learning & sense of mastery. Further investigation is needed into how their experience may influence their future career as science teachers.

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ON THE MEANING-MAKING OF LARGE AND SMALL SPATIAL SCALES: A CASE STUDY OF EXPERTS IN MOLECULAR BIOLOGY

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Abstract

Spatial scales are fundamental for understanding many scientific phenomena and processes. Understanding small and large scales is at the same time something that is perceived as very difficult by students, risking limiting the interest for science; the subjects are simply seen as difficult. The purpose of this project is therefore to gain more knowledge about how and what semiotic resources can facilitate the understanding of spatial scales and thereby enhance the meaning-making of scientific phenomena and processes. We see this as imperative to create interest in science, something that is important both for having scientifically literate citizens and generating more engineers and doctors in science. In this case study we will investigate this by using exercises tailored for understanding spatial scales through semiotic resources. We have video recorded interviews of experts in molecular biology. These interviews are analyzed with a focus on scale aspects, and will contribute to insights into how the meaning-making of small and large spatial scales can be described and how it is communicated within the discipline. The results show that there are limited numbers of strategies used by the participants. The results will contribute to advices and guidelines for working with spatial scales in science teaching.

1 Introduction

A hallmark of much of scientific practice is the necessity of dealing with phenomena that are much larger or much smaller than oneself. This presents scientists and students of science with an ever-present perspectival challenge to 'see' beyond their immediate experiences in non-experienceable spatial scales, usually by proxy of data collected with scientific instruments and/or the depictions of scientific visualisations. However, despite the near ubiquity of unfamiliar spatial scales inside and outside the doing/teaching/learning of science, remarkably little has been done to investigate how people come to make meaning and communicate spatial scales and which types of teaching interventions can best support learning in this interdisciplinary area. We have previously conducted a pilot study on experts in space physics where various strategies for communicating meaning-making were identified (Eriksson & Hellgren, 2023). Most other research to date relevant to spatial scales has focused on specific scale domains in specific disciplines, from evolution in biology (Göransson, 2021; Tibell & Harms, 2017) to cosmological scales in astronomy (Brock et al. 2018; Salimpour et al. 2022; Stenlund 2023). Our study approaches students' awareness of spatial scales from the perspective of spatial size *per se*, and will examine how experts´ knowledge in one spatial domain can be transferred into other domains. As such, the research team views the understanding of spatial scales as imperative for all science disciplines and as a pressing educational challenge to address for all science pupils and students, regardless of level in the educational system. These topics are severely under-researched as of now, but identified as difficult for secondary school students and university students to understand and comprehend (e.g., Tretter et al. 2006; Eriksson et al. 2014; Wait, et al., 2019).

Spatial thinking, where spatial scales is part, is a concept that has been increasingly associated with success in STEM subjects (NRC 2006; Tretter 2006). Several longitudinal studies have found that students' spatial thinking ability statistically accounts for the variation in which of those students chooses to study science (e.g., Hegarty, 2014), and elsewhere it has been claimed that spatial thinking skills predict the success of and how far a student will progress in science education (Newcombe, 2012; Uttal and Cohen, 2012; Wai, Lubinski & Benbow, 2009). However, little is known about the learning possibilities that such collection of semiotic resources can present to 'reflective learners' (Linder & Marshall, 2003) and how the ability to extrapolate three-dimensionality is related students' level of disciplinary knowledge (Eriksson et al., 2014). In fact, very little conclusive evidence has yet been found in the literature to support this connection (Hegarty, 2011; Heyer et al., 2013).

2 Theoretical backgrounds

The theoretical framing of our project draws on *Social Semiotic in University Physics Education* (Airey & Linder, 2017) in general and in particular on Eriksson's recent research and theoretical contributions to social semiotic (see reference list). To support the analysis and theory construction, *phenomenography* and *variation theory of learning* will be used (Marton & Booth 1997).

Based on the above, we aim to address the following research questions:

RQ1: -*What are the qualitatively different ways the experts experience and communicate spatial scales?*
RQ2: -*How do the experts convey their experience of spatial scales during engagement with their peers?*

3 Research methods

This study is predicated on an exploration of how science students experience spatial scales inspired by combining social semiotics and variation theory of learning (Eriksson, M., et al., 2020), which can be considered amongst the family of inductive analytic frameworks that endeavour to examine what emerges from the data itself rather than from the application of an existing theory. Data collection comprised video recordings of participants while they completed a ranking task for objects ranging in size from a Proton to the Universe, see Figure 1. The task was designed to encourage the participants to elaborate on their subjective experience of spatial scales. The participants' meaning-making experiences of spatial scales were interpreted from their multimodal utterances, patterns of experience will be identified, and a set of qualitatively different strategies of experiencing and communicating spatial scales will be generated.

Figure 1*. The participants were asked to rank the objects based on their size.*

4 Results and discussion

We have identified five different strategies, including sub-strategies, that experts in physical chemistry engage in (see Table 1). The analysis has revealed that the experts in physical chemistry uses iconic representation to a higher degree for submicroscopic/microscopic objects than for astronomical objects. Additionally, they engaged in the strategy Relating objects to a higher degree for submicroscopic/microscopic objects than the astronomical objects, in other words for the topics of their expertise.

Table 1: *Strategies identified from the data analysis.*

Strategies	Sub-strategies
Anchoring	**Object anchoring**
	Number anchoring
	Experience anchoring
Analogies	**Utilising analogies**
	Resisting analogies
Scales	**Linear scales**
	Logarithmic scales
Representation usage	**Reps. as symbol -Pictorial**
	Reps. as detail-bearing pictures-Iconic
Relating objects	**Nestedness of objects**
	Interaction of objects
	Calculation

4 Discussion and conclusion

From the study we have performed we find that the experts in physical chemistry uses similar strategies as the experts in space physics (Eriksson & Hellgren, 2023). Beside this we find that the physical chemists use various strategies to make meaning and communicating the spatial scales of the objects, however this group hesitated about using logarithmic or linear scales, but decided to use the logarithmic scale at the end. The ranking task was a real challenge when it comes to communicating and explaining how big or small a particular object is in relation to another. When communicating their reasoning about their choices for placing the objects on the scale, the physical chemists mainly engaged in strategies involving analogies and experiences, and this was rarely done during their own discussions.

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MEANING MAKING OF WORDS IN MULTILINGUAL SCHOOL SCIENCE SETTINGS

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Abstract

The aim of the presented project is to investigate language related issues in relation to meaning making of school science in multilingual settings. This is done through a multidisciplinary (science education and linguistics) and quantitative approach in Swedish secondary schools. Meaning making of words was estimated through web-based vocabulary tests given to 232 students in grade 7-9. This data made it possible to calculate potential significant differences between groups of students and categories of words. On a general level, significant differences were found between the performance of students with Swedish as mother tongue and those with other mother tongues. When focusing word types, we found differences between the groups in relation to two categories: “general academic words” (e.g. cause and consist of) and “colloquial but content related words” (e.g. pass and branch). On the other hand, difficult word categories for all students were “academic and content-related words” (e.g. trait and process) and “academic and content-typical words” (e.g. occur and indicator). We argue that, especially regarding students with another mother tongue than the language of instruction, it is important to give attention to the words that are general academic words along with the common focus on content-specific words – the concepts.

1 Introduction and theoretical background

Several scholars (e.g., Martin & Veel, 1998; Seah et al., 2014) have emphasized that language usage in school science contexts may be characterized by high lexical density, abstraction, and technicality. In addition, the language in science classrooms has, according to Lemke (1990) specific characteristics related to the use of words, grammar, and semantic patterns that may be a particularly challenging issue. At the word-level, following Nation (2013) language use in science can be grouped into three categories: (a) science-exclusive words; concepts (e.g. allopatric, exothermic reaction, and force), (b) words found both in science and elsewhere, but with different meanings; homonyms (e.g. adapt, cycle, and energy), and (c) general academic words (e.g. converted, proceeds, and originates). All types of words are important in meaning making of science to appropriate the semantic pattern of how science is communicated in classrooms. In other words, teachers must understand how language influences learning and develop strategies to enhance students’ successful appropriation of scientific language in the continuum between every-day and scientific registers and increase the students’ discursive awareness and mobility in relation to content and language (Authors, 2019; Schleppegrell, 2016). Furthermore, might a specific focus on words be beneficial in the students´ meaning making processes (Logan & Kieffer, 2021).

Starting with the triadic idea from Nation (2013) have Authors (2019) developed a more fine-grained categorization with two main parts with three subcategories each. These are a) content neutral words divided in 1) common words (e.g. talk); 2) unusual words (e.g. disappointment) and 3) general academic words (e.g. consider) and b) content related words divided in 4) homonyms (e.g. pressure); 5) content-typical words (e.g. pollution) and 6) content-specific words (e.g. photosynthesis). Historically science education and classroom practice have been focusing the latter category - the concepts.

The aim of this project is to investigate language related issues in relation to meaning making of school science in multilingual settings. This is done through a multidisciplinary (science education and linguistics) and quantitative approach in Swedish secondary schools. The research question is: what kind of words are challenging for students with Swedish language background and students with other language backgrounds.

2 Research methods

Starting out as a multi-disciplinary collaboration, between science educators and linguistics, meaning making of words was estimated through four different web-based vocabulary tests given to 232 students in grade 7-9. Each test had 15 words selected from the textbook that the students would study two weeks later. One sentence was chosen in which one word was made bold and the students were given four alternative suggestions as synonyms. The words belonged to five of the six categories mentioned above (common words was excluded) and academic/official dictionaries was used to categorize the words. Example of words in the textbooks that we chose were: 2) unusual words (e.g. contemplate); 3) general academic words (e.g. process); 4) homonyms (e.g. solution); 5) content-typical words (e.g. indicator) and 6) content-specific words (e.g. symbiosis). In addition, the students were asked about their first language and how long time they studied in Swedish school. This data made it possible to calculate potential significant differences between groups of students and categories of words.

3 Results

On a general level, significant differences were found between the performance (score 1-15 on the tests) of students with Swedish as mother tongue and those with other mother tongues (see Figure 1) and within the group that arrived in Sweden later than school start (see Fig. 2).

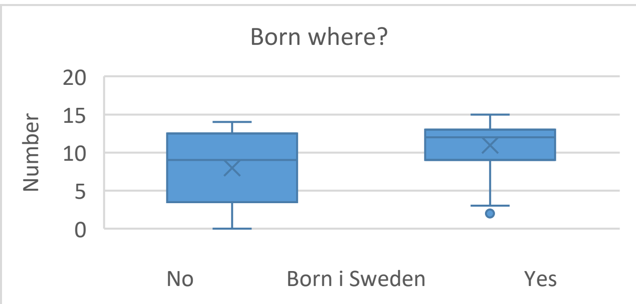

Figure 1. *Where were you born?*

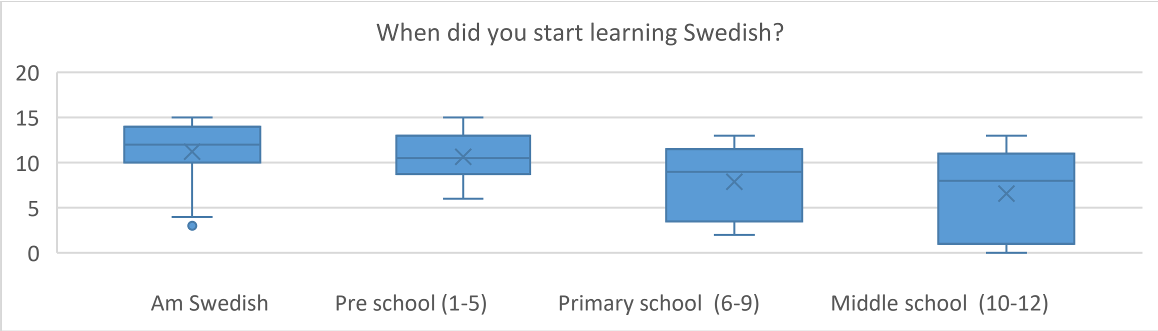

***Figure 2**. How long have you learned Swedish?*

When focusing different types of words, we first found a need to differentiate our previous model for interpretation of homonyms (group 4) into to two subcategories, namely homonyms that were 4a) colloquial but content related words and 4b) academic and content specific words. This alteration was guided by both the empirical data and newly produced dictionaries differentiating colloquial and academic words.

We found significant differences towards two categories of words between students with Swedish as mother tongue and those with other mother tongues: 3) general academic words (e.g. cause and consist of) and 4a) colloquial but content related words (e.g. pass and branch). However, difficult word categories for all students were also two categories: academic and content-related words (e.g. trait and process) and academic and content-typical words (e.g. occur and indicator).

4 Discussion and conclusion

It is not surprising that students with another mother tongue that Swedish scored less on a general vocabulary test and that the result correlate to time that the student has learned Swedish. It has been shown before (c.f. Authors, 2019; Logan & Kieffer, 2021) but it indicates that the tests have some reliability.

The main contribution of this study is that it points towards types of words that are extra hard for the students to make meaning of. We argue that, with respect to students with another mother tongue than the language of instruction, it is especially important to give attention to the words that belong to the category general academic words. These general academic words are important in the science classroom since they are the "glue", or connectors (Gibbons, 2003), between the concepts. In other words, a scientific explanation is incomprehensible without the connectors that bind concepts (Silseth, 2018). It is hard to make sense of the important concepts without words like consist of or because. Therefore, science teaching should emphasize these words along with the concepts.

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FACT OR FAKE?! STRATEGIES OF PRE-SERVICE CHEMISTRY TEACHERS FOR SEARCHING CREDIBLE INFORMATION ON THE INTERNET

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Abstract

Young adults are poorly competent in dealing with disinformation on the Internet (e.g., Breakstone et al., 2021) – whether in the private or in the professional field. It is young teachers in particular who use the Internet for lesson planning. That is why, we ask ourselves: How do pre-service teachers search information on the Internet and how do they assess the credibility of searched information? We investigated both the strategies pre-service chemistry teachers use to investigate a scientific question as well as their procedures to assess the credibility of online information. Adapting the method proposed by Barzilai & Zohar (2012), we videotaped 25 chemistry pre-service teachers conducting open-ended Internet search on the question if smoking e cigarettes is healthier than conventional combustion cigarettes. To analyse the pre-service teacher's activities, we used the think-aloud-method and conducted retrospective interviews. Our results demonstrate that pre-service teachers from this study rarely use functional techniques – such as those used by professional fact-checkers – to obtain credible information. Thus, these findings provide initial indications for the need of contemporary educational programs for pre-service teachers – and we assume also for in-service teachers – that focus on strategies for functional searching of credible information on the Internet.

1. Starting point

Since young people use the Internet intensively but have great difficulty in recognising disinformation (e.g., Breakstone et al., 2021), teaching the competencies to search for credible information on the Internet is a central educational task. The acquisition of competencies for researching credible information on the Internet is included in the German national educational standards for science teaching (e.g., KMK, 2020). It is therefore essential that teachers themselves have the necessary competencies to search for credible information on the Internet - especially considering that the Internet is an essential resource for young teachers to plan their lessons. As there is currently no research on how German pre-service teachers approach searching online information and how they evaluate the credibility of the gathered information, we address this research gap in this study.

2. Theoretical Framework

Novices use time-efficient cognitive processes – so-called heuristics – to assess the credibility of online sources (Metzger et al., 2010). These heuristics are widely described in the literature (see tab. 1). However, professional fact-checkers generally do not use heuristics, but elaborated strategies for assessing the credibility of information on the Internet (Wineburg et al., 2022). These strategies include among others *"click restraint"* (avoiding checking only the first results of an online search engine output) and *"lateral reading"* (checking in further tabs of the web browser: 1st Who is behind the information? 2nd What is the evidence? and 3rd What do other sources say? (Wineburg et al., 2022, p. 897)).

In the future, pre-service chemistry teachers must teach students how to search credible information on the Internet. Therefore, we are interested in discovering the following research questions:

1.a) How do pre-service chemistry teachers proceed when they search for information on the Internet to answer a scientific question?
1.b) To what extent does this procedure match that of professional fact-checkers?
2.a) How do pre-service chemistry teachers proceed to assess the credibility of information they identified on the websites?
2.b) To what extent does this procedure match that of professional fact-checkers?

3. Methods

We asked pre-service teachers to spend 30 minutes investigating a scientific question on the Internet. Following Barzilai and Zohar (2012), we videotaped pre-service teachers conducting open-ended Internet search using the *"thinking aloud"* method. Afterwards we interviewed them to reconstruct the reasons for the credibility assessments they made. Since both the search process and the assessment of the credibility of online sources depend on how motivated the participants are to deal with the given task (Metzger et al., 2010), it was necessary to choose a task that is a subject of contemporary public controversy and that cannot be answered conclusively from a scientific point of view. Therefore, we asked the participants to answer the question of whether the use of e-cigarettes is a healthier alternative compared to conventional tobacco cigarette use. In our opinion, addressing this issue is a valuable task for pre-service teachers, since German adolescents have increasingly consumed e-cigarettes in recent years (Kotz et al., 2022).

For the qualitative content analysis of the pre-service teacher's statements during the Internet search and the interviews, we deductively developed a category system based on the literature (see tab. 1). We tested our category system using interrater reliability analyses. We determined a Cohen's Kappa of 0.90, which is *“very good”* according to Altman (1991).

4. Results

25 pre-service chemistry teachers in the master's program participated in the study. The participants (male: 14, female: 11) were on average 26.7 ± 4.5 years old. They worked on the given task on average 28.9 minutes. The participants checked on average 8.8 ± 3.8 websites to answer the given task. In 63% of the cases, the participants selected websites that were among the first three results displayed in the search engine. During their Internet search, only 3 of 25 participants selected a search result from the second page of the search engine output.

On average, we reconstructed a credibility assessment for 5.3 ± 2.5 websites per participant by analysing the transcripts from the thinking aloud and the interview protocols. In the course of reconstructing the participants’ credibility assessment for a specific web page, we observed that the participants frequently relied on more than one heuristic for their assessment of the credibility of a single website. The participants used on average 8.4 ± 4.2 heuristics during their whole Internet search. The heuristics used by the participants are presented in table 1.

Table 1. Theory-based category system for analysing credibility judgments regarding online sources ([1] Scholz-Crane, 1998; [2] Fogg et al., 2003; [3] Metzger, 2007; [4] Hilligoss & Rieh, 2008; [5] Metzger et al., 2010; [6] Barzilai & Zohar, 2012; [7] Choi & Stvilia, 2015) including results on category occupancy frequencies: N_1: number of pre-service teachers who used the heuristic at least once; N_2: number of analysis units out of a total of 209 analysis units from the thinking aloud and the interview protocols.

***Table 1** Theory-based category system for analysing credibility judgments regarding online sources ([1] Scholz-Crane, 1998; [2] Fogg et al., 2003; [3] Metzger, 2007; [4] Hilligoss & Rieh, 2008; [5] Metzger et al., 2010; [6] Barzilai & Zohar, 2012; [7] Choi & Stvilia, 2015) including results on category occupancy frequencies: N_1: number of pre-service teachers who used the heuristic at least once; N_2: number of analysis units out of a total of 209 analysis units from the thinking aloud and the interview protocols.*

heuristic	cat.	category description	N_1 of 25 teachers	N_2 of 209 analysis units
reputation	R1	due to perceived expertise [1–7]	19	40
	R2	due to own experience [2–6]	16	31
evidence	Ev1	indication of references [3,7]	11	17
	Ev2	frequency of citation of the online source	2	2
	Ev3	plausibility of arguments, factual logic [3,5]	0	0
	Ev4	informational content [3,5,6]	2	2
consistency	C1	information is specifically checked on another website [3,5,7]	2	4
	C2	consistency of one piece of information is randomly compared in another web page [2]	5	6
endorsement	En1	seal of an entity perceived as credible [3,6]	0	0
	En2	institution [4,5]	0	0
	En3	friends and relatives [4,7]	1	1
	En4	search engine result output [3,6]	9	14
aesthetics	Ae1	professional design [2,3,4,7]	6	7
	Ae1	orthographic errors [3,6]	0	0
	Ae2	technical functionality of the website [2,3,6]	1	1
persuasive intent	PI1	author/sponsor/organization [1,2,5,6]	20	37
	PI2	name of the website [3,6]	16	23
	PI3	used language [2,3,6,7]	4	6
	PI4	advertising of own product [3,5,7]	4	4
	PI5	cookies [3]	2	2
expectancy violation	Pr1	information does not match the prior knowledge [5]	2	2
transparency	T1	author is named [2,3]	0	0
	T2	author's contact details/impressum [2,3]	1	1
topicality	To1	specification of a date or time stamp [1,3,7]	7	9
	To2	correction of incorrect data with indication [7]	0	0
	To3	presence of a newsletter	0	0

Most frequently, the participants applied the heuristics *"reputation"* (R1 and R2) and *"persuasive intent"* (PI1 and PI2) to assess the credibility of a website. For example, 19 out of 25 pre-service teachers named the reputation of the author of a website at least once as a credibility-generating attribute (R1). Even 20 out of 25 pre-service teachers explicitly mentioned a possible persuasive intention of the author at least once (PI1). These two heuristics combine 71 analysis units (R1 and R2) and 66 analysis units (PI1-PI5), nearly two thirds of the total 209 statements of all students we identified and coded.

11 out of 25 participants named the citation of sources as a credibility-generating attribute at least once (Ev1). Other arguments that belong to the evidence heuristic, such as the frequency of citation of the website (Ev2) and the plausibility of the arguments (Ev3) were hardly considered by the pre-service teachers to assess the credibility of an online source.

Only 2 out of 25 pre-service teachers actively looked for confirmation of information on other websites (C1). Also, only 5 out of 25 participants randomly recognized information from a previous webpage and therefore rated the currently visited page as credible (C2).

Especially regarding the selection of websites described above, it is remarkable that 9 out of 25 participants named the search engine result as a credibility-generating attribute at least once (En4).

5. Discussion and conclusion

The results show that the pre-service chemistry teachers of our study are aware that authors of websites sometimes publish information with an intention to persuade. However, the comparison with the practice of professional fact-checkers also reveals a significant knowledge gap among our participants. For example, the participants mainly relied on the first search engine results and, in some cases, explicitly named the position of the search engine result as a credibility-generating attribute. Strategies of lateral reading – especially the systematic checking of information on other websites – are (unfortunately) hardly applied.

In the following, we will examine the question of whether students act in the same way when they are researching on the Internet in a more professional setting, e.g., when they are asked to plan a lesson. We are also working on a professional development program that teaches both pre- and in-service teachers strategies for researching credible information on the Internet from professional fact-checkers.

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SUPPORTING 10TH GRADE STUDENTS' EXPLANATIONS ABOUT MASS CONSERVATION IN COMBUSTION REACTIONS

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Abstract

In this presentation, we will explore how to support 10th grade students' explanations about mass conservation in combustion reactions. An inquiry-based activity was created based on the predict, observe, explain (POE) model; the activity was developed in a cyclic process inspired by action research. The teaching was conducted in two classes, following a pilot. Video data were collected from eight small groups of students and the data were transcribed and analyzed using NVivo software. Through abductive analyses of the students' conversations about combustion of steel wool, we investigated what characterized the students' explanations in different parts of the activity. We found that the students struggled with the differentiation between chemical reaction versus physical change, whether gas has a mass or not and the role of oxygen in combustion reactions. However, their ideas about combustion gradually improved through the different steps of the activity. The most significant improvement occurred after their explanations had been supported by guiding cards and guiding questions. We intend to further investigate how such support should be provided both to support a more scientific understanding of the practical activity, but also to maintain students' engagement and autonomy.

1 Introduction

The objective of this study is to explore how to support students' explanations about mass conservation in combustion reactions. Mass conservation and combustion reactions are central concepts in the Norwegian science curriculum through the curricular aim stating that the students after 10th grade should be able to "explore chemical reactions, explain mass conservation and explain the importance of some combustion reactions" (Norwegian Directorate for Education and Training, 2020). However, students tend to have both misconceptions and show fragmented understanding (Doucerain & Schwartz, 2010; Kind, 2004). This is especially related to understanding the role of oxygen in combustion reactions and that gases have mass (Kind, 2004).

With this as a background, we created an activity where the students were supposed to predict what happened to the mass of steel wool after combustion. In this presentation, we pose the research question: *What characterizes the students' explanations in different parts of an inquiry-based activity involving combustion of steel wool?* We further pose two auxiliary research questions:

- What ideas about combustion do the students express in the different parts of the activity?
- How do the students talk about combustion in the different parts of the activity?

2 Theoretical backgrounds

Several studies have pointed to the challenge of finding ways to support students' use of theoretical ideas and models to interpret observations from practical activities (Abrahams & Millar, 2008; Osborne, 2015). In chemistry, this challenge is seen as especially demanding since explanatory ideas often involve abstract ideas and interactions between invisible molecules and atoms (Treagust et al., 2014). The students also need to handle shifts between different representations of the phenomenon. To overcome this challenge, a well-designed inquiry-based, and student-active approach has been suggested (Hofstein, 2017).

Review studies emphasize that teacher support is essential to help students to develop a scientific conceptualization of their sensory inputs from practical activities (Furtak et al, 2012). However, several teachers find it difficult to provide students with appropriate structures to work inquiry-based, and also how and when to give students space for their own initiatives and autonomy (Bjønness & Kolstø, 2015).

One example of a more guided inquiry-approach is the predict, observe, explain (POE) activity (White and Gunstone, 1992), where the students predict observations related to a practical activity, observe the outcome, and use their observations to suggest an explanation. The aim is that the students use time to delve into observations and to formulate their own interpretations that can be revised and reformulated through discussions and further testing.

3 Research methods

This study is a part of the Teachers' Research Literacy in Science teaching (TRELIS) project and inspired by action research (Øgreid, 2021). The activity was developed jointly by the first- and third authors through two cycles, following a pilot. The two cycles consisted of 90 minutes teaching in two 10th grade classes, as described in Table 1.

Table 10: *Overview of the teaching activity with sub-activities and support*

Sub-activity	Support
Startup	Short teacher introduction of central concepts
Predict	Template, think-pair-share
Observe a teacher demonstration	Formulate observation in template
Explain	Template, individually and collective formulation of explanation
Lecture	
Theoretical explanation (Why has the mass increased?)	Guiding cards with micromodels Guiding questions

First, the teacher gave a short introduction to the central concepts of the lecture before the students were introduced to the experiment. Thereafter, the students came up with their own ideas or reasons to explain their predictions, before they observed the experiment and revised their explanations, supported by teacher instructions and guiding cards.

Teaching and data collection were conducted by the third author. Video data were collected from eight small groups of students. Segments of content-related talk were transcribed and will be analyzed in two steps using NVivo software. First, the ideas of combustion the students expressed were analyzed using abductive content analysis. In this process, literature about students' understanding of combustion and mass conservation (e.g., Kind, 2004) was consulted to form preliminary categories that were adapted during the analysis and new categories were added. Before the conference, the transcripts will be further analyzed with respect to how the students talked about combustion.

4 Results

An overview of the result of the analysis is given in Table 2. As can be seen from the table, the students displayed many wrong ideas about combustion both before and after the experiment, although the proportion of correct ideas increased after the experiment. However, after working with the guiding cards, the students displayed more correct ideas.

Table 11: *Ideas about combustion presented in the groups before, during and after the experiment, and after using guiding cards to understand the activity*

All	Before	During	After	Guiding cards
Correct	13	14	20	27
Partly correct	19	22	7	12
Wrong	32	13	23	7

The analysis revealed that the students in general struggled with three concepts: the differentiation between chemical reaction versus physical change, whether gas has a mass or not and the role of oxygen in combustion reactions. They also struggle to understand the role of carbon in the reaction, and they mixed up some scientific concepts. One example is taken from Group D, who in the beginning talked about steel wool as a soft metal with air inside:

> Emma: Because the thing is that it actually weighs quite a bit, and there is a lot of air in it, so when it is less… or is it like the air gathers in a way and it becomes heavier?
>
> Silje: No, no. I don't think the air… I know that we need oxygen for combustion, but I don't think it will attract any oxygen?
>
> Emma: Not that it attracts, but there is oxygen in here [in the steel wool], but okey… so it will weigh more?
>
> Silje: I think so… (…)
>
> Emma: But when it is denser, it will be heavier?

As can be seen from this excerpt, the students mixed up the concepts mass and volume and they argued that the volume would decrease, while the mass would increase. During the experiment, they assumed that the mass had decreased, before they returned to an explanation that it would be denser: "The steel has melted together. Then the air disappears, and it becomes denser" (Emma). It was not before the last part of the activity, working with the guiding cards, where they develop their understanding towards the correct idea, explaining that oxygen has reacted with iron.

These results, together with results from other groups and the second part of the analysis will be further explored on the conference.

4 Discussion and conclusion

Our results showing that the students struggled to understand whether gas has a mass or not and the role of oxygen in combustion reactions is in line with prior studies on the role of oxygen in combustion reactions (Kind, 2004). However, their ideas gradually improved through the different steps of the POE-activity. The most significant improvement occurred after their explanations had been supported by guiding cards and guiding questions. This is in line with studies emphasizing time and teacher support when the students are supposed to consolidate their understanding (Ødegaard et al., 2021). We intend to further investigate how such support should be provided both to support a more scientific understanding of the practical activity, but also to maintain students' engagement and autonomy.

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ASSESSING ENVIRONMENTAL KNOWLEDGE: WHICH ITEMS ARE MORE DIFFICULT ACROSS GRADES AND NORDIC COUNTRIES?

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Abstract

This study assesses Environmental Knowledge (EK) through an item-level analysis of the Trends in International Mathematics and Science Study (TIMSS) 2019 across Nordic countries. EK, a critical component of education for sustainable development, equips students to address environmental challenges and contribute to global sustainability goals. However, gaps in our understanding of how EK varies across countries and the specific difficulties students face remain. This study fills these gaps by analysing EK item difficulties in Grades 4 and 8 from Norway, Sweden, Denmark, and Finland. Utilizing the TIMSS 2019 database and a two-parameter logistic item response theory model, the study compares students' EK across Nordic countries and identifies challenging items. The results show Finnish students consistently outperforming their Nordic counterparts, indicating a stronger foundational EK. Moreover, constructed response items emerge as more challenging, suggesting the need for enhanced instructional support in communicating EK. This research contributes to a deeper understanding of EK and informs targeted strategies for more effective science teaching and learning.

1 Introduction

Environmental knowledge (EK) holds paramount significance in the contemporary educational landscape. It equips students with the competence and skills to comprehend and address pressing environmental challenges, fostering a population that is not only scientifically literate but also environmentally conscious. By integrating EK into curricula, students are prepared to make informed decisions and take responsible actions, contributing to sustainable development and environmental stewardship in our increasingly complex world (Jónsson et al., 2021; OECD, 2019). This aligns with global movements and frameworks such as the United Nations Sustainable Development Goals, which emphasize the critical role of education in achieving sustainability (United Nations, 2015).

Despite the recognized importance of EK, current research often lacks a detailed, item-level analysis necessary for understanding students' specific strengths and weaknesses in this area. Moreover, there is a scarcity of comparative studies on item difficulty in EK across different countries, particularly within the Nordic region. This detailed analysis is crucial for tailoring education strategies to better address the nuances of environmental understanding and misconceptions among students.

This study aims to fill the identified gaps by conducting a thorough analysis of student performance on the Trends in International Mathematics and Science Study (TIMSS). Choosing TIMSS data for this study is strategic due to its nationally representative nature, enabling comparative analysis across Nordic countries and ensuring that findings reflect diverse student demographics. This study includes comparative analyses of students' EK in Norway, Sweden, Denmark, and Finland in Grades 4 and 8. By providing an in-depth, item-level analysis, it will illuminate areas of difficulty and identify gaps in student knowledge. These detailed insights are crucial for refining teaching methodologies and curriculum design in order to facilitate the development of EK in the classrooms.

The following research questions (RQs) are used to guide the present study:

1. *How does students' EK vary across Nordic countries?*
2. *Which EK items are more difficult for students across Nordic countries?*

2 Theoretical backgrounds

EK has been defined in various ways across academic disciplines, reflecting the complex and multifaceted nature of understanding environmental concepts, processes, and issues. Scholars like Hungerford and Volk (1990) emphasize EK as an understanding of environmental concepts, processes, and issues. Meanwhile, Frick et al. (2004) differentiate between factual knowledge about specific environmental problems and systemic knowledge, which encompasses an understanding of ecological systems and principles. Further expanding this view, Negev et al. (2008) further expand on this by considering EK as multidimensional, including ecological knowledge, knowledge of environmental issues, and knowledge of action strategies.

In this study, the TIMSS' environmental awareness (EA) scale is employed, arguing that it more accurately reflects the diverse nature of students' EK rather EA. This is because the TIMSS EA scale measures students' understanding of various environmental concepts and issues (Mullis et al., 2022), thus aligning more closely with the notion of knowledge. EK refers to what one knows about the environment, encompassing an understanding of environmental concepts, facts, and information. EA, conversely, involves recognizing and understanding the impact of human activities on the environment (Liu et al., 2020). It is about being conscious of the environmental consequences of actions. These concepts are interconnected, as increased EK can lead to heightened EA. This awareness can drive the desire to acquire more knowledge, influencing attitudes and behaviours towards environmental choices and practices (Liu et al., 2020).

3 Research methods

Data sets for this study were obtained from the TIMSS 2019 international database (IEA, 2023). The data consisted of student responses to EA items. Specifically, 33 items for Grade 4 and 41 items for Grade 8 were included in the analysis.

The final sample comprised responses from 15,873 Grade 4 students and 13,445 Grade 8 students. The student responses were then recoded into dichotomous outcomes (0 = incorrect, 1 = correct and partially correct). Figure 1 shows an example of an item measuring EK in TIMSS Grade 4.

To analyse the data, IDB Analyzer was utilized to merge and manage the datasets efficiently. Subsequently, Mplus Version 8.10 was employed to estimate item parameters using the two-parameter logistic (2PL) Item Response Theory (IRT) model.

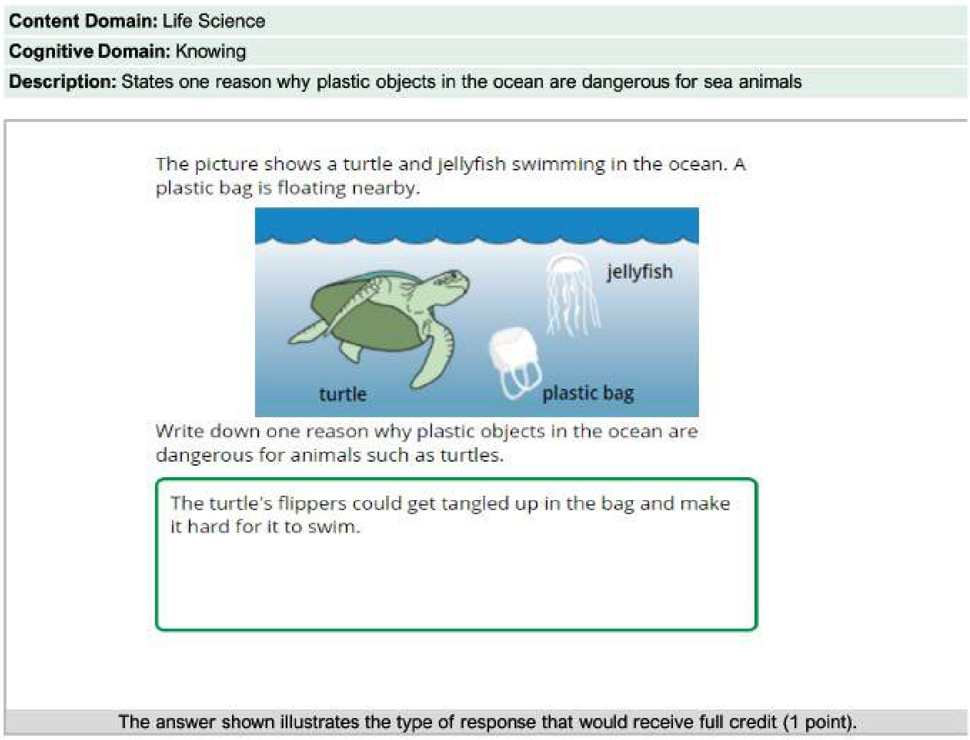

Figure 1. *An example of an item measuring EK in Grade 4.*

4 Results, Discussion, and Conclusion

RQ1: Students' EK across Nordic countries

In Grade 4, Finland demonstrated a statistically significant higher performance in EK with an average score of 559 compared to Sweden, Norway, and Denmark. The mean averages for Sweden, Norway, and Denmark were 549, 548, and 536, respectively, with no significant differences observed among these three countries.

In Grade 8, Finland again showed a statistically significant higher performance in EK with an average score of 543, outperforming both Sweden and Norway. Sweden's average performance was 525, which was significantly higher than Norway's average of 503. Denmark did not participate in the Grade 8 TIMSS 2019.

These findings suggest that Finland's higher EK scores compared to other Nordic countries may indicate a stronger foundation of environmental knowledge among its students. EK can potentially lead to better EA, as a solid knowledge base can drive the desire to understand the environmental consequences of human actions, influencing attitudes and behaviours towards environmental choices and practices (Liu et al., 2020; McBeth and Volk, 2009).

RQ2: Item difficulty in EK across Nordic countries

Figure 2 illustrates the range of item difficulties for EK in both grades, using Norway's performance as the reference point. On the horizontal axis, EK items are arranged from the easiest to the hardest, based on the results from Norwegian students, with items from Grade 5 on the left and Grade 9 on the right. The vertical axis shows the difficulty parameter estimates for each item. A black line connects the point estimates of the difficulty for each item, and the accompanying error bars indicate the 95% confidence interval for each estimate, assuming a 5% significance level was achieved. Additionally, in order to test the mode effect, multiple-choice items were marked in blue while constructed responses were in red.

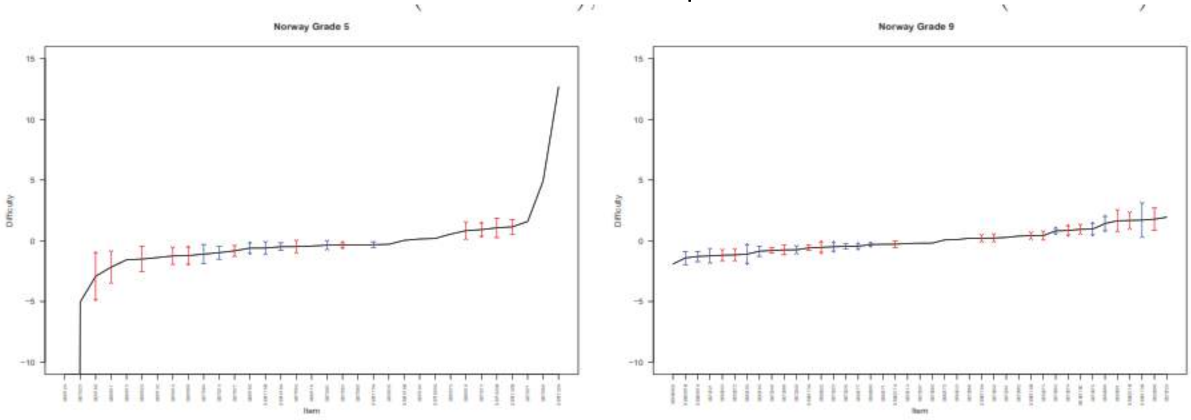

Figure 2. *Item difficulties in Grades 4 and 8 with Norway as the reference point.*

In Grade 4, item SE51132B, titled “Hamad’s Garden: Plant structure,” was identified as the most challenging. It required students to provide a constructed response by applying their knowledge of life science’s organisms, environment, and interactions. Interestingly, the next three most difficult items (SE71920B, SE71213, and SE61019) in Grade 4 were also constructed response tasks, indicating a potential mode effect that suggests students may benefit from additional support in expressing their EK through constructed responses.

A similar pattern was observed in Grade 8. An earth science question about earth’s resources, their use, and conservation was presented in the task “Trees protect soil from erosion,” requiring candidates to provide a constructed response. Similarly, the next three most challenging items (E62173B, SE62211B, and SE52021) were predominantly constructed responses.

Taken together, the findings from Grades 4 and 8 TIMSS assessments underscore the significance of evaluating and improving students’ capacity to effectively convey their scientific understanding. Offering targeted support and training in constructing scientific explanations holds the potential to enhance both students’ performance and their grasp of scientific concepts (Pellegrino et al., 2001).

These findings have relevance in the context of EK as well. Effective communication of scientific understanding is crucial when addressing complex environmental issues and concepts. Enhancing students’ ability to articulate their knowledge not only aids in their overall scientific comprehension but also plays a pivotal role in promoting EA and a sense of responsibility (Liu et al., 2020).

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SCAFFOLDING SCIENTIFIC INQUIRY: ADAPTING TINY EARTH FOR ENGAGING HIGH SCHOOL STUDENTS AND THEIR TEACHERS IN AUTHENTIC RESEARCH

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Abstract

Initiatives to engage high school and undergraduate students in research-like STEM projects are proliferating based on aims related to promoting students' interests and persistence in STEM higher education. Novice students do not yet have qualifications to work with research literature and methods, so it places high demands on STEM teachers' professional skills to scaffold students' scientific inquiries in a way that makes them feel they can do well. Here we present the adaptation of the research-based course Tiny Earth to the context of a university outreach program for high school students. The course addresses socio-scientific issues related to antimicrobial resistance, guiding students through the authentic discovery of new antibiotics.

Referring to models on research-based teaching, we analyse how university researchers and high school teachers scaffold students' work and how students engage during the phases of the discovery process. Based on data from interviews and post-course surveys, we investigate how students and teachers perceive outcomes and challenges in their participation in and contribution to authentic research. We discuss how scaffolding strategies influence students' interests, outcomes, and self-efficacy in science inquiry, and how participation in outreach initiatives may promote teachers' professional development.

1 Introduction

There is growing demand for STEM education to embrace evidence-based teaching practices. A particular focus is on promoting research-based teaching, allowing students to address socio-scientific issues early in their STEM education (Handelsman et al., 2004). Such learning experiences have the potential to enhance students' learning, interest, and persistence in STEM education (Russell et al., 2007). However, cookbook-like instructional strategies still dominate STEM classrooms and labs.

In this context, we present an outreach program where high school students and their teachers participate in cutting-edge research at the university. The paper aims to broaden our understanding of how participation in such research experiences may influence 1) students' interests, outcomes, and self-efficacy in relation to science education, and 2) teachers' professional development, including the adoption of inquiry-based practices.

2 Theoretical backgrounds

Referring to the model of research-based learning from Healy (2005), previous studies have demonstrated that students' learning outcomes from reserach-based activities are highly dependent on efficient scaffolding of their work with both research content and inquiry processes (Healy, 2005; Nielsen et al., 2020). Students' persistence in STEM education can be approached through theories about agency and students' experience of competence, autonomy, and a sense of belonging (Jääskelä et al., 2017; Trujillo & Tanner, 2014). Considering this, it is of particular concern to scaffold novice students' scientific inquiries in a way so that they feel they can do well. Therefore, the successful adoption of research-based teaching practices places high demands on STEM teachers' pedagogical content knowledge and topic-specific professional skills (Carlson, 2019). Participation in research-based outreach programs provides a unique opportunity to promote teachers' professional development, as they gain first-hand experience with new teaching practices in collaboration with researchers (Aslam et al., 2018).

In this study, a course on antibiotic discovery, Tiny Earth, was adapted as an outreach program for high school students offered by the university. Tiny Earth was initiated by Jo Handelsman and now includes an international network of instructors and students addressing the socio-scientific challenge of antibacterial resistance (Penprase, 2020). The course design is based on the principle of student-sourcing, making students participants in cutting-edge research. In this way, enrolled students contribute with scientific knowledge to a real research community, and high school teachers collaborate with researchers on scaffolding students' work with research content and processes.

The study aims to explore the learning opportunities, challenges, and outcomes experienced by both students and teachers participating in the adapted Tiny Earth course.

1. How does the Tiny Earth course contribute to a research-like experience, considering theories of research-based teaching and from a student perspective?

2. How does participation in the course influence students' self-efficacy, mastery beliefs in science research, and perceived relevance of science in relation to socio-scientific issues and owncareer choices?

3. What aims and outcomes can be identified regarding teachers' own teaching practice and professional growth?

3 Research methods

The data reported was collected in the project period 2019-2024. A post-course questionnaire (N=265) distributed to students included closed category questions related to perceived outcomes, challenges, and relevance (RQ1) and both closed category and open reflections related to self-efficacy, mastery beliefs, and agency (RQ2) (Trujillo & Tanner, 2014; Jääskelä et al., 2017). Qualitative analysis of the course design is included to answer RQ1 and semi-structured focus group interviews (four groups of 2-3 students) will further inform RQ1 and RQ2. Interviews with teachers (N=7) addressed items related to pedagogical content knowledge and professional development (RQ3) (Carlson, 2019). Likert-scale items are analyzed by frequency analysis and cross tabulations, and open reflections by thematic analysis (Braun & Clarke, 2006).

4 Results

The Tiny Earth initiative was adjusted and aligned with the Danish high school curriculum and 1400 students from 37 high schools participated in the course during the first four years. The program consists of four modules (Figure 1) where students 1) learn theoretical background on antibiotic resistance and discovery, 2) collect and prepare soil samples at a site in nature by their choice, and choose colonies for bacterial analysis, 3) visit the university and perform biochemical experiments on collected samples with guidance from teacher and researchers, and 4) perform bioinformatic analyzes and share data with researchers in a database. Other reporting is facilitated by the high school teacher (Figure 1).

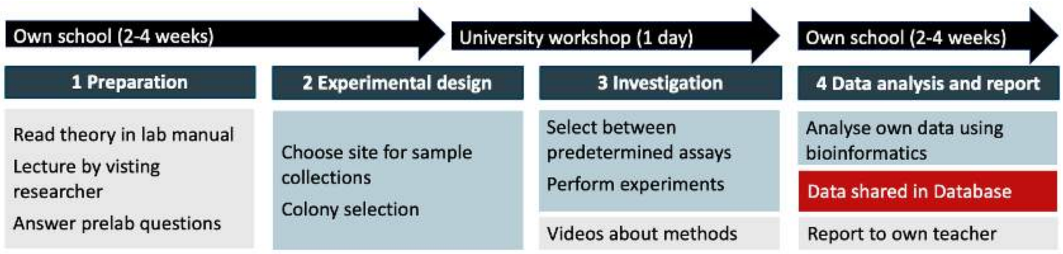

Figure 1. *Overview of the program illustrated as four phases in a research process (grey, research content; light blue, research processes and methods; red, contributing to research community*

In the 4-8 week duration of Tiny Earth, high school teachers collaborate with researchers before, during, and after the university workshop, using materials offered by the researchers in their own teaching practice.

The majority of students found participation in the project to be interesting and educative to a high or very high extent. In open reflections, students highlighted a twofold outcome, gaining knowledge related to the socio-scientific aspect of antimicrobial resistance and insight into working as a scientist: "Before Tiny Earth, I wasn't aware that antibiotic resistance was and is a big problem" and "insight into a working day as a scientist."

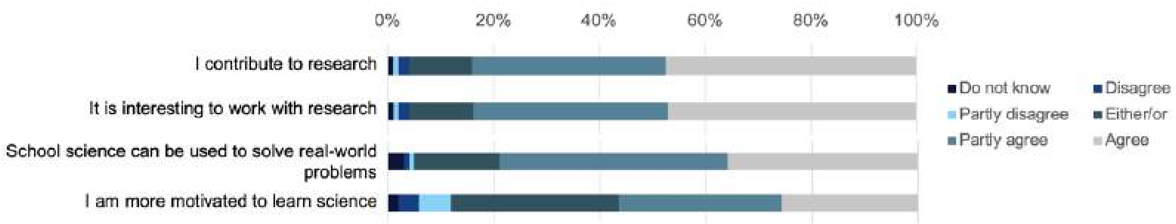

Figure 2. *Data from post-course survey. Students' answers to questions related to participation in research and experienced relevance of and motivation to learn science (N=265).*

The students felt to a high or very high degree (70-80 %) that they understood the main topics and concepts and successfully conducted the experiments, with 60% expressing confidence in their performance. Regarding their own contribution to research, 90% reported a high or very high level of involvement and interest in research during Tiny Earth (Figure 2). In open reflections several students characterized their role as assembling a small part of a larger picture: "*I am an assisting pioneer and a practical help for the researcher*", "*if everyone does this, then at some point we may find new antibiotics*". In interview, students emphasized that they were contributing with new knowledge via their own unique inquiries and that this is different from their previous experience with experimental work: *"Often, we conduct experiments where we expect a result. Here, we need to find a result that isn't already out there. I find it exciting, especially because it involves solving a relevant issue."*

Moreover, 80% strongly agreed that their learning from school science is applicable to solving real-life problems. Both survey and interview data indicate that participation in Tiny Earth enhanced students' interest in science as both a school subject and a career path (Figure 2).

High school teachers' motivation for participating in the project, as expressed in the interviews (N=7), focused on covering specific curriculum areas (theory) and utilizing research methods and equipment (research method) which are unavailable in their home schools.

In relation to students' outcomes, teachers highlighted the experience of "being part of something, which has a purpose" and how this made the students "do an effort because we might actually need (the data) it is not just a cook-book lab". Other outcomes included students' improved abilities to organize experimental work, handle larger data sets, and communicate with researchers. The high school teachers attributed these outcomes to the use of inquiry-based approaches and socio-scientific issues but expressed that constraints related to time and curriculum make it difficult to adopt this in own teaching practice.

4 Discussion and conclusion

The present study suggests that during the participation in Tiny Earth, the high school students experienced to contribute to knowledge building within an authentic cutting-edge STEM research project via their own inquiries. The students expressed high self-efficacy in relation to completing their tasks in the project and they recognised the potential of applying school science in a real-world context.

In collaboration the high school teachers and university researchers effectively scaffolded research-based teaching for high school students. While the high-school teachers focus on supporting students' motivation to learn science and covering the high-school curriculum (inquiry for learning), they observe salient outcomes from the authentic inquires and cutting-edge research problems framed by the university researchers. Referring to models for development of teacher pedagogical content knowledge (Carlson, 2019), such experience may stimulate the high school teachers' future enactments in own STEM teaching practice.

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ELEVERS MOTIVASJON FOR UTESCKOLI I KALDT VINTERVÆR

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Abstract

Outdoor schooling in winter can be extra demanding due to cold winter weather and will need a lot of clothes and equipment for the students. To study whether the cold affects student motivation, we carried out a teaching plan for two weeks in grades 5-7 on feeding birds in winter. The teaching was carried out with a pre-work, a session of outdoor teaching, and a post-work. The temperature approached minus 20 degrees during the outdoor session.

After the end of two weeks of teaching, a group interview was conducted with the students to evaluate their motivation for outdoor schooling under these cold conditions. The results show that, considering selected motivational theories, most students' motivation for outdoor schooling was not affected by the low temperatures, neither in relation to the current teaching about birds nor for outdoor schooling in general. Although a few students thought it was cold, they also said that the activities were fun and interesting. Only one student did not like outdoor schooling because he or she did not want to freeze or get wet.

1 Introduksjon

De fleste studier på uteskole om vinteren viser at aktivitetene er rettet inn mot friluftsliv (Remmen & Iversen, 2022). Undervisningen i studiet vårt er basert på et opplegg fra Miljølære om fugler på foringsplassen (Miljølære, u.å.). Opplegget ble gjennomført over to uker i begynnelsen av mars og inkluderer forarbeid som introduserer oppgavene og gir noe faglig informasjon, og et etterarbeid med egne bilder av fugler tatt på foringsbrettet. I utedelen av opplegget, med oppsetting av foringsautomat og viltkamera, var det utfordrende forhold med temperaturer ned mot 20 grader minus. Studiet gir derfor en god test på hvorvidt det er mulig å ivareta elevenes motivasjon for arbeid med fag under så pass krevende forhold. Vi stiller følgende forskningsspørsmål: *Hvordan er elevenes motivasjon for uteskole i kaldt vintervær – en case studie av fugler på fuglebrettet.*

For å gi et grunnlag for å evaluere elevenes motivasjon for uteundervisningen, inkludert for- og etterarbeidet, ble elevene intervjuet i grupper etter at undervisningen var avsluttet.

2 Teoretisk bakgrunn

Ryan og Deci (2009) skiller mellom indre og ytre motivasjon i selvbestemmelsesteorien. Om elevene er indre motivert, syns elevene det de gjør er interessant, og de gjør det fordi de har lyst. Motsatt handler kontrollert ytre motivasjon om at en føler at en tvinges til å gjøre noe, at en ikke har noe valg (Ryan & Deci, 2009).

Teorien om mestringsforventning handler om forventningene elevene har om hvor vidt de tror de kan gjennomføre ulike oppgaver. Med tanke på uteskole er dette sentralt fordi det kan gi elever andre typer mestringsforventning og -opplevelse, for eksempel ved at de får jobbe mer praktisk.

Relevans er et sentralt begrep i undervisning og læring (Stuckey et al., 2013). Opplevelse av relevans er viktig for elevenes motivasjon og interesse og kan også påvirke elevenes resultater og generelle skolemotivasjon (Menthe & Parchmann, 2014).

3 Metode

Undervisningsopplegget om fugler på foringsplassen ble gjennomført over to uker i begynnelsen av mars med totalt tre skoletimer fordelt over tre økter. Opplegget ble gjennomført to ganger i to grupper a 15 elever på 5.-7. trinn i en skole i landlige omgivelser. Skolen hadde tradisjon for å brukt nærmiljøet i undervisningen.

Etter endt opplegg ble elevene intervjuet i grupper med 3 elever per gruppe. Utvalget består av til sammen 30 elever. De elevene som ble med på gjennomføringen av gruppeintervju, ble valgt ut fra hvem som hadde samtykke fra foresatte og hvilke elever som selv hadde lyst, totalt 12 elever fordelt på sju jenter og fem gutter. Gruppene ble delt inn etter hvem som hadde jobbet sammen gjennom opplegget.

I intervjuene fikk elevene spørsmål knyttet til temaet fugler, hva de hadde lært, hvordan de fant navnet på fuglene, hva de syntes om opplegget spesielt og om uteskole generelt.

Det ble gjort audioopptak av intervjuene med elevene. Disse ble så transkribert, og det ble gjort en tematisk innholdsanalyse i tråd med Braun og Clark (2006) for å systematisere elevenes refleksjoner knyttet til opplegget om fugler, samt om deres opplevelse av uteskole generelt. Prosjektet er godkjent av Kunnskapssektorens tjenesteleverandør (Sikt, u.å.)

4 Resultater

Nesten alle elevene syns undervisningsopplegget om fugler på foringsplassen enten var morsomt eller helt greit. Analysene avdekket følgende tema for refleksjon fra elevene knyttet til opplegget om fugler og uteskole generelt: *Å jobbe praktisk og være ute, Nærmiljøet, Vær og temperatur* og *Etterarbeidet kan bli kjedelig*.

Å jobbe praktisk og være ute

Å henge ut viltkamera og se på bildene i etterkant er tydelig det elevene syns var mest spennende og morsomt:

G1E3 (gruppe 1 elev 3): «Favorittdelen min var når jeg så på bilder fra viltkameraet og fikk lage en presentasjon av en av artene på bildene.»
G2E2: «Jeg syns det var artig fordi det var ikke bare å sitte stille på pulten sin. Det var moro å sette opp foringsstasjon og viltkamera og sånt. Også moro å se bildene etterpå.»

Flere trekker frem at de liker uteskole, sier det ikke er så kjedelig som inneskole, og at man får gjøre andre ting:

G1E1«Liker at vi ikke må sitte inne hele tida»
G3E2: «Det er moro å jobbe litt ute i naturen også. Få frisk luft og bevege seg»

Nærmiljøet

Tre av elevene, som var på samme gruppe, argumenterer med kunnskap og opplevelser knyttet til nærmiljøet:
G3E1: «Det er veldig gøy for da kan vi gå ut å se det på ordentlig, i stedet for at vi bare ser et bilde på tavla.»
G3E2: «Så får vi brukt nærmiljøet vårt og bli bedre kjent der.»

Vær og temperatur

Tre elever på samme gruppe trekker frem at temperaturen ute påvirket hva de syntes om opplegget. En av de sa det slik:

G3E3: «At det var litt kaldt ute, når vi var ute. Men ellers var alt gøy."

Det er imidlertid kun en av gruppene, dvs. tre elever, som påpeker at temperaturen påvirket deres syn på opplegget. Men, noen av elevene som sier at de syns uteskole er gøy, trekker også frem at de helst vil ha fint vær:

G4E1: «Jeg liker det, men det er artigst når det er fint vær og varmt.»
Kun en elev sier at hen ikke liker uteskole siden man kan fryse eller bli våt:

G2E2: «Jeg vil heller være inne, fordi da slipper jeg å fryse eller bli bløt om det regner.»

Etterarbeidet kan bli kjedelig

Elevene fikk også spørsmål om hva de ikke likte eller hva de ikke syns var så gøy med opplegget. Noen svarer at de ikke syns noe var kjedelig, andre trekker frem aktiviteten der de måtte lage artskort:

G1E2: «Hvis jeg må velge, så var det å lage presentasjonen. Men om vi hadde fått litt bedre tid så jeg fikk gjort den ferdig, så hadde det vært gøy.»

Dette utsagnet viser også at de fikk litt dårlig tid i etterarbeidet, og det kan ha påvirka elevenes motivasjon til denne delen.

Oppsummert

Både i tilknytning til undervisningsopplegget og uteskole generelt viser de fleste elevene at de syns det er spennende og morsomt med uteskole. Kaldt vær synes ikke å redusere motivasjonen i betydelig grad, men flere elever uttrykker at uteskole er bedre når det er godt vær.

5 Diskusjon og konklusjon

Vi vil her diskutere resultatene i lys av de valgte teoriene om motivasjon.

I Ryan og Deci (2009) sin selvbestemmelsesteori er elevene indre motivert når de er interessert i det de gjør og ser det som verdifullt for seg. Våre resultater viser at elevene syns det de har holdt på med var interessant. De trekker frem ulike aktiviteter de syns var spennende, de sier de vil lære mer om fugler, og at de liker uteskole fordi de får jobbe ute og praktisk. Det at disse uttalelsene fra elevene kommer på tross av at det var svært kaldt ute, styrker resultatene ytterlig.

Ut fra elevintervjuene er det ingen indikasjon på at elevene er preget av en kontrollert ytre motivasjon (Ryan & Deci, 2009). Det var ingen elever som sa de gjorde det fordi de måtte, og at de følte de ikke hadde noe annet valg.

Mestring er viktig for elevenes motivasjon og læring (Bandura, 1997). Resultatene indikerer at de fleste elevene hadde en mestringsopplevelse. De syntes aktivitetene var gøy og interessante, da henger det oftest sammen med en følelse av at man får noe til.

Et annet aspekt som er viktig for elevenes motivasjon, er følelsen av relevans (Stuckey et al., 2013). I dette opplegget viste flere av elevene at det vi holdt på med var knyttet til deres liv, enten i form av at de matet fugler hjemme, eller at de ville lære mer om fugler.

Motivasjonen til noen elever ble påvirket negativt av lave temperaturer, men de aller fleste elevene sa de likte både opplegget med fugler og uteskole generelt. De som syntes det var kaldt ute, syns likevel resten av opplegget var morsomt.

Konklusjon

Sett i lys av de valgte motivasjonsteoriene viser resultatene at de aller fleste elevene er motivert for å ha uteskole, på tross av lave temperaturer. De fleste er også motivert for for- og etterarbeid inne, men noen av de aktivitetene kan oppleves som kjedelig.

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DRAWING IN SQUARES: INVESTIGATING TEACHER STUDENTS CONCEPTS OF BIODIVERSITY AND EVOLUTION USING THE DRAW-AND WRITE TECHNIQUE

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Abstract

This contribution reports from a pilot study, employing an arts-informed visual approach, the draw-and-write technique (Hartel, 2020), to explore concepts of 'Biodiversity' and 'Evolution' held by teacher students at a Norwegian university.

Teacher students (42) enrolled in science courses were asked "What is biodiversity?" and "What is evolution?". They were then instructed to respond to each question by drawing and writing on 10x10 centimetres squares of paper, with a black ink pen, and within a time lapse of 10 minutes. Preliminary analysis of the drawings combined compositional interpretation (Engelhardt, 2002) with qualitative analysis inspired by thematic analysis (Braun & Clarke, 2006). This analysis was guided by the research questions: 1) How are the concepts rendered? and 2) What themes and motives appear in the drawings, and how these relate to the scientific concepts studied?

Interestingly, regardless of small data-sets, patterns can be seen that project to the students' understandings, or misunderstandings, of the topics. For example, representations of evolution show a linear process with humans at the 'top-end'. Taken together the experiences from this study show that the draw-and-write technique, and the analytical strategy employed, work nicely to investigate understandings of scientific topics, and can be adapted for pedagogical purposes.

Introduction

In science education students and teachers often meet 'difficult words' that enclose complex and elusive concepts. Communicating these can be challenging for teachers while in turn student's mental models can also be difficult to uncover. Probing into these elusive concepts, is thus important for improving understanding in education and research contexts. Biodiversity and Evolution are two such 'words': familiar but with that well-known vibe 'I know it, but I can't explain…'. Whereas evolution is foundational to the science of biology, and yet understanding of it is generally poor among students and teachers (Reiss & Harms, 2019), biodiversity is an important concept for topics like ecology, evolution and sustainability. Current methods for probing into internalized concepts, which rely strongly on language and text, can advantageously be complemented with other approaches.

Drawing is widely used by scientists to refine their conceptions, communicate ideas, and advance scientific thought. Just as it is useful to scientists, there is widespread consensus that creating and revising drawings can lead to learners' deeper understanding of scientific concepts (e.g. Waldrip & Prain, 2012). In addition, images can capture the hard-to-put in words, thus visual methods have the potential to make student's understandings visible and explicit, in powerful ways.

2 The draw-and-write technique

The draw-and-write technique, is an an arts-informed research methodology in which informants are asked to answer a question by drawing and further prompted to write or speak about their drawing. The method produces a data-set consisting of visual and textual data that can be analysed in varied ways, either quantitatively or qualitatively, either deductively or inductively (Hartel, 2017, 2020). It has been applied mainly in education, but also other fields to investigate a plethora of social scientific concepts, including ‘information’, ‘knowledge’, ‘energy’, ‘transitions’ in sustainability to name a few (see. Hartel, 2020). Scientific concepts have been less explored.

In this pilot study, the draw-and-write technique is combined with compositional interpretation (Engelhardt, 2002) and thematic analysis (Braun & Clarke, 2006) to probe into the concepts of biodiversity and evolution held by teacher students in an Norwegian university. The resesarch is guided by the explorative questions: 1) How are the concepts rendered? And 2) What themes and motives appear in the drawings, and how these relate to the scientific concept.

3 Research method

For data collection, 42 teacher students were asked “what is biodiversity” and “what is evolution” and given 10 minutes to draw-and-write a response, an a 10x10 cm square paper, named the bSquares and eSquares, respectively (inspired in the iSquare protocol - http://www.isquares.info/). The investigation occurred in classroom setting, at the beginning of a class, in science courses.

To answer the question “How are the concepts rendered?” the drawings were examined first using *compositional interpretation*, which entails ‘a way of looking very carefully at the content and form of images’ (Rose, 2007), and analytical attention is placed on the images themselves. Using the framework developed by von Engelhardt (2002), the drawings were examined and classified as *pictorial literal* (representing ‘what is’) or *pictorial non-literal* (for example metonymic, using ‘part to represent the whole’, symbolic or metaphoric) (p.126). Drawings were then placed in the primary types of representations (Cap.3): *picture; statistical chart; time chart; link diagram; grouping diagram; table; symbol and written text* (see also Hartel, 2017).

To address the question “What themes and motives appear, and how do these relate to definitions of the concept” a preliminary analysis inspired by *thematic analysis* was used (Braun & Clarke, 2006). Thematic analysis is a qualitative flexible method for finding patterns within data which can have an inductive or deductive epistemological stance or mix the two. Here, a predominantly deductive analysis was applied to the bSquares, while an inductive-deductive process guided the eSquares analysis.

4 Preliminary findings

In this study, most students produced graphic representations that are according to Englehart's typology *pictures* (Fig.1), *link diagrams* (Fig.3) or *grouping diagrams* (Fig.4,5), and are predominantly *pictorial* and *literal*. Most drawings in the bSquares were pictures and a few were link diagrams while other types did not appear (Table 1).

Table 1. *Graphic representations types (Engelhardt, (2002). *Types not represented are omitted*

Type* of Graphic representation	bSquares (n=42)	eSquares (n=42)
Picture	37	15
Link diagram	5	17
Grouping diagram	-	10

Biodiversity is mostly represented as a landscape: 26 of the drawings represent a diversity of life forms placed in a landscape, consisting of varied ecosystems (Fig.1a-c). Some drawings (9) show diverse life forms as elements on the graphical space, with no apparent connection between them (as an inventory) (Fig.1e), or in hierarchical schemes (3) alluding to biological classification (Fig.2b,c). In the representations, the themes of diversity of species and of ecosystems are present, while genetic diversity appears only twice (Fig.1d). Interestingly, humans appear in barely 25% of the drawings.

Figure 1. *Graphical representations (literal pictures) of Biodiversity as landscapes (a, b, c) and as inventory (d,e)*

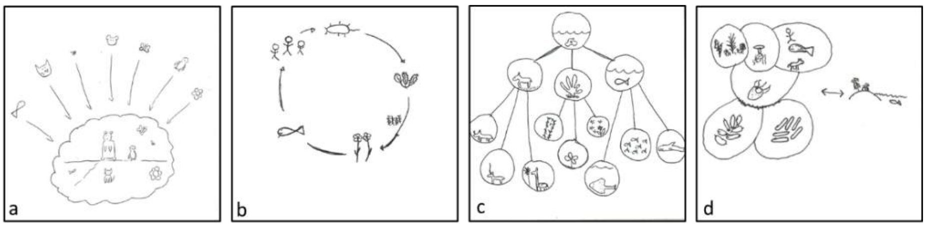

Figure 2. *Graphical representations of Biodiversity: link diagrams (a:linear, b:circular, c:tree); and a possible grouped diagram.*

Finally, while most bSquares are quite similar, two stand out presenting intriguingly and creative renderings: an imaginary creature and a sequence starting with diverse life and ending with an empty square (Fig.3).

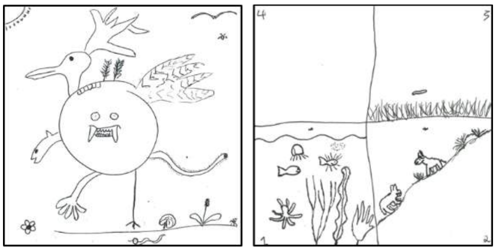

Figure 3. *The 'stand-out' bSquares.*

The compositional interpretation of drawings of evolution, identified a majority of *link diagrams* and *grouping diagrams* but also quite many *pictures* (Table 1.). Many renderings were considered *pictorial non-literal* (e.g. *metonymic*).

Across types, evolution is frequently rendered as a variation of the common cartoon that represents evolution as a linear process from primitive life forms to humans (Fig.4). This motive, with variations, appears in a total of 29 eSquares.

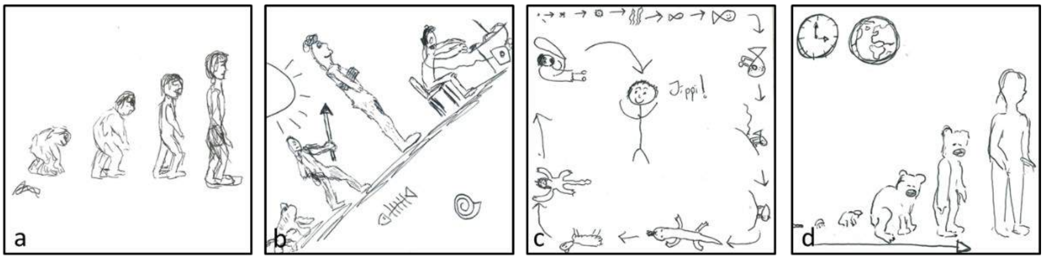

Figure 4. *Evolution as a linear process ending with Humans in pictures (a,b), link diagram (c) an a grouping diagram (d).*

Other common motives are birds (8) in representations also containing islands, referring to Darwin's finches and speciation, more explicitly (Fig.5). These allude to common text-book accounts of the Darwin theory of evolution. Darwin himself appears once (Fig.5a). Allusions to time as an important factor of evolution, appear seldom, fossils appearing only once (Fig.4b). Few representations indicate understandings of evolution as nonlinear, happening at a planetary scale (Fig.6a,b).

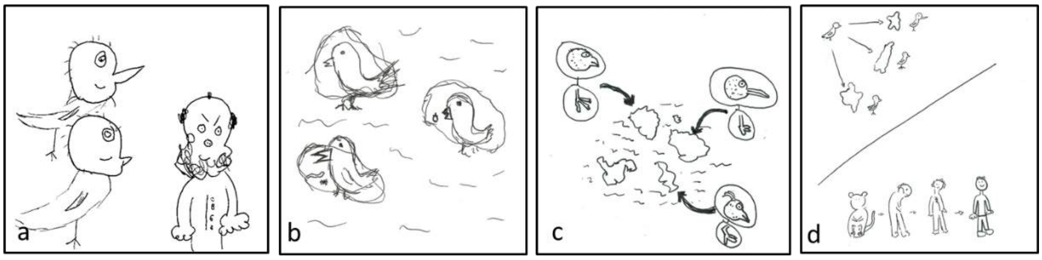

***Figure 5**. Evolution represented by the motives birds and islands, pertaining to the Darwin finches, and Darwin in pictures (a, b), link diagrams (c) and grouping diagrams (d).*

Finally, one intriguing representation stands out (Fig.6c), with its caption: "Evolution: development for better and worse!"

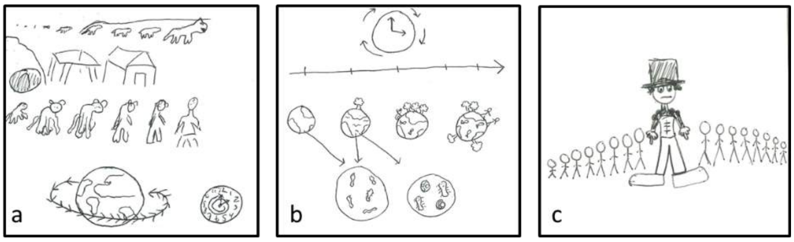

***Figure 6.** Less common representations*

4 Discussion

The nature of the study, a pilot generating a relatively small data-set, does not lend itself so much to draw conclusions as to raise points for discussion.

Whereas most students render biodiversity by drawing literal pictures, meaning they represent *what is*, link and grouping diagrams are prevalent in representations of evolution and are often non-literal, metonymic, meaning one part used to represent the whole (Engelhardt, 2002).

One prevalent motive was a canonical cartoon to represent evolution. This may highlight one of the limitations of the draw-and write technique, namely that informants may draw something simple, that they feel they can draw, rather than what they originally imagined (Hartel et al. 2018). In these renderings students represent evolution as a linear process with humans as 'end-product'. Whereas evolution may be a too complex topic, leading students to make 'tough choices' due to time constraints, the choices may also reflect real prevalent (mis)conceptions of evolution (Reiss &Harms, 2019).

Interestingly, regardless a quite small data-sets, patterns that project directly to the students' knowledge of the topics can be seen. For example, the representation of evolution with humans at the 'top-end, affirm common misconceptions documented in the literature (e.g. Reis & Harms, 2029). It would be interesting to repeat the study before and after instruction and compare representations diverse populations at different time points.

The study places analytical attention exclusively on the drawings. Further development includes contrasting text and image and draw the full power of the draw-and-write technique. Likewise, aspects pertaining to drawing as a social-cultural literacy may be important to ponder ahead of future investigations.

Taken together the experiences from this study show that the draw-and-write technique, and the analytical strategy employed, work nicely to investigate understandings of scientific topics, and can with advantages be adapted to pedagogical purposes.

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SAMSPELET AV SEMIOTISKA RESURSER I ETT TRANSSPRÅKANDE NO-KLASSRUM

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Abstract

The aim of this study is to gain a deeper insight into how various socially shaped and culturally and disciplinary given resources for meaning making are used and can be used in a translanguaging science classroom, and how these resources interact and complement each other based on how they are used, and the meaning potential that each resource constitutes. The research questions are: What semiotic resources do students and teachers employ as they engage in science? What do the various resources contribute to in the learning processes, and what are – or might be – their limitations? In the paper, data previously used to explore multilingually students´ authentic use of their first and second languages in a translanguaging science classroom, from a sociocultural perspective are reanalysed using multimodal interaction analysis, which is a powerful tool for examining multilingual students' use of multiple modalities, including gesture, facial expression, and drawing in science practices.

By extension, this can create knowledge about how teaching can be designed so that a wide range of semiotic resources are incorporated, both verbal and non-verbal, in multilingual science classrooms to create increased opportunities for active participation for all students.

Inledning

I NO-undervisning (undervisning i naturorienterande ämnen) utgör ämnesspråket en viktig förutsättning för att förstå och organisera ämnesinnehåll och aktiviteter (Lemke, 1990). Men även olika multimodala representationer såsom modeller, grafer och symbolspråk har en avgörande betydelse i medieringen av det naturvetenskapliga ämnesinnehållet (Lemke, 1998). Vidare visar forskning att ett aktivt deltagande med utgångspunkt i elevernas bakgrund, tidigare erfarenheter, språk och kunskaper är avgörande för elevers socialisering in i ett mer naturvetenskapligt sätt att se på världen (t.ex. Buxton et al., 2022). En central frågeställning är därför hur undervisningen i flerspråkiga NO-klassrum, där flera av eleverna står inför den dubbla uppgiften att lära sig ett andraspråk samtidigt som de lär på ett andraspråk, kan utformas och anpassas till elevernas ämneskunskaper och därmed bli kognitivt utmanande. Ett sätt att möta denna utmaning är via transspråkande pedagogik som utvecklats runt om i världen (Jakobsson et al., 2022). I en transspråkande undervisning uppmuntras elever att använda alla sina språkliga resurser såsom exempelvis första- och andraspråk, gester, ansiktsuttryck osv. för att utveckla förståelse och uttrycka kunskap. Flera studier visar hur detta skapar en mer inkluderande lärmiljö som främjar flerspråkiga elevers språkutveckling och begreppsförståelse samt den kognitiva utvecklingen (Jakobsson et al., 2022). I en svensk studie av tvåspråkig (svensk-arabiska) NO-undervisning visar Karlsson et al. (2019) hur flerspråkiga elever som uppmuntras att använda alla kommunikativa resurser ofta använder sitt första språk (arabiska) när de rör sig mot en vardaglig diskurs och sitt andraspråk (svenska) när de förflyttar sig mot den mer ämnesspecifika diskursen. Denna typ av flerspråkiga diskursiva loopar är särskilt vanliga i situationer där studenter förhandlar och relaterar det naturvetenskapliga ämnets innehåll till vardagliga och praktiska erfarenheter.

Vidare visar samma studie att det är vanligt att elever använder flera semiotiska resurser för att utveckla förståelsen för ämnesord och begrepp. Studien visar hur eleverna relaterar ämnesspecifika begrepp (uttryckta på andraspråket) semantiskt till varandra med beskrivande, förklarande och länkande ord och uttryck (uttryckta på förstaspråket) samtidigt som de använder gester för att förtydliga innebörden. Elevernas användning av både första och andra språk och gester visar att ett komplement av semiotiska resurser är viktigt eftersom varje resurs meningspotential kan ha begränsningar (Kress & Van Leeuwen, 2021).

Under de senaste åren har forskning kring transspråkande NO-undervisning alltmer börjat fokusera på de multimodala aspekterna (t.ex. Cheng et al., 2020; Ünsal et al., 2018). Studier belyser hur elever och lärare använder semiotiska resurser på sätt som är nära kopplade till situationen och skapar mening genom interaktiva processer. Studierna tydliggör på vilka sätt semiotiska resurser som bildspråk, gester, föremål och kroppsspråk samt digitala hjälpmedel kan skapa ökade möjligheter för meningsskapande i NO-klassrum. Studierna är därför speciellt betydelsefulla för utvecklingen av NO-undervisningen i klassrum där elever är ensamma om att tala ett språk, vilket är vanligt förekommande i många svenska klassrum idag. En annan utmaning i flerspråkiga NO-klassrum handlar om att elevers kommunikativa repertoarer är starkt kopplade till deras kulturella, sociala och psykologiska historia (Kress & van Leeuwen, 2021), vilket betyder att inte bara verbalspråket kan användas och tolkas på olika sätt utan även de multimodala resurserna (Ünsal et al., 2018). Med andra ord finns det behov av ytterligare forskning för att öka kunskapen om hur olika kulturella, sociala och disciplinära semiotiska resurser samverkar och integreras funktionellt i en transspråkande NO-undervisning. Detta konferensbidrag kommer med hjälp av multimodal interaktionsanalys (Wilmes & Siry, 2021) fokusera på hur semiotiska resurser i ett transspråkande NO-klassrum samverkar och integreras i lärprocesserna. I sin tur kan denna kunskap bidra till att öka medvetenheten om hur semiotiska resurser kan användas för att främja alla elevers möjligheter att utveckla kunskaper och litteracitet i de naturvetenskapliga ämnena.

Syfte och frågeställningar

Syftet med denna studie är att få en djupare insikt i hur socialt formade och kulturellt och disciplinärt givna resurser för meningsskapande används i ett transspråkande NO-klassrum, och hur dessa resurser interagerar och kompletterar varandra utifrån hur de används, och den meningspotential som varje resurs konstituerar. Forskningsfrågorna är följande:

- Vilka semiotiska resurser använder elever och lärare i ett transspråkande NO-klassrum?
- Vad bidrar de olika semiotiska resurserna till i lärprocesserna och vilka är deras begränsningar?
- På vilket sätt interagerar och kompletterar resurserna varandra?

Teoretiska utgångspunkter

Ett central antagande inom sociokulturella perspektiv är att all mänsklig interaktion förmedlas av kulturella och semiotiska verktyg. Det innebär att analysen ramas in inom socialsemiotisk teori, både när det gäller systemisk funktionell lingvistik (Halliday & Matthiessen, 2004) och socialsemiotiskt perspektiv på multimodalitet (Kress & van Leeuwen, 2021). Teorier om socialsemiotik och multimodalitet hävdar att varje instans av social kommunikation innefattar flera olika modaliteter, där varje modalitet bidrar på sitt sätt till formandet av en övergripande helhet. Således bidrar det multimodala perspektivet i analysen till att det breda spektrum av resurser som används i interaktion såsom exempelvis gester, blickar, kroppspositioneringar, teckningar och skisser uppmärksammas. Teorier om transspråkade (García & Wei, 2014) som tidigare framför allt fokuserat på verbalspråk har på senare år intagit ett mer multimodalt perspektiv på kommunikation. Exempelvis använder Wilmes et al. (2018) begreppet, transmodaling för att betona att flerspråkiga elever inte bara använder olika verbalspråk, utan även andra resurser för att uttrycka förståelse inom naturvetenskap.

Metod

För att fånga den autentiska interaktionen och kommunikationen mellan elever och mellan lärare och elever har en etnografisk datainsamling och forskningsdesign (Denscombe, 2014) använts. Deltagarnas meningsskapande processer och deras användning av semiotiska resurser har stått i fokus. I syfte att tydliggöra den komplexa användningen av semiotiska resurser i ett transspråkande NO-klassrum har multimodal interaktionsanalys (MIA) använts (Wilmes & Siry, 2021). MIA innebär en strukturerad process som omfattar fyra sammanlänkade faser. De fyra faserna är: (a) tillhandahålla en detaljerad och heltäckande beskrivning av sammanhanget, (b) titta på videoinspelningar utan ljud, fokusera på de visuella aspekterna för att avslöja icke-verbal kommunikation och interaktioner, (c) välja analytiskt fokus, och (d) integrera analysen av verbal kommunikation, lägga till ytterligare ett lager till undersökningen.

Resultat

Resultatet visar att både elever och lärare, i meningsskapande dialoger, vanligtvis använder flera olika semiotiska resurser och att resurserna på olika sätt interagerar och kompletterar varandra. Exempelvis använder en av eleverna gester för att visa hur en tornado rör sig, eleven ritar även rörelserna på ett papper, samtidigt som eleven verbalt förklarar vad en tornado är och hur den kan påverka omgivningen. Sammantaget bidrar varje modalitet (gester, ritande och verbalspråk) på sitt sätt till formandet av en övergripande helhet om vad en tornado är. Excerptet utgör ett av många exempel på hur olika semiotiska resurser samspelar i ett transspråkande NO-klassrum. Fler exempel kommer att presenteras på konferensen. Exemplen visar hur elever och lärare använder en mängd olika semiotiska resurser (och hur de samspelar) i olika lärprocesser och hur detta skapar ökade möjligheter för eleverna att utveckla kunskap och litteracitet i de naturvetenskapliga ämnena.

Diskussion och slutsatser

Genom att inkludera elevers hela språkliga repertoar i dialogiska och meningsskapande processer har transspråkande pedagogik potential att utveckla elevers förmåga att använda ett brett utbud av semiotiska resurser för att utveckla kunskaper och litteracitet i de naturvetenskapliga ämnena. I analysen framkommer att både elever och lärare använder flera olika semiotiska resurser och att dessa integrerar och samspelar med varandra på olika sätt. Således utgör transspråkande en värdefull beståndsdel i en språk- och kunskapsutvecklande

NO-undervisning, eftersom elevers resurser uppmärksammas och används i syfte att främja elevers utveckling av ämneskunskaper och ämneslitteracitet. Därigenom finns det behov av ytterligare forskning för att utveckla förståelsen för hur olika resurser kan samverka funktionellt och integreras i undervisningen för att öka alla elevers möjligheter till inkludering och ett aktivt deltagande i NO-undervisningen.

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STUDENTS' USE OF LANGUAGE TO CREATE MEANING IN SCIENCE DISCUSSIONS

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Abstract

The ability to participate in scientific discourse is becoming increasingly important for democratic citizenship in modern societies. It is therefore essential to understand scientific concepts and words. This study investigates how 8th grade students create meaning by moving between everyday and scientific language in dialogues. We analyzed audio recordings of group discussions from an inquiry-based teaching project on antibiotic-resistant bacteria, as well as corresponding video recordings of whole-class discussions. The analytical frameworks of practical epistemology analysis and discourse mobility yielded interesting results in this context. We identified semantic waves in students' talk, where language shifted between everyday and scientific language, especially in situations where the students negotiated meaning, challenged claims, or asked questions. The findings suggest that prior experiences are crucial for meaning-making in science dialogues. However, students can get caught up in negotiations about everyday words rather than scientific concepts. The findings also suggest that students often lack awareness of how they use language to make meaning. This may have implications for how teachers facilitate and explicate the process of scientific meaning-making through classroom dialogues.

1 Introduction

Science education has among its goals to prepare students for participation in modern society (NGSS Lead States, 2013). To be able to make reasoned evaluations concerning complex socioscientific issues, it is vital to understand scientific concepts and language (Osborne, 2002). Learning science includes being able to utilize linguistic and symbolic tools such as words, concepts, or equations to express and interpret meaning (Knain et al., 2011). The concepts and phenomena that students encounter in the science classroom are often somewhat familiar from everyday life, such as gravity or bacteria. Several researchers have described a middle ground that occurs when explaining science concepts using everyday language (Serder & Jakobsson, 2016).

We believe this study is novel in combining the frameworks of *practical epistemology analysis* (PEA; e.g., Lidar et al., 2010) and *semantic waves* (Maton, 2015) to describe 8th grade students use of language to create meaning in science dialogues. We try to answer the following research questions.

1) *How do students move between everyday and scientific language in science dialogues?*

2) *How does meaning-making occur in students' science dialogues?*

2 Theoretical backgrounds

The movement of language between different modes can be described as discursive mobility (Larsson & Jakobsson, 2017; Maton, 2015), with semantic waves flowing from everyday to scientific language. The movements occur along two axes: *semantic gravity*, and *semantic density*. Semantic gravity denotes to which degree meaning and context are related. A high level of specificity denotes stronger semantic gravity. Semantic density denotes to which degree meanings are condensed within contexts. The word "gold" in everyday language has a different meaning than in the field of chemistry. In chemistry it is situated within a semantic structure relating to several chemical and physical properties. The latter implies a stronger density.

Practical epistemology analysis is a framework for analyzing students' meaning-making and learning in institutionalized and social practices (Lidar et al., 2010). *Practical* epistemology signifies that what counts as relevant differs between practices. This pragmatic perspective implies the possibility of investigating epistemology through analysis of people's actions in the specific context (Lidar et al., 2010). Wickman and Östman (2002) introduced four key terms in their use of PEA. Certain words in a conversation that are understood without question are called *stand fast*. When something is not directly comprehended, that is an *encounter* where meaning-making occurs, and the question that needs to be answered is a *gap*. To create meaning, participants establish *relations* between what was not comprehended and what is standing fast.

3 Research methods

Audio and video data from whole-class and student discussions within a teaching unit about antibiotic resistance were gathered. The teaching unit was part of a school development project (see, in Norwegian, argument.uib.no) in Norway. This study used data from four groups of student-student discussions in one 8th grade classroom, selected based on relevance. The analysis consisted of two phases. First, the discursive movement between everyday and science language was described and visualized using semantic waves (Larsson & Jakobsson, 2017; Maton, 2015). Second, PEA was used to describe how meaning-making occurs (Wickman & Östman, 2002).

4 Results and discussion

Table 1 shows an excerpt from a group discussion where students S1, S2, and S3 work on making rules for use of antibiotics.

Table 1*: Semantic waves*

Stronger semantic gravity **Weaker semantic density** Everyday language.	**Weaker semantic gravity** **Stronger semantic density** Subject specific. More abstract.
← →	
S1: Eat proper food – like, get nutrition	
S2: Not just eat „what" (?) they find on the street	
S1: Not just eat lots of that junk food, for example	
S2: Yes, but don't if you find a pack of gum, don't e – on the ground, don't eat it – was that what you meant?	
S1: Huh?	
S2: Was that what you meant or did you mean something else?	
S1: I meant, like, eating, like, a nutritious food	
	S2: Yes am a bit uncertain if that has something to do with bacteria –
yes might depend on what way food is prepared but – if that/	
S3: That was like him… him that ate McDonalds	
S2: Huh	
S3: He who was going to eat McDonalds for like a month or something	
S2: Sick man	
S3: He did become sick - //or	

VG: Yes the reason that he puked that is because// ate way too much and the stomach could not…	
S1: He ate too much // -	
But like for example vegetables and greens are supposed to give you – nutrition/	
S2: You can puke and eat lots of vegetables/	
S1: Because like –	
If we don't eat properly then like the body gets weaker and then you more easily can get sick	

Discursive mobility

The discussion starts with S1 suggesting a rule for antibiotics use should be “eat proper food”. The use of the word “nutrition”, which has stronger semantic density, combined with “get”, which is more contextual, places this in the middle of everyday and scientific language. “Get nutrition” is more abstract than “eat food”, and thus it has weaker semantic gravity.

The next utterances seeks to clarify what S1 meant. S2 first interprets S1’s meaning as not eating food found on the street. S1 clarifies that proper food is at least not junk food. This exchange uses everyday language. S1 restates the original claim about “nutritious food”, strengthening semantic density.

S2 challenges the suggestion by expressing doubts about whether nutritious food relates to “bacteria”, a denser term, leading the conversation towards scientific discourse. The utterance introduces a higher level of abstraction than previously seen in the dialogue, before moving towards the specific by stating a possible relation between bacteria and food preparation.

PEA

S1 seems to believe that there is a relation between food and the use of antibiotics. This relation is not stand fast, as S2 questions it. S1 might have meant that nutritious foods keep us healthier and reduces the need for antibiotics, as specified in S1’s last utterance. S2 seems to have a different relation of food and antibiotics, where food must be prepared to kill any potential bad bacteria. This creates a gap in the discourse, leading the conversation into a process of meaning-making through negotiation of the relations between food, nutrition, bacteria, and antibiotics.

S3 establishes the relation food – sickness, probably to support the relation food – antibiotics, as antibiotics is one known way to treat certain illnesses. Thus, S3 uses a stand fast previous experience concerning unhealthy food making people sick to create meaning of the relation food – sickness in this new context. Lidar et al. (2010) would say that such use of previous experiences in a new context always implies that new meaning has been created.

It could be noted that more academic terms, like nutrition and bacteria, are used to systematize everyday expressions, like “proper food”, similar to a study by Ash (2008). Moreover, “proper food” has become more dense within this context due to being linked to terms like “nutrition”. This is what Serder and Jakobsson (2016) would call a unique *meaning of use*.

4 Conclusion and practical implications

The findings of this study suggest that students need to be explicitly taught about the nature of scientific language, including its conventions and terminology, as well as how to use it to communicate effectively. In addition, teachers can help students to develop their scientific language skills by providing opportunities for students to practice using scientific language in a variety of contexts and providing feedback on students' use of scientific language.

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LIFE SKILLS IN SCIENCE EDUCATION – WHAT DO SCIENCE TEACHERS SAY AND DO IN THE CLASSROOM?

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Abstract

In science education, life skills are associated with subject-specific topics such as sexuality, nutrition, body functions and mental health. In this study we investigated how science teachers define and include life skills in the classroom. We included 14 teachers and 22 science classrooms in our study. All teachers were asked to log their lessons both before and after instruction, reporting if they planned to include life skills in their lessons and whether they did teach life skills. Additionally, all lessons were videotaped, and the teachers were interviewed in retrospect, when all the lesson sequences were performed and videotaped. Results showed that the teachers included life skills in almost half of the videotaped lessons, and that the lessons included not only subject-specific topics, but also to competencies such as critical thinking, problem-solving, communication and collaboration, important for the development of life skills. The findings also indicate that the teachers have a wide definition of life skills. This study may increase the understanding of how life skills education may be related to science education.

1 Introduction

Preparing young people for future citizenship demands educators to focus on more than school subcjets in their teaching. The development of transferable skills and knowledge, often referred to as "21st century skills" (Pellegrino & Hilton, 2012), has emerged as an essential part of the curriculum in many countries over recent years. These skills refer to cognitive skills as well as interpersonal and intrapersonal skills and can be related to life skills as defined by the World Health Organization (WHO): "*Abilities for adaptive and positive behaviour that enable individuals to deal effectively with the demands and challenges of everyday life*" (WHO, 1993). According to WHO, core life skills include decision-making and problem-solving, critical and creative thinking, communication and interpersonal relationships, self-awareness and empathy; and coping with stress and emotion. To develop these skills WHO has suggested the concept "Life Skills Education" to be implemented in schools: including both cognitive, emotional and social skills, all important for both physical and mental health.

2 Theoretical backgrounds

In science education, life skills are associated with subject-specific topics such as sexuality, nutrition, body functions and mental health. Additionally, science education has an important role in cross-curricular subjects and particularly socio-scientific issues (Kyburz-Graber, 2018; Bybee, 2018). Some of the above mentioned WHO core skills are closely related to scientific inquiry such as problem-solving, critical and creative thinking and communication, essential for the inquiry process.

Life skills in science education can also be related to the concept "health literacy" (WHO, 2020). Health literacy entwines with science education through topics such as environmental issues and health related issues, and also through critical thinking and practical skills (Bybee, 2018; Paakkari & Paakkari, 2012).

Life skills and health literacy are parts of the national science curriculum in our country, and the foundation for this study. We aimed to investigate how science teachers across primary, secondary and high school work with life skills in their classroom. Our research questions are:

1. *How do science teachers across grades perceive life skills in both the national curriculum and their teaching?*
2. *How can life skills be observed in science teaching across grades in the light of a new national curriculum?*

3 Research methods

This study is part of a larger study including several school subjects and a large number of teachers and classrooms, using mixed methods to capture both qualitative and quantitative aspects of life skills education. Video data offers the opportunity to capture complex teaching situations, providing rich data that can be studied repeatedly, enabling detailed classroom analysis (Blikstad-Balas, 2017). In the video design, 4 consecutive lessons in each classroom were videotaped using two cameras mounted in the front and the back of the classroom. We included 14 teachers and 22 science classrooms in our study.

All teachers were asked to log their lessons both before and after instruction, reporting if they planned to include life skills in their lessons and whether they did teach life skills. There were no interventions included in the study. Participating schools represented both rural and urban areas, and the teachers varied with respect to age, education, gender and teacher experience. The interviews were done in retrospect to the videotaping in order to get the teachers perspective on the teaching itself and the planning before. The teachers were asked to elaborate on what they reported about e.g., life skills in the teacher logs before and after the lesson.

Video data was analyzed using an observation teaching protocol developed for life skills by the research group for the larger study, representing the three categories *Content*, *Action and attitude* and *Subject-specific life skills*. All lessons were divided into 15-minutes segments, and each segment was scored 1 through 4 according to the protocol, based on evidence found for each of the practices in the protocol.

4 Results

Table 1 shows an overview of the findings and total lessons videotaped and logged in 8th grade[13]. In total, 36 lessons and 117 segments were videotaped, and life skills content were reported in the teacher logs as planned in 47% of the lessons and performed in 75%. Our video observations differed from both planned and performed LS content, as we identified less elements of life skills than reported by the teachers. All three protocol categories were identified in the lessons, dominated by codes at level 2 with a few cases of level 3 and 4. Our findings showed that the teachers' instruction and student participation mostly are co-related, but sometimes the teachers present life skill related topics without related student activities.

[13] The data collected in the 11th grade is still under analysis and is therefore not included in table 1.

Table 1. *Overview of the video data (8th grade) and how life skills (LS) are represented in the lessons, both as reported by the teachers and our observations.*

	Total				Reported (Teacher logs)		Observed (video)
	Schools	Class-rooms	Lessons	Segments	LS lessons planned	LS lessons	LS lessons
Number	4	9	36	117	17	27	16
Percentage					47 %	75%	44%

The three different categories in the observation teaching protocol focus on academic use of life skills and student participation in the observed lessons. Examples of how teachers thematizes non-academic life skills also occur in the science classrooms.

During a lesson about the periodic table, a student asks the teacher a question related to another topic: the human body, specifically the male reproductive system. The student firstly restates subject related facts they have been taught, that "when things get cold, they become smaller and move around less. Is it the same for male testicles? That when it gets warm it moves more and when it gets cold it stays firmer?". The teacher allows the students to discuss a bit before ending the discussion by stating "well is it not like, something with how these sperm cells need a correct temperature, that's why they´re hanging. The testicles are hanging on the outside, so it does not become too warm, or they regulate the temperature a lot better when they´re hanging there and then they shrink together if it's too cold. Out when it becomes too warm in order to cool down, but we will find out more about this later, just not right now. Let's try to rewind to the periodic table.

Figure 1. *Teaching moment: academic use of life skills*

Non-academic situations are important foundations for the students´ mastery of their own lives and the teaching about life skills. Figures 1 and 2 show examples of how teachers thematize both academic and non-academic use of life skills.

During a lesson, the teacher stops the lesson and explains to the class why they should not whisper in a private conversation between learning partners whilst looking across the classroom. This is connected to interpersonal relations:
Teacher: Because if you look a lot across [the classroom], no one knows what you are talking about, and that might be uncomfortable for others, so when you two talk across the classroom we might not know … it's not certain that others understand […] and then they think "oh, are they talking about me?", that is very uncomfortable, so that is like an "across conversation" across the classroom. That might feel very uncomfortable for those who are not involved in the conversation and that is why it is important for us to understand that talking excludes others. Okay, is that okay?

Figure 2*. Teaching moment: academic use of life skills.*

When interviewed, the teachers in 8th grade comment on different sides of life skills in their science teaching. However, the relation between science and understanding and participating in the society with the help of science was emphasized, to be able to "master life and make good life choices" (transcription, teacher interview), and the importance of working with mental health and "educating children who are able to reflect, assess and evaluate what they are reading". The value of a social community and building relationships were also highlighted by some teachers. Findings from interviews with 11th grade teachers indicate that some are more concerned with the academic use of life skills than 8th grade teachers, and some highlight similar topics related to life skills as the 8th grade teachers[14].

4 Discussion and conclusion

Our findings show a connection between what the teachers express about life skills in the interviews and what we observe in the video recorded science lessons. Life skills in science instruction are related to subject-specific topics, but also to competencies such as critical thinking, problem-solving, communication and collaboration, important for the development of life skills (WHO, 2013). The national curriculum emphasizes life skills as focusing on understanding one's own body in connection to science, but also critical thinking, which is consistent with some of the video material in this study. This is in line with literature related to health literacy and life skills in science education (Bybee, 2018; Paakkari & Paakkari, 2012).

The interviews and video material show how some teachers in 8th grade, 11th grade, and elementary school share similar understandings connected to life skills and therefore show a similar focus on topics in their teaching. Additionally, our findings show that the teachers have a varying understanding and focus considering life skills in science, especially across grades. One could question whether this is due to the age of the students and thus their need for emotional support in their educational journey, or due to other factors.

As a concluding remark, our study will compare how life skills are incorporated in science lessons: by highlighting what life skills look like in practice, through e.g., teaching moments across grades (from elementary, secondary and high school). This study may increase the understanding of how life skills education may be connected to science education, and in that sense make a contribution to science teaching.

[14] The data from the 11th grade is still under analysis and examples from lessons or transcriptions from interviews will therefore not be part of the abstract's findings.

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HOLD SPENNINGEN OPPE: TILRETTELEGGING FOR LÆRERSTUDENTERS UFORSKING AV ARGUMENTER OM ENERGIPRODUKSJON

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Abstract

This study explores how to facilitate discussions on energy production and CO2 emissions in pre-service teacher education. A teaching unit was developed and implemented in three cycles, involving students in roleplaying scenarios as experts and representatives of interest groups. Within a simulated conference setting, they engaged in debates addressing challenges associated with various energy production technologies. The initial phase of the conference focused on persuasive argumentation, aiming to sway the opinions of opposing parties. Conversely, the latter phase emphasized consensus-building, seeking common ground for collaborative solutions.

Analysing the students' argumentation in the first implementation revealed distinct patterns between the persuasive and consensus-driven discussions. While claims were to a large degree justified and supported during the persuasive phase, consensus-oriented discussions tended to gravitate towards unquestioning agreement. This resulted in a lack of critical engagement, with unsubstantiated claims and controversial perspectives rarely challenged or explored. In the second and third cycle two changes in the teaching unit were implemented to enable the students to use time and effort to evaluate and challenge assertions, even when striving for consensus.

1 Innledning

Å forholde seg til spørsmål knyttet til elektrisk energiproduksjon krever evne til å undersøke og vurdere informasjon for å kunne ta beslutninger og handle (OECD,2023). Læreres måte å praktisere naturfagundervisning på er ifølge flere studier lite egnet til å ta for seg komplekse tverrfaglige tema knyttet til bærekraft eller medborgerskap (Bjønness & Sinnes, 2019; Sinnes & Jegstad, 2011). Sundstrøm m fl (2019) hevder at lærerutdanninga bør bidra med erfaringer og verktøy som gir fremtidige lærere en mer helhetlig tilnærming til ulike tema.

Denne studien presenterer og diskuterer tre utprøvinger av *Teknologikonferansen* et undervisningsforløp i naturfaglærerutdanningen der studentene skal sette seg inn i kunnskap, vurdere informasjon og diskutere argument knyttet til hvordan man kan produsere utslippsfri elektrisk energi. Målet med gjennomføringene er å legge til rette for at elevene trener i å være lyttende, men samtidig kritisk vurderende til egne og hverandres argumenter.
Problemstillingen er som følger:
Hvordan legge til rette for at lærerstudenter får trening i å undersøke og vurdere argumenter knyttet til produksjon av elektrisk energi?

2 Teoretisk bakgrunn

Argumentasjon handler om å gi gode begrunnelser for en påstand (Osborne & Patterson, 2011). Formålet med en slik praksis kan ifølge Walton (2009) å *overtale* en annen part om et spesielt synspunkt. Bailin og Battersby (2016) fremhever at formålet med å argumentere også være å undersøke en påstand for å komme best mulig begrunnet synspunkt. For å få dette til, så krever det at den som argumenterer må være undersøkende, lyttende og vurderende i forhold til egne og andres begrunnelser (s 370).

Felton et al. (2015) sammenlignet elevdiskusjoner der formålet var å overtale motparten med diskusjoner der formålet var å bli enige. De fant at når målet var å overtale så ble diskusjonene mer avbrutte og dominert av ubegrunnet kritikk av motparten, mens når målet var konsensus så brukte elevene mer tid på å lytte til, utvikle og integrere argumentene til hverandre.

3 Metode

Undervisningsforløpet inngår som en del av et emne i naturfaglærerutdanningen og er basert på Kolstø (2000) sin ide om *konsensusprosjekt* i skolen. Studentene deltar på en konferanse der de spiller roller ekspert- eller interessegrupper som argumenterer rundt ulike måter å produsere elektrisk energi på.

I *del en* av konferansen la hver gruppe frem argumenter for sin produksjonsteknologi. Gruppene ble utfordret av en miljøgruppe som hadde som hadde forberedt motargumenter. Formålet med denne diskusjonen var altså å overtale motparten. I *del to* av konferansen gikk studentene ut av rollen sin for å diskutere i grupper for å bli enige om å finne beste løsninger på hvordan man kan produsere utslippsfri elektrisk energi. Tabell 1 viser data som er samlet inn fra selve konferansen. I tillegg ble fire studenter intervjuet etter tredje utprøving.

Tabel 2 *Data*

	n	**Opptak under konferansen**	
		Del en Plenum	Del to Gruppediskusjon
Første utprøving	25	Video	Lyd 3 grupper
Andre utprøving	12	Lyd	Lyd 2 av av grupper
Tredje utprøving	24	Video	Lyd av 4 grupper

Lyd og videoopptak fra første utprøving ble transkribert og analysert av to masterstudenter (Barm & Solheim, 2022). Det ble gjort endringer i det didaktiske designet i utprøving to og tre basert på funn fra denne oppgaven. Masterstudentene videreutviklet også et rammeverk for analyse av studentenes ytringer som i løpet av vår 2024 vil bli brukt i videre analyse av innsamlede dataene. Målet er å undersøke hvilke elementer i undervisningsforløpet som kan bidra til at studentene bruker tid på å undersøke og vurdere påstander som blir diskutert. Dette er i tråd med en designbasert forskningstilnærming (Andersen & Shattuck, 2012).

Analysen av studentenes ytringer har tatt utgangspunkt i Gronostay (2016, p. 46) sine hovedkategorier *co-construction (enighet)*, *opposition (uenighet)* og *integration (integrering)*. Gjennom analysen ble det klart at diskusjoner ofte starter med at noen stiller et spørsmål der de enten etterspør informasjon eller ønsker å avklare en påstand. Derfor er kategoriene *spørsmål* og *tilsvar* i Felton et al. (2015) sitt rammeverk inkludert *spørsmål* som overordnet kategori. Videre ble underkategorier utviklet ut fra ytringenes innhold og blir presentert i resultatdelen. Disse samsvarer i flere tilfeller med underkategoriene i rammeverket til Gronostay (2016) og Felton et al. (2015).

4 Resultat

Gjennom analysen utviklet vi til sammen 15 ulike kategorier for å beskrive studentenes ytringer i teknologikonferansen. Disse blir presenter i tabell 3 som underkategorier til hovedkategoriene i tabell 2.

Tabell 1: *Hovedkategorier for analysen med tilhørende underkategori.*

Hoved-kategori	**Underkategori**	**Forklaring blir presenter på konferansen**
Spørsmål	Etterspør avklaring	
	Etterspør informasjon	
	Etterspør løsning	
Tilsvar	Avklaring	
	Informasjonssvar	
Enighet	Ubegrunnet enighet	
	Fortsettelse	
	Utdyping	
	Lokalt fokusskifte	
Uenighet	Ubegrunnet uenighet	
	Motargument frittstående	
	Motargument tilsvar	
Integrering	Å innse	
	Lokal aksept	
	Kvalifisering	

Kategorisering av studentytringene ble brukt til å sammenligne hva som kjennetegner diskusjonene i de to ulike delene av konferansen. Diagram 1 og 2 viser fordelingen av ulike ytringer når studentene er i og utenfor rolle.

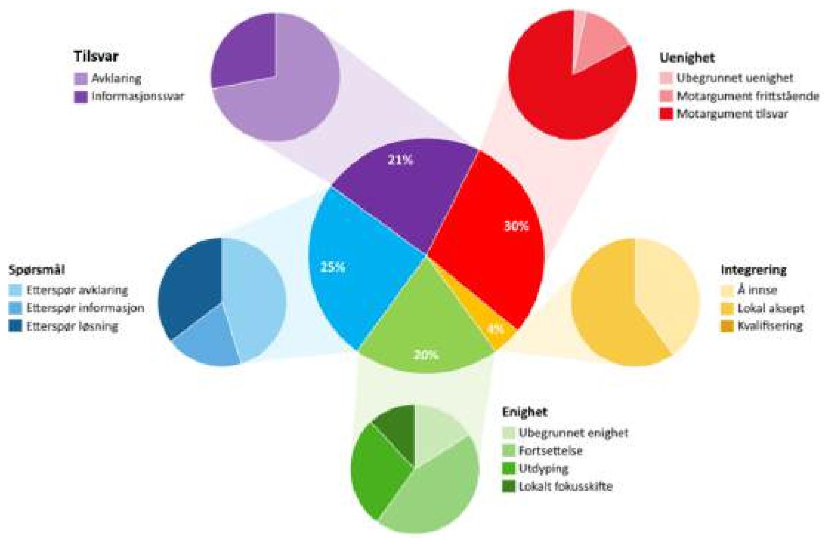

***Diagram** 1 Studentenes ytringer i diskusjon med mål om å overtale*

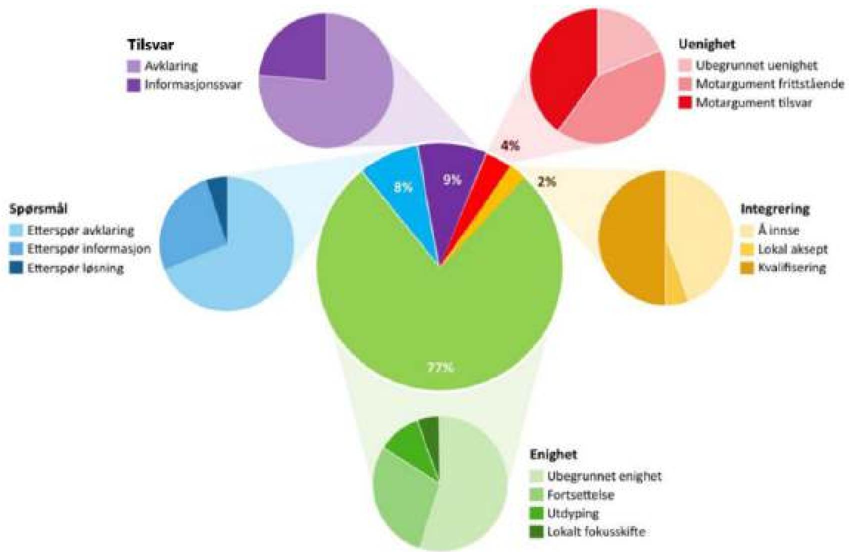

***Diagram 2** Studentenes ytringer i diskusjon med mål om konsensus*

Diagram 1 viser jevn fordeling mellom hovedkategoriene når studentene diskuterte med mål om å overtale. Underkategoriene synliggjør at når studentenes uttrykker enighet eller uenighet, så er dette i hovedsak begrunnet på ulike måter. Det er forholdsvis få ubegrunnete ytringer.

Når studentene diskuterer i grupper i del to av konferansen diskusjonene som vi ser av diagram 2, dominert av enighetsdiskusjon. Her er det spesielt interessant at over halvparten av disse ytringene er kategorisert som ubegrunnet enighet. Videre viser diagram 2 at det er svært få ytringer som uttrykker uenighet eller integrering. En videre analyse av dialogen tyder på at studentene i stor grad sa seg enige i påstander, selv om de var faglig feil eller uttrykte kontroversielle synspunkt (Anonym, 2023).

4 Diskusjon og konklusjon

I motsetning til Felton et al. (2015) sin studie så var gruppediskusjoner med mål om konsensus dominert av ubegrunnede enighetsytringer. Vår tolkning er at enighetsfokuset hindret dybde i diskusjonen fordi det bidrog til at synspunkt, kunnskapspåstander og uttrykte verdier ikke ble utfordret eller utforsket. Vi vil peke på to problemer med vår tilrettelegging.

For det første, studentene skulle i løpet av 55 minutter bli enig om hvordan vi i *fremtidens kan produsere utslippsfri elektrisk energi*. Dette er en omfattende problemstilling. I Felton et al (2015) sin studie fikk studentene like lang tid på mye mer avgrensede problemstillinger. Derfor endret vi det didaktiske designet av gruppediskusjonene på de to neste utprøvingene. I andre utprøving fikk studentene i oppgave å identifisere vanskelige dilemmaer som skulle tas opp senere i semesteret. I tredje utprøving ble det formulert mer avgrensede dilemmaer basert på helklassediskusjonen i del en av konferansen. Hver gruppe fikk undersøke sitt dilemma og de ble bedt om finne for- og motargumenter og deretter bli enige om en konklusjon.
For det andre, i den første utprøvingen ble studentene oppfordret legge vekk egne synspunkt og til å lytte og forstå argumentene som ble ytret i diskusjonen. Dette kan ha bidratt til at studentene i liten grad uttrykte uenighet eller utfordrer medstudentene sine påstander. I tredje utprøving ble studentene oppfordret både til å lytte til hverandre og til å utfordre påstander og uttrykke egne motforestillinger. Foreløpige resultat fra tredje utprøving tyder på at tilrettelegging for mer uenighet, mer spenning i debatten, bidrar til større engasjement for å undersøke og vurdere påstander som kommer opp, også i diskusjoner der målet er å bli enige. En grundigere analyse av disse dataene blir gjennomført våren 24 og presentert på konferansen.

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EXAMINING FIRST GRADERS' SCIENTIFIC LANGUAGE AND VOCABULARY USE

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Abstract

To meet the need for improved science and disciplinary oral language instruction in elementary classrooms, teachers and researchers need to better understand what young students' science discourse may look like and how teachers can support this scientific language development. This paper reports on the nature of first graders' language and vocabulary use when explaining science phenomenon with the goal of better understanding how their language is developing because of an integrated science and literacy curriculum.

1 Introduction

The value of science for the early grades is still not widely recognized despite the important role of education in developing a global citizenry prepared to address the challenges of climate change. In fact, science instruction is receiving less attention in elementary schools (Banilower et al., 2018; Dorph et al., 2011; Marx & Harris, 2006). Yet, the research is clear. All students in the earliest grades, regardless of background or circumstance, have the capacity to learn science (NRC, 2007). While children are capable of advanced scientific thinking and inquiry (e.g., Duschl, Schweingruber, & Shouse, 2007; Metz, 2008), their thinking may be masked by the vast differences in children's facility with science language. These differences can lead to inequities in discussions and dramatic differences in children's ability to demonstrate understanding (Samarapungavan, Mantzicoupoulos, & Patrick, 2008) and develop the thinking and reasoning skills that science requires. A promising approach to increasing science instruction and facility with science language is found in approaches that integrate science and literacy (Billman & Pearson, 2018; Cervetti et al., 2012; Lee & Stephens, 2020; Pearson & Billman, 2016; Wright & Gotwals, 2017). As students investigate to understand and explain phenomena, they learn scientific ways of talking, reading, and writing to communicate findings and provide explanations (Bailey et al., 2007; Billman & Pearson, 2013; Pearson & Billman, 2016).

2 Theoretical Background

Sociolinguistic theories of language development identify language as the prototypical resource for making meaning (Halliday, 1993; Nasir et al., 2021; Wells, 1994). In other words, language is central for engaging in learning science and is critical for constructing and expressing science understanding. Language is a system for organizing science knowledge and a resource for understanding and participating (through reading, writing, listening, speaking, and thinking critically) in a science community. In that respect, science and literacy are interwoven and synergistic rather than isolated (Hart & Lee, 2003; Pearson, Moje, & Greenleaf, 2010; Stoddart et al., 2002). As children investigate to understand phenomena, they learn scientific words and ways of talking to communicate findings and provide explanations supported by evidence (Bailey, Butler, Stevens, & Lord, 2007; Pearson & Billman, 2016). As children are learning scientific language and using scientific language to learn, they are also learning about language (how it is structured and how it is encoded in text) and mastering a set of reading and writing skills.

Acquiring language and the rudiments of domain-related vocabulary begin at the earliest ages as children learn about the world (Billman & Pearson, 2013; Lindfors, 1999; Wells, 1986). Sophisticated language repertoires develop over time as children bring the language(s) they know to new contexts. Initially, children participate in learning science by using the language and ways of speaking that they know well—their everyday language(s) or registers (Grapin et al., 2019). Through supportive teaching and authentic opportunities for situated practice (Wells, 2000) that embed opportunities to learn and use the specialized words, phrases, and ways of talking and writing, their language evolves (Bailey et al., 2007; Pearson & Billman, 2016). Over time, their participation leads to facility with the new language and ways of speaking that are germane to the new context.

3 Research methods

This research reported here is part of a larger, design-based research (DBR) project. First grade students participated in an implementation trial of an integrated literacy-science curriculum designed to provide opportunities to learn key science concepts and the oral and written language structures relevant to science. Using an "intentional" case study methodology (e.g., Dyson & Genishi, 2005), we examined the conceptual and linguistic richness of students' pre and post responses to a Science Knowledge Assessment (Authors, 2015). After scoring pre/post SKA assessments for all participants in the curriculum implementation study, we selected nine students (see Table 1) based on their profiles of growth in science content knowledge and vocabulary as cases for further study. All were emergent bilinguals.

Table 1: *Participants*

Life Science SKA Score	Student	Home Language
Moderately low at pretest	1. Nina 2. Marcus	Spanish Spanish
Very low at pretest	3. Andrea 4. Sonia	Spanish Spanish
Moderately low at pretest; lower at posttest	5. Monica*	Arabic
Physical Science SKA Score		
Moderately low at pretest	1. Monica* 2. Mumtaz	Arabic Arabic
Very low at pretest	3. Elvis 4. Jairo	Spanish Spanish
Moderately high at pretest; higher at posttest	5. Juan	Spanish
*Monica was retained in first grade and so participated in both integrated units.		

Science Knowledge Assessment (SKA).

The SKA is a performance-based assessment that measures multiple aspects of science specific knowledge and abilities in first graders through a one-on-one interview. The assessment format consists of a series of strategically designed and sequenced tasks organized around explaining a unit-specific phenomenon. The assessment includes hands-on materials and a set of prompts and questions to measure four constructs 1) understanding of science concepts, 2) understanding of scientific terminology, 3) understanding explanatory language structures, and 4) understanding a science or engineering practice. In general, evidence of students' understanding is assumed to be use, that is, employing a concept, language, or practice to complete a particular task. Students who can use concepts, words, or language in more complex, less supported tasks are inferred to have more completely developed understanding of the concepts and facility with the practices than those whose use is limited to more targeted, supported tasks.

Data and Analysis

Data sources were video-taped interviews of students' performance on the SKA. Each 1:1 interview was video-recorded and scored using a quantitative coding scheme. Using SKA quantitative scores, we identified five children representing a range of performance profiles in two domains: science knowledge and use of unit science vocabulary We used an iterative design methodology to develop a discourse-based coding scheme to examine students' use of scientific language as they participated in the interviews (Glaser & Strauss, 1967; Strauss & Corbin, 1998). This resulted in coding scales for science knowledge, explanatory language, and vocabulary use. We revised the scales as we encountered examples that challenged our in-progress version. We analyzed those students' video recordings to produce a narrative description of each first grader's reasoning during a complex science task.

4 Results

The fine-grained analysis of students' language showed a consistent growth in the use of intervention specific vocabulary from pre-post, but little growth in the use of explanatory discourse patterns. Students were able to articulate understanding of science concepts; however, there were frequent examples of students translating unit language into informal language and evidence of students anthropomorphizing phenomenon.

Anthropomorphism

Students like to personify material phenomena as well as animals, often attributing motives and purpose. On the physical science pre-test, Sonia said that it is not fair that some plastic pieces have colors and other pieces do not. "These two. Because it is not fair that these two have colors and these don't. That's why it lets this one be white. Because these are not fair, they get to have the colors and not them." Similarly, Mumtaz assigned human emotion to an inanimate object. She described the porcupine as expressing hate towards the predator (the coyote during the life science unit). "Because it has things. He can put in [animals] and die. The porcupine is going to hate the coyote… It has these things… If they are scared of you they are going to hate you with these things [points to fluffy part of porcupine] and poke you."

Conceptual Misunderstandings

Conceptual misunderstandings abound in these domains, and they affect both meaning making and communication. In the physical science unit, some students had a challenging time understanding the difference between key concepts. For example, Sonia misunderstood the difference between color, brightness, and opacity. She responded to the following question: Which of these three pieces of plastic blocks the light from the flashlight? What do you see that makes you think that? “This. Because there is not color on this one only on these two.”

Vocabulary Development

Finally, during the life science unit, we saw lots of examples of inventive ways of translating unit language into personal or informal language that the students could more readily relate to. Many could not handle the term, spines to define the quills, and so used prior knowledge to support their new understanding. Jairo, as an example, referred to spines as “spikey” when describing the porcupine during this post-test. Other such terms also emerged, such as splint, splinty, poke, and pokey.

4 Discussion and conclusion

The SKA task proved to be challenging for all students that participated in the larger study and especially challenging for ELs. Consequently, we were not able to distinguish, with a high degree of confidence, between conceptual and linguistic explanations of student successes and failures in performance on the SKA. It stands to reason that when students begin learning a new domain, they will use the language and ways of speaking that they know well—their everyday language(s) or registers. This led us to conclude that we had not provided teachers with enough support for modeling and scaffolding scientific ways of using vocabulary and scientific discourse patterns for their students.

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UNVEILING SCIENCE CAPITAL IN EVERYDAY LIFE: EXPLORING THE POTENTIAL OF FAMILY EVERYDAY LIFE IN SHAPING PRIMARY AND LOWER SECONDARY DANISH STUDENT' SCIENCE CAPITAL

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Abstract

Based on 54 interviews with Danish families of pupils aged 6 to 15, the article explores how families' everyday life influence children's opportunities for shaping their science capital in informal settings. Our results indicate that parents' own life history, leisure activities, interests, values, attitudes, knowledge, and skills strongly influence how science is approach, talked about and enacted within the family. All factors which are widely considered as influential in shaping children's science capital. Additionally, our findings suggest that although family everyday life involved a large range of science-related experiences they are often not recognised, related to, or framed as relevant to formal education by the families. Instead, parents predominantly value these experiences for their perceived contributions to: lifelong skills for everyday life and personal development; bonding within the family and friendships through shared experiences; and physical and mental well-being. Moreover, the results implied that families primarily interact with natural objects and phenomena through a sensory, creative, and aesthetic approach. Finally, the data indicates that the place of residence, including both home and local community resources, significantly influences families' science-related experience. Implications for science education are discussed, considering the use of a "Science Capital Teaching Approach".

Introduction

Students' everyday life beyond the classroom shapes the form of science capital they bring with them when entering the science classroom (Archer et al., 2012). This, in turn, influences how they participate, relate to, and identify with current and future science education (Nomikou, Archer, & King, 2017).

Drawing on Bourdieu's conceptualization of 'capital', the concept of science capital combines three forms of science-related capital: (1) *Science-related cultural capital* encompassing: Scientific literacy; values; and attitudes, (2) *Science-related behaviours and practices* (e.g., curiosity in seeking science-related knowledge, participating in science-related activities), and (1) *Science-related forms of social capital* (e.g., science-talk in daily life, knowing and interacting with people engaged in science-based hobbies, work or study) (Archer et al., 2012; 2015).

Identifying and understanding students' science capital diversity, based on what form of science capital is cultivated in various family-everyday life, can contribute to the enhancement of a more relevant and inclusive science teaching practice.

Against this background, we set out to answer the following research question:

How do everyday family life experiences contribute to shape Danish students' science capital?

Research methods

Interviews were conducted with families of students from five distinct Danish schools, selected to represent diversity in terms of geography, urbanity, students' socio-economic and ethnic backgrounds. Based on a maximum variation approach 15 students were selected from each school, across grades 0, 5, and 8. Out of the planned 75 interviews 54 were conducted. The interviews, taking place in families' homes, included primary caregivers as the main informants, with students also participating in most sessions.

Drawing on Archer et al.'s (2015) science capital concept, a semi-structured interview guide was used, complemented by a ”family wheel”, illustrating physical and temporal arenas related to the families' everyday life. Throughout the interviews, family members and the interviewer contributed to the family wheel with drawings, comments, and examples. All interviews were recorded, transcribed, and analysed using a combined deductive and inductive thematic analysis approach (Braun & Clarke, 2006).

Results

Our findings suggest that parents' individual and collective 'science capital portfolio' strongly influences how science is approached, talked about and enacted within the family. Parents exert their influence across all the three main forms of science-related capital: cultural capital (e.g., attitudes, knowledge, values related to food quality and cooking skills); behaviours and practices (e.g., technological curiosity, involvement in the scouting movement); and social capital (e.g., residing in proximity to their own parents and their farm).

In a similar vein, although parents foster individual student interests, the types of organised activities most students engage in during their leisure time (e.g., team sports; music; scouting; horseback riding) often mirror or reflect their parents' childhood leisure pursuits. Similarly, parents frequently integrate their personal interests (e.g., gardening), skills (e.g., home repairs), values (e.g., technology-embracing), and hobbies (e.g., constructing model airplanes) into family activities. In this way distinctions found in parents’ own “life portfolio science capital” (e.g., raised up in a farm or in a city; career related/unrelated to science) hold different potentials for shaping students’ science capital. For example, comparatively, parents with a background in science, technology or pedagogy often seek science-related knowledge with their children, naming natural objects, and acknowledging curiosity.

Additionally, although family everyday life involved a large range of science-related individually (e.g. jewellery crafting, mobile snaps pics, strength training) and collective activities (e.g. forest outing, cooking, hunting/fishing, gardening, tractor drag, collecting nature artefacts, beauty shopping, home repairs) they are often not recognised, related to, or framed as relevant to school science by the families. Instead, parents predominantly value these activities for their perceived contributions to lifelong skills for everyday life and personal development; bonding within the family and friendships through shared experiences; and physical and mental well-being. Moreover, most families primarily interact with natural objects and phenomena through a sensory, creative, and aesthetic approach.

Finally, certain activities, such as museum visits and isolated holiday events, are more commonly recognized and contextualized as being associated with school science when contrasted with recurring and more persistent family activities at home or in the local surroundings. Indeed, family everyday life activities are highly tied to the place of residence and our findings show that the geographical location and urbanity, including both home and local community resources, significantly influences families' science-related activities. Specific access to organized leisure activities, natural areas, playgrounds, and whether one has a garden or not, impacts the quantity and variety of activities.

Discussion and conclusion

Aligned with previous research, our findings show that parents' own science capital play a crucial role in why and how students lifeworld beyond the classroom holds potentials for cultivating different forms of science capital (Archer et al., 2012; Suortti, Havu-Nuutinen & Kärkkäinen, 2023). Other parallels to previous studies pertain to the distinct variations in the 'exchange value' of how families engage with everyday science-related talk, issues, and objects (Nomikou, Archer, & King, 2017). Indeed, parents naming scientific objects aligns more closely with school science compared to parents expressing the aesthetic value of naturel phenomena. Although our findings in this way reflect former studies highlighting variation in students' prospects for shaping different forms of science capital and the exchange value in a school context, our findings also reveal deviations and nuances from prior research.

In contrast to previous studies, Danish parents' focus is not to enhance their children's performance in school science or fostering science aspirations when cultivating their children's science-related participations in everyday life. Instead, parents primarily value these experiences for their perceived contributions to family bonding, well-being, lifelong competencies, and personal development. Previous science capital research has mainly been conducted in the United Kingdom (UK), where (aligned with most other OECD countries and in contrast to Denmark) emphasis is on testing and early differentiation into practical and academic tracks (Ejdrup & Hansen, 2023). This distinction, coupled with a comparable, more crucial significance of achieving social and economic upward mobility in UK (Archer et al., 2015), might partly explain the finding deviations.

Moreover, our findings show that numerous science-related everyday experiences are often not recognised, related to, or framed as relevant to school science by the families. Furthermore, our data highlight that family everyday life experience is highly tied to the place of residence and local community resources. In this way, and in line with the "Science Capital Teaching Approach" (Nomikou, Archer, & King, 2017), our results show that there are plenty of (untapped) potentials in unveiling and linking students' family and leisure experiences as well as local surroundings to school science.

Personalising and localising school science in this way hold promise for highlighting the relevance of science to students' daily lives and for actively expanding the scope of what is considered 'science' in the classroom.

Finally, our results imply that incorporating a more sensory, creative, and aesthetic approach to science teaching holds promise for relating to and acknowledging the way students' approach and value natural objects and phenomena together with their families.

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EXPANDING SCIENCE LITERACY IN ICELAND THROUGH HANDS-ON SCIENCE OUTREACH

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Abstract

Two of the challenges associated with increasing scientific and associated literacies in classrooms in Iceland is the comfort level of educators with scientific material and access to lessons that fit the national curriculum with minimal time investment. One strategy for accomplishing these tasks is through carefully planned science outreach designed around purpose-built “kits” to take science into existing classrooms while simultaneously training future teachers in the material. Our work was aimed at investigating teacher attitudes towards science education and to determine if intervention in the form of science outreach as a means of demonstrating hands-on experimentation to teachers was an effective means of increasing confidence as determined with a post-survey. Surveys and interviews with teachers in Iceland has revealed that a confidence with hands-on science experiments in the classroom may be a barrier to brining STEM into the classroom. Science outreach interventions were conducted at several schools in Northern Iceland using modular science lessons for upper elementary school students themed around sustainability adjacent topics that make use of easily obtainable materials. It was found that interventions generally improved teachers´ perceptions of hands-on science instruction.

1 Introduction

Two of the challenges associated with increasing scientific and associated literacies in classrooms in Iceland is the comfort level of educators with scientific material and access to lessons that fit the national curriculum with minimal time investment. One strategy for accomplishing these tasks is through carefully planned science outreach designed around purpose-built “kits” to take science into existing classrooms while simultaneously training future teachers in the material. Models such as the 5E Instructional Model (Engage-Explore-Explain-Elaborate-Evaluate) offer a convenient teacher-friendly framework to design science lessons that parallel to the scientific method.

In this project we prepared 10 science lessons and kits that could be used in elementary schools for teaching. The aim of the work was to 1) understand Icelandic teacher´s attitudes towards science instruction in the classroom and 2) study the efficacy and impact of external hands-on instruction in their classrooms on their attitudes towards science instruction. It was hypothesized that the majority of teachers that were hesitant to engage in robust science education though hands on experiments stemmed from a lack of confidence with these methods. The lessons described herein provide a context-rich vehicle to promote scientific literacy through authentic, hands-on problems by developing a portable, loan-able science kit and 10 high-quality science education to students in Iceland, particularly for schools in rural areas and non-native Icelandic students.

2 Theoretical backgrounds

Iceland’s recent performance on the PISA assessments in science, mathematics, and literacy (OECD, 2005, 2009) is lacking in light of Iceland’s high socio-economic status. The PISA scores of immigrant students highlights a major gap within the education system which is particularly troubling given the large number of children that speak non-Icelandic languages at home. With the 2022 PISA assessments focusing on mathematics, immediate action is needed to address the problem of high-quality science and math education in Icelandic classrooms. The OECD recommends that one means of increasing scientific literacy is to increase exposure to quality science education (OECD, 2009).

While there is no unified definition of quality education, education should aim to present students with challenging and authentic problems that require critical thinking skills to solve. Furthermore, weaving “21st Century skills”, such as polyliteracy, collaboration, and creativity, weave into STEM education helps students further develop the basic skills that they need to succeed. Thus, the problems posed by climate change and issues relating to sustainability provide a rich backdrop against which to frame basic lessons in the sciences.

A variety of models exist for teaching science, often designed with the goal of modelling exercises around the scientific method. The Biological Science Curriculum Study (BSCS) 5E Instructional Model was developed by Bybee & Landes (1990), whom described 5E instructional model, which is itself a modification of Atkins and Karpus´s earlier learning cycle model (1962). The 5E model adds two phases to the earlier described learning cycle. The 5E model consists of five phases: engagement, exploration, explanation, elaboration, and evaluation. This model has been widely used to successfully teach science-related subjects. The 5E instructional model has been widely applied to disciplines beyond biology including mathematics, physics (Akbulut, Sahin, & Cepni, 2012) as well as STEM instruction in primary schools (Choirunnisa, Prabowo, & Suryanti, 2018; Siwawetkul & Koraneekij, 2018) and middle schools (Fazelian, Ebrahim, & Soraghi, 2010).

3 Research methods

A science literacy and attitudes survey was designed and administered to primary and secondary school educators in Iceland between 2019 to 2022. Additionally, interviews with educators were conducted to probe attitudes and methods of science instruction during the same period and subjected to thematic analysis.

Portable science kit was designed to be portable between schools such that resources could be shared, which may be particularly relevant for schools in outlying areas that are underserved. The lessons designed around the kit provided materials for small groups of students (2-6) and contained authentic materials to create a genuine experience. Thus, approximately 8 kits were required to meet the needs of an average-sized classroom. As an example, a lesson on catalysts was designed around the well-known decomposition of hydrogen peroxide in the presence of some metal salts. Other experiments focused on the preparation of biofuels and bioplastics as well as traditional topics such as chemical reactions and interactions with light. Additionally, the materials were sufficiently robust, either plastic or safety coated glass, such that teachers do not need to worry about materials breaking.

Science lessons were developed using the 5E instructional model around the sustainability themes and around the aforementioned portable kit. Participating teachers (6-8th grade) in Akureyri and surrounding rural areas were interviewed on their attitudes about science and the challenges of science education. Two to three science lessons from the developed lessons were then administered by the authors over a period of several weeks. At the end of each lesson, students were given a post test and teachers were interviewed regarding their attitudes towards science education.

4 Results

During interviews, many educators in Iceland expressed concern over the lack of materials for teaching science and noted low confidence among colleagues with teaching science related subjects associated with Iceland´s National Curriculum. This was supported by the science literacy and attitude survey. Several schools were selected for targeted outreach and teachers were given a simple pre-intervention survey on their attitudes. After ten lessons were developed around a "science kit", two schools (one rural, one urban) were visited and 4 of the ten lessons were administered to students in the 6-8th grades. Teachers were again surveyed after the outreach activities for their attitudes related to confidence with using hands-on techniques for teaching science; the respondents indicated that confidence with such methods increased and indicated that additional support would be welcome. The students also decleared a better understaning of some basic science concepts as well as expressing their excitement over doing hands-on projects.

5 Discussion and conclusion

Providing a positive example of how science can be taught in the classroom is of great importance in order to increase high quality STEM education in Icelandic classrooms. While this work was limited, it provides a basis for further expansion into other schools and a framework to potentially train education students to conduct science lessons while supporting the existing needs of teachers. While the initial pilot of this program was stalled due to an unforeseen pandemic, work on expanding this program to other schools using undergraduate university school students is currently being planned in close collaboration with local primary schools.

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ICELANDIC DEBATES ABOUT INSTRUCTION TIME IN LOWER SECONDARY SCIENCE EDUCATION

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Abstract

Results of compulsory science education in Iceland have for decades been substandard in international comparison. There are many causes for that situation, one possibly being the limited time for science instruction in lower secondary education which is one of the shortest in Europe. Following a disappointing PISA result in 2018 the Icelandic Ministry of Education announced 2020 its intent to substantially increase instruction time for science in lower secondary education. Reactions appeared in the Government Consultation Portal, most of them negative. The ministry decided to postpone or abandon implementation of the proposal. To shed light on the debate about science instruction time in Iceland formal reactions from 75 different sources to the proposal were analyzed with the focus on identifying the basic arguments. In many of the texts opposing the proposal it was stated that increasing instruction time would not improve achievement. Concerns were raised about limiting the freedom of students to choose subjects to study, particularly limiting the opportunities to engage with arts and crafts. Another theme was resistance to accepting international comparative tests like PISA as a legitimate measure of school systems and another was that subject integration made it obsolete to allocate instruction time to specific subjects.

1. Introduction and theoretical background

The importance of science education can hardly be overemphasized in times when societies face challenges of climate change and subsequent questions about energy sources, public health threats and economic changes related to the fourth industrial revolution. The Icelandic education system has not adequately prepared the Icelandic public to tackle questions or take part in debates involving scientific issues in such regards. The results of compulsory science education in Iceland have for decades been substandard in international comparison. The achievement of Icelandic students in science have consistently been well below IEA and OECD average on TIMSS 1995 and on PISA from 2000 to the present (Pálsdóttir, A., 2019; Magnúsdóttir, E.E. and Arason, H., 2023). In PISA 2022 the average performance of Icelandic students in science was 447, 38 points below the OECD average (OECD, 2023). This is significant as the learning gain over one year of schooling among 15-year-old can be roughly estimated to be around 20 points on the PISA test (Avvisati, F. and Givord, P., 2021, 2023). The number of high achieving students is also extremely low with only 2% of Icelandic students reaching the top two levels in PISA compared to the OECD average of 7% (OECD, 2023).

Without doubt there are many entwined causes for that situation and one of those is possibly the limited time for science instruction in Icelandic secondary education. The time allocated to science instruction in Icelandic secondary education is one of the shortest in Europe. The instruction time for science in lower secondary education in Iceland is only 68 hours per year. This can be compared to an average of 109 hours for nations with available data in a 2022 Eurydice report and an average of 137 hours for eighth grade students across the TIMSS 2019 countries (Eurydice, 2022; Magnúsdóttir, E.E. and Arason, H. 2023; Mullis, I. V. S., Martin, M. O., Foy, P., Kelly, D. L., & Fishbein, B. 2020).

Questions about the effects of instruction time on academic achievement have been debated within research by authors such as Lavy (2015) and Andersen, Humlum and Nandrup (2016). They indicate a positive effect of longer instruction time on achievement while research by Bietenbeck and Collins (2023) indicates a less important role of time for learning. The overall conclusion of a review in the 2022 Eurydice report is that research evidence indicates a positive effect of increased instruction time (Eurydice, 2022). We would also like to raise the possibility that increasing a very limited instruction time could have significantly more positive effect on achievement than increases where more time is already allocated to science instruction. Results of Cattaneo, Oggenfuss and Wolter (2017) and Barrios-Fernandez (2023) indicate that increasing instruction time is more beneficial for high-performing students. This might possibly explain the lack of high achieving students in Iceland.

As early as 1987 the OECD (1987) identified the short instruction time in science as a potential weakness in the Icelandic education system. Following a disappointing result for Iceland on TIMSS 1995 attempts were made to improve the performance in science with a new official curriculum in 1999 but the instruction time for science in lower secondary education was not increased. Following one more disappointing PISA result in science in 2018 and reliable data about instruction time form the European commission in 2019 the Icelandic ministry of education announced in 2020 its intent to substantial increase instruction time for science in lower secondary education (Mennta- og menningarmálaráðuneytið, 2020). After receiving negative response, the Icelandic ministry of education decided to postpone implementation of the proposal and at present there seems to be no intention to continue with this change.

2. Research methods

To shed light on the debate in Iceland about science instruction time we analyzed the 75 responses from different sources and stakeholders to seek answers to the following research questions:

- *What are their primary arguments against increasing instruction time in lower secondary science education?*
- *What are their primary arguments in support of increasing instruction time in lower secondary science education?*

Consequently the 75 reactions from various individuals, groups and organizations that appeared in the official Government Consultation Portal were scrutinized and put in a broader context according to different school policies. These texts are official and available documents. They were coded and themes generated. Most of the themes could be classified in line with three broad categories. They were practices in science education, themes about effects on other aspects of the education system and themes about epistemological bases of the proposal.

3. Results

Most of the responses were analysed as negative towards the proposed increase. Importantly none of the major organizations such as the Icelandic Teachers' Union, The Association of

Headteachers and Icelandic Association of Local Authorities supported the proposal and either opposed the details of the implementation or the idea of an increase altogether.

The two main themes in arguments made in Iceland in support of increasing instruction time in lower secondary science education that emerged are the dismal performance of Icelandic teens on the PISA science tests and the very limited instruction time in international comparison. In addition, it was indicated that the limited instruction time led to well documented limited emphasis on hands on learning in Icelandic science classrooms and inquiry oriented work, bearing in mind that practical work is considered an indispensable part of science education. In broader terms there was emphasis on the importance of science and science education both for individuals and for society. In many of the texts in favor of the proposed increase in instruction time it was stressed that other measures to improve science education were also important, nonetheless increased time would by itself lead to improvements.

This last point was in stark contrast to one of the major themes in the texts opposing the proposed increase where it was stated that increasing instruction timeper se would not improve achievement. In connection with statements of this nature it was frequently mentioned that improved curricular materials, improving science teacher education, different instructional methods and supporting science teachers should be the approach used to improve science education instead of increasing instruction time. Among those advocating increased instruction time the same measures were frequently suggested in addition to increased time.

In several texts opposing the increase of science instruction time, there was a concern about the effects on the freedom of students in lower secondary education to choose subjects to study, particularly that it would limit the opportunities to engage with arts and crafts. In that context it is interesting to note that science was frequently described as a “book subject” rather than a hands-on subject, where in fact it should be a combination of both. Another theme was resistance to accept international comparative tests such as PISA a legitimate measure of the quality of school systems and another was that subject integration made it obsolete to allocate instruction time to specific subjects.

4. Discussion

Most of the arguments put forward in this debate have to do with educational policy and must be dealt with at that level. Empirical data can however shed light on the question whether increasing instruction time is likely to improve achievement and according to the report “Increasing achievement and motivation in mathematics and science learning in schools” from the European Education and Culture Executive Agency the indication is that increasing instruction time is indeed likely to improve achievement. It is also interesting to note that other measures to improve science education such as better curricular materials, improved science teacher education, different instructional methods and supporting science teachers were emphasized as necessary both by advocates and opponents of the proposed increased science instruction time. In that context, it is interesting to note results by Kolbe, Steele and White (2020) that indicate that teachers with limited instruction time are unlikely to use inquiry-oriented instructional practices irrespective of teacher qualifications and it is well known that there is very little emphasis on hands on work and Inquiry based methods in Icelandic science education (PISA, 2016; Þórólfsson, M., Macdonald, A. and Lárusson, E., 2007). It can thus be speculated that some of the arguments made by important agents in educational debate in Iceland indicate lack of understanding of major features that distinguish teaching and learning in the field of natural science from other educational endeavors.

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ARTEFACT-MEDIATED NARRATIVES USED IN FORMATIVE AND SUMMATIVE ASSESSMENT IN AN PRESERVICE TEACHER BIOLOGY CLASS

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Abstract

This study presents results from an ecology course with 25 preservice biology teachers conducted in 2023-24. The aim of the study was to evaluate how narratives mediated by students self-produced artefacts can be used as a mean of formative assessment of learning outcomes. The hypothesis is that artefacts can act as placeholders for our understanding of the world, and that artefacts can be used to build "islands of coherence" in the coconstruction of curricular content. The preliminary results from observations as well as statements from a focus group interview suggest that artefacts as learning objects motivated students and potentially support their construction of biology narratives. The narratives both checked their understanding and was suitable for making topical trajectories during the course. Moreover, students evolved a common language to communicate about both assessment of their future students in biology in lower secondary school as well as coherence-making using artefact-mediated narratives. Whether the students use the method in their own practice has to await a second round of interviews planned to be held after their internship in early spring 2024.

1 Introduction

Når elever oplever usammenhængende undervisning, har de svært ved at lære, fordi det vanskeliggør kobling mellem eksisterende viden og det nye, der skal læres jf. konstruktivistisk læringsteori (fx Dolin 2020).

Omvendt styrkes elevers mulighed for at skabe faglig mening og lære, hvis læreren anvender eksplicitte didaktiske og dialogiske strategier til at skabe sammenhænge med det, de har lært (Vygotsky 1987).

Dette udtrykker en forestilling om, at hvis læring involverer konstruktion af forbindelser mellem faglige indholdselementer, så må disse forbindelser adresseres *af* underviseren *i* undervisningen (Scott et al. 2011, s. 4).

I denne undersøgelse fokuser vi på lærerstuderendes kompetencer til at skabe forbindelser og dermed forstå sammenhænge i biologifaget vha. faglige narrativer, der understøttes af selvproducerede analoge artefakter.

Med afsæt i en hypotese om at det ofte overlades til elever selv at skabe sammenhæng i deres læringsforløb, har vi formuleret to spørgsmål. De tager begge afsæt i, at artefaktunderstøttede faglige narrativer brugt som evalueringsværktøj *også* er en didaktisk strategi, der kan skabe mere sammenhæng i undervisningen:

1. Hvordan kan artefaktunderstøttede faglige narrativer, der bl.a. trænes i peer-to-peer situationer bruges *formativt evaluerende*, så de samtidig bidrager til at styrke de studerendes sammenhængsforståelse i emnet økologi?

2. Hvordan kan artefaktunderstøttede faglige narrativer i modulafsluttende samtaler mellem individuelle studerende og underviser bruges til at afdække de studerendes sammenhængsforståelse i emnet økologi (*summativ evaluering*)?

Nedenunder disse to spørgsmål ligger en interesse for hvorvidt og hvordan man i en skolepraksis kan anvende artefaktunderstøttede narrativer

- til at skabe associationer til et bestemt indhold (lærings- og huskeperspektiv)
- som referencepunkt, når tematikker og indholdselementer skal forbindes med hinanden (sammenhængsperspektiv)
- til at skabe progression og flere deltagelsesmuligheder for de studerende i deres tilegnelse af naturfagligt sprogbrug (progressionsperspektiv)

Svar på de fem spørgsmål kan bidrage til at dokumentere, om artefaktunderstøttede faglige narrativer egner sig som evalueringsform, og om narrativer kan tilbyde en konkret didaktisk løsning på, hvordan elevers oplevelse af sammenhæng i biologifaget kan styrkes.

2 Theoretical backgrounds

I udvikling af en didaktik der kan hjælpe elever med at skabe sammenhæng (DISA, DIdaktik for SAmmenhæng), er Pedagogical Link-Making (PLM) centralt. PLM (Scott et al. 2011, Rocksén & Olander 2016) tager udgangspunkt i en sociokulturel forståelse af undervisning og læring som samskabelse af mening og viden over tid. PLM har således fokus på tidsaspektet i undervisning og læring, og på læreres strategier til at støtte elevers læring og skabe mening indenfor en lektion, et forløb samt på tværs af klassetrin.

PLM er en gren af dialogisk undervisning og læring, som blandt andet er kendetegnet ved, at viden opfattes som kumulativ, dvs. at deltagerne skaber sammenhænge ved at bygge videre på egne og andres bidrag (Alexander 2018). Undersøgelser har dokumenteret, at "*elever forbedrer deres viden, testresultater, og til og med intelligens, når de arbejder dialogbaseret*" (Dysthe et al. 2020).

Klasserumsforskning af effekten af PLM i naturfagsundervisning viser, at elevers engagement og dybdeforståelse af naturvidenskabelige begreber styrkes, når naturfaglærere sammen med deres elever skaber mening, og til stadighed over tid uddyber klassens 'scientific stories' (Scott et al. 2011).

Artefakter er genstand for det kognitionsforskningen kalder extended kognition, hvor genstande bruges til at tænke med; når vi ser en genstand, så vil vi (den) aktivere relevante neurale systemer. I denne optik er artefakter pladsholdere for vores forståelse af Verden (Schilab 2022).

Værdien af at inddrage artefakter i naturfagsundervisning til at fremme elevers faglige *dialog og forståelse* er undersøgt af fx Achiam (2016). Dokumentationen gælder imidlertid ikke *elevproducerede* artefakter, hvor erfaringer skal hentes fra kulturfag. Her er det vist, at PLM har effekt på begge dele, når de medieres gennem elevers egne artefakter (Jensen 2019). Og at selv halvfærdige artefakter fra lavt præsterende elevgrupper kan løfte den faglige dialog, fordi artefakter fastholder elevers fokus. Desuden er elevproducerede artefakter en ressource, læreren kan vende tilbage til og anvende til at skabe sammenhæng mellem undervisningsforløb (Jensen 2019).

I vores undersøgelse ses studenterproducerede artefakter som fysiske, håndgribelige repræsentationer af de studerendes erkendelse og udbytte af undervisningsforløb jf. Subero et al. (2018), fx:

- et scenarie opbygget i legoklodser, modellervoks, papmache, puslespilsbrikker
- et tableau af planter, sten, udstoppede eller levende dyr, vand/jord
- en plakat, planche, frise
- en forsøgsopstilling/undersøgelse

Der stilles to krav til artefakterne: Dels skal de repræsentere de studerendes idé om naturfaglige begreber, forklaringer og fænomener, og dels skal de kunne anvendes til at støtte de studerendes indbyrdes dialog i formative peer-to-peer evalueringer og en afsluttende summativ evaluering med underviser. Artefakterne betragtes som "privilegerede tegn på elevers [de studerendes] læring" (Hansen & Skovmand 2011).

3 Research methods

Genstandsfeltet er 25 studerendes brug af artefaktunderstøttede narrativer til formativ og summativ evaluering i et modul om økologi på læreruddannelsen (de studerendes første modul i faget).

Undersøgelsen er baseret på principper fra klasserumsforskning i en longitudinel designramme, der tidsmæssigt strækker sig over efterårssemestret 2023 med en forventning om at fortsætte i vinteren 2024, hvor de studerende er i 3.-års blokpraktik.

Svar på undersøgelsesspørgsmålene baserer sig på et semistruktureret fokusgruppeinterviews med 3 udvalgte studerende fra holdet foretaget i sidste del af modulet. Dette interview har fokus på artefaktunderstøttede narrativer brugt til formativ evaluering. Desuden er et survey med fokus på artefaktunderstøttede narrativer brugt til summativ evaluering udsendt, og det afventer de studerendes svar.

Endelig omfatter undersøgelsens data undervisers oplevelser af og noter fra de summative evalueringssamtaler samt de løbende observationer af de studerendes artefakter og brug af dem til at understøtte deres faglige samtaler både i den daglige undervisning og i forbindelse med fx en præsentation af deres biotoparbejde.

Pga. risikoen for at miste de fysiske artefakter over tid, har de studerende løbende fotograferet og gemt dem i digitale individuelle portfoliemapper på læreruddannelsens læringsportal. Dette blev de studerende jævnligt opfordret til at gøre af underviser i begyndelsen af modulet. Herefter overgik ansvaret gradvist til de studerende selv.

Materialebanken skulle også udvikledes løbende for at sikre, at den blev et brugbart redskab til modulevalueringen. Her blev de studerende bedt om at præsentere udvalgte artefakter i en såkaldt book-bento, der oprindelig er en æstetisk måde at formidle og anmelde bøger. I en book-bento overvejer man samspillet mellem den læste bog og en række artefakter samt book-bentoens baggrund. Materialet arrangeres sammen med bogens forside i et enkelt foto. De studerende skulle overføre denne formidlingsform til deres egen evalueringssamtale om økologi med underviser. Book-bentos er lige som de studerendes individuelle, digitaliserede artefakter tilgængelige på Itslearning og udgør dermed også en del af undersøgelsens samlede dataproduktion.

4 Results

I den konkrete undersøgelse har de studerende selvstændigt i større eller mindre omfang alle udviklet deres egne digitale materialebanker.

Artefakterne blev senere, fx til den følgende undervisningsgang, på opfordring af underviser taget frem af de studerendes og brugt til at genkalde, fortsætte og uddybe deres naturfaglige narrativer. I begyndelsen af undervisningen dannede et eksemplarisk artefakt fra seneste undervisningsgang som eksempelvis en flaskehave således udgangspunkt for de studerendes narrativer om kredsløb præsenteret parvis for hinanden.

Det var intensionen at alle undervisningsgange skulle begynde må tilsvarende måde, men fordi det var nødvendigt først at introducere de studerende for artefakter, narrativer, sammenhæng i undervisningen udtrykt som "islands of coherence" foruden forskellige evalueringsperspektiver, blev aktiviteten først indarbejdet i undervisningspraksis i den senere del af modulet. Til trods for dette, peger undersøgelsens foreløbige resultater på, at de studerende:

- inspireres af læring hvor selvproducerede artefakter vægtes højt – også selvom de synes, det er svært fx at tegne og bygge fysiske modeller
- viser tegn på at artefakter fungerer som bærere af deres egne naturfaglige narrativer
- kan reflektere over brugen af artefaktunderstøttede narrativer både i et lærings- og huskeperspektiv, et sammenhængsperspektiv, samt et progressionsperspektiv jf. beskrivelsen i indledningen
- udvikler et fælles didaktisk sprog til at kommunikere om sammenhæng i biologifaget
- anvender artefakter fra materialebanken som en del af deres naturfagsdidaktiske repertoire
- tager ejerskab over DISA ved fx at kommunikere om deres brug af DISA i vikararbejde

De meget tidlige resultater tyder altså på, at de studerende har taget artefaktunderstøttede narrativer til sig som en didaktisk metode, de kan anvende i deres egen undervisning for at understøtte elevers sammenhængsforståelse, progression og kvalificering af fagsprog. Ikke mindst er de blevet opmærksomme på, at artefakter kan bruges som en evalueringsmetode ved at understøtte elevers faglige fortællinger.

4 Discussion and conclusion

Undersøgelsens resultater kan afhjælpe en central udfordring både i et dansk perspektiv og i et internationalt naturfagsdidaktisk forsknings- og praksisperspektiv ved at:

- skabe opmærksomhed på og viden om behovet for et større didaktisk fokus på sammenhæng i naturfagsundervisning
- producere en case om hvordan lærere vha. artefaktmedieret naturfagsdidaktik kan facilitere en sammenhængende naturfagsundervisning og understøtte elevers dybdelæring
- understøtte læreres (formative) evalueringskultur

Tilrettelæggelsen af undervisningen i et dobbeltdidaktisk perspektiv betyder, at målet er, at de lærerstuderende selv bliver i stand til at mestre metoder til formativ og summativ evaluering, der kan bidrage til at elever oplever en bedre sammenhæng i dansk grundskoles biologiundervisning. Om og hvordan de studerende reelt benytter sig af artefakter som middel til at understøtte dette, kan vi endnu ikke dokumentere, idet deres praktik er placeret vinteren 2024, hvor opfølgende fokusgruppeinterviews vil klarlægge om det er tilfældet. Indtil videre kan resultaterne opfattes som et første bidrag til udformning af en case, der kan vise, hvordan en didaktik for sammenhæng *kan* udmøntes i praksis.

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ETWINNING IN SCIENCE LEARNING: THE PERSPECTIVES OF PRE-SERVICE PRIMARY SCHOOL TEACHERS

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Abstract

eTwinning is a community of European schools that promote networking and transnational collaboration projects. As part of the Initial Teacher Education (ITE) initiative 251 pre-service primary school teachers from Spain, Iceland and Slovenia designed and carried out joint research projects on scientific topics. The aim was to gain insight into their self-assessment of their knowledge of the platform and to what extent they improved their digital skills and science knowledge. An electronic questionnaire was used as the main instrument for data collection. It turned out that the pre-service teachers enjoyed this international collaboration, but also found it challenging. By the end of the projects, they were familiar with the eTwinning platform, although the least engaged prospective teachers recognized that they needed strong support and considered the platform a non-intuitive environment. Overall, they were willing to use the platform with pupils in the future, which is in line with the aim of the ITE initiative.

1 Introduction

eTwinning is a European platform for collaborative projects across countries, aiming to enhance teachers' and students' technical, language, and intercultural skills. The initiative aims to incorporate eTwinning into initial teacher training (ITE) to engage trainee teachers and increase their use of the platform in future practice. This study involved pre-service primary school teachers from Iceland, Slovenia, and Spain in an eTwinning project, where students researched nature phenomena varying with latitude and shared results across regions. The project aimed to familiarize students with the platform and expose them to real research scenarios for collaboration in eTwinning with international peers.

2 Theoretical backgrounds

eTwinning is a European initiative that enhances intercultural interaction and equips students with 21st-century skills like collaboration and communication (Camilleri, 2016). It has been shown to promote student-centered instructional strategies, increase alignment between real and hidden curricula, (Vangrieken et al., 2015), and active teaching, practices involving projects, group work, and new technologies (Macià & García, 2016). DigCompEdu the ICT competency framework for teachers (Redecker & Punie, 2017) emphasizes the importance of creating, sharing, communicating. Teachers are also expected to collaborating using ICT to leverage professional and educational competences and promote students' digital competence (Redecker & Punie, 2017). However, teachers often report only mild levels of digital competence, allowing for technology appropriation but not innovative or transformative practices (Krumsvik et al., 2016). Newly qualified teachers often report scarce and poor-quality ICT training during their teacher education, leading to negative experiences in the classroom (Guðmundsdóttir & Hatlevik, 2017).

Training teachers in ICT involves professionalizing their practice, incorporating desirable professional competencies, and optimizing professional performance (Michos & Hernández-Leo, 2020). This involves incorporating ICT into the trainee curriculum and providing significant experiences with ICT (Khan, 2014). eTwinning has been shown to increase teachers' digital competences, as it requires them to use ICT in various ways (Huertas-Abril and Palacios-Hidalgo, 2023).

Preparing elementary science teachers has been a major focus of science education reforms. Many preservice teachers enter college with limited knowledge of science content and inadequate understanding of many science topics (Tekkaya et al., 2004). This influences the development of their identity (Yoon et al., 2006),as preservice teachers' beliefs about science serve as a lens through which they build their professional projections (Burden et al., 2016).

Content knowledge is vital for good science teaching, and deep knowledge gained through rigorous academic study provides a solid teaching background (Kind, 2009). However, pedagogical knowledge is also necessary to make science accessible to students through 'school science' (Arzi & White, 2007). Trainee teachers must be exposed to learning situations where they can deepen their knowledge, enhance their skills, and nurture their pedagogical insights (Kang et al., 2013; Lewis, 2019). Going through these experiences encourages teachers to try different things with their students as well (Forbes, 2013).

3 Research methods

A study involving 251 trainee teachers from the University of Ljubljana (n=86), the University of Iceland (n=53), and the Public University of Navarre (n=152) involved students from each country in 15 mixed clusters, spanning six weeks in four phases, with each group focusing on specific learning objectives (See table 1).

***Table 1**. Schedule by Phases, Including Activities and Learning Objectives.*

Phase	Objective	Learning objective
I. Nice to meet you!	Ice breaking, getting to know each other	Communication in online communities, sharing photos related to science to the platform
II. Sorry, may I ask you a question?	Research question, experimental design, communicate this to their cluster.	Writing good research questions Variables, procedures and methods
III. Data, data, data! Recording and sharing Analysing the results	Gathering data for other countries and sharing to cluster Basic representation and statistical analysis	Recording, storing and representing data (tables, graphics, basic statistics)
IV. Let me show you something	Presenting results in scientific posters or videos to eTwinning platform	Instructions and tools for [interactive digital] scientific posters or videos

The project concluded with a live online event, where selected groups presented their work. A questionnaire was used to collect data, with a response rate of 91%. The questionnaire included views on the project, learning in science, technology use, and language, as well as background information about previous interests and technology availability. Semi-structured interviews were conducted with seven students with different engagement levels.

4 Results

All students completed the project; 37 scientific posters, 14 videos and 9 PowerPoint presentations were submitted as final reports of the research projects. Overall, 27% of the posters and videos were of high quality, 55% of medium quality and 18% of low quality. The projects were assessed by the quality of the research question, the soundness of the data collection process, and the diversity and coherence with the evidence of the conclusions reached. In some of the groups, technical quality was also considered.

It could be seen from the research questions suggested and posed by the student groups that their initial knowledge of vegetation, animal life and weather in the three countries was limited. One group asked the cluster to collect data on fruits and vegetables that do not grow in Iceland and another to count birch buds far too early for Iceland. The nature data collection was reported by students to have opened their eyes to how latitude influences many natural phenomena and even to the flora and fauna in their own countries. Students showed varied skills in organizing and presenting their data but indicated in interviews that the project improved their data management skills both in collecting for their cluster and organizing the data they got from the other countries. Some difficulties were also mentioned with missing data sets and presentations of poor quality could also be seen.

Responses on knowledge acquired through project development, such as on nature, culture or social issues, show that 63% of pre-service teachers stated that they had learnt “a lot” or “some” about the nature of their country, and 59% about the nature of the other two countries. A lower perception was attained concerning culture and other aspects (49%)

Students considered that online communication and collaboration were ‘hard’ (31% and 20%, respectively). Of those who pointed to communication, 23% reported that they recognized the importance of effective communication and 41% of giving clear instructions when working in groups. Of those who talked about collaboration, around half of the students used positive adjectives, such as useful, enjoyable, fun (45%), and 52% stated that they learned to collaborate.

After participating in this eTwinning project, 46% of the pre-service teachers would like to try eTwinning with their students in future, and 31% would like to participate in other similar projects as part of their teacher training.

The interviews confirmed that students liked the project (5 out of 7 interviewees), mainly because it brought them into contact with foreign people.

Most of them also highlighted that working in groups was challenging but also enriching.

4 Discussion and conclusion

The main research questions were to what extent an immersive experience with eTwinning, which included a collaborative scientific research project, impacted on the trainee teachers' self-assessed pedagogical knowledge and the technical affordances of the eTwinning platform, and what the main barriers to practical implementation were.

Approximately half of the students liked the opportunities provided in the project, learning science through active methodologies, to develop transversal skills, such as communicating and collaborating remotely, as noted in previous studies (Camilleri, 2016) in a language other than their mother tongue. As such, the eTwinning project was found challenging but enriching by the participating trainee teachers.

The participants found the project useful for learning science, though challenging working with the scientific method. Many prospective teachers have only very basic knowledge and therefore lack confidence in teaching science (Murphy et al., 2007). In turn, the best way to learn science is to practice the different ways of doing, talking and thinking about science in the classroom and consistently the students interviewed valued the opportunity to participate in the research project. The student teachers increased knowledge of the pedagogical affordances of the platform, are in line with the conclusions of the study by Acar and Peker (2021), in which in-service teachers from different subject areas report on the contribution of eTwinning to their professional development and collaboration as well as to their personal development.

Finally, the students to acquired enough basic knowledge about the platform to have intentions to use the platform in the classroom and had developed digital skills, as reported in other studies (Huertas-Abril & Palacios-Hidalgo, 2023; Kostas & Ioannidou, 2023).

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THE MANIFESTATION OF SCIENCE IN STEM AND MAKERSPACE ACTIVITIES

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Abstract

Makerspaces projects and tasks have become increasingly popular in schools and science teaching time is often dedicated for these projects. That raises the question of how science knowledge and concepts are manifested in these projects. Descriptions of projects and lessons were collected in a three-year project with three schools involved collaborating in implementing makerspaces with an emphasis on design and creativity. The lesson descriptions and interviews with teachers are analyzed to explore the status and visibility of science knowledge and concepts. The results indicate that science is often an underlying idea but not explicitly stated in lesson plans and assessment. STEM ideas around design and structures are prevalent in many lessons and some lessons show a clear connection to science concepts such as electricity. This may be a concern as precious teaching time is dedicated to these tasks but also has the potential to kindle interest in science related topics. The results depend on teachers shifting the focus towards the underlying science of the tasks and making sure the science is part of the assessment of the learning activities.

Introduction

In the current educational landscape, there is a high emphasis on 21st century skills, skills such as critical thinking, creative thinking and communication that transcend school subjects. Drake and Reed (2018) have argued that integration is an effective way to develop those skills and possibly boost achievement. The Icelandic national curriculum (Aðalnámskrá grunnskóla, 2011) gives guidelines on how much time should be dedicated to school subjects but at the same time states that school subjects are not a goal in and of themselves an encourages the integration of subjects. Schools have increasingly implemented makerspace work in their curriculum, with teachers believing such work aligning well with their vision for teaching and learning (Sólveig Jakobssdóttir et al 2019). On top of 21st century skills makerspaces often emphasize innovation, student agency and enhancing digital skills. Furthermore, makerspaces have been touted as a way to developing STEM knowledge and skills and this potential questioned (Falloon, etal 2022). Implementing makerspace work in schools means dedicating time to them and thereby taking time from school subjects such as science. Raising the question of how science knowledge and concepts are manifested in these projects.

Theoretical background

Makerspaces in schools are creative, hands-on learning environments designed to foster innovation, collaboration, and problem-solving among students. They provide opportunities to engage with tools, materials, and technology, encouraging students to design, build, and experiment (Blum-Ross et al., 2019). Makerspaces are valuable in promoting STEM education, as they integrate practical, real-world applications with academic concepts, sparking curiosity and interest in these fields (Sheffield et al 2017). Beyond STEM, they also nurture essential skills such as critical thinking, creativity, digital skills, equipping students with competencies for the modern world (Rayna and Striukova, 2021).

Research indicates that instruction time effects academic achievement (Andersen, Humlum and Nandrup (2016). But concerns have been raised that teaching time for science is already less than curriculum guidelines recommend, and student achievement has been inadequate (Menntamálastofun,2019).

Method

Data was collected in a three-year project with three schools involved collaborating in implementing makerspaces with an emphasis on design and creativity. One of the schools has years 1-10, whereas the other two have 1-7. During the three years teachers were asked to write brief descriptions of lessons and tasks they had planned as part of the project.

The schools submitted 553 descriptions in a form. The form asked for

- • the name of the project,
- • when the project was taught,
- • a brief description (the aims, the topic, technology, tools and other resources used and competence criteria)
- • the age of the students

Lessons were also observed during the project and student artifacts and results were photographed and at the end of the project we held focus three group interviews with teachers in each of the schools talking about the project, what kind of tasks and topics they had done. their pedagogy, assessment and other relevant issues.

The lesson descriptions and interview transcripts were analysed to explore how the lessons are planned and the visibility of science knowledge and concepts. As the lesson descriptions were in many cases not marked by the teachers, a word search was conducted for all the documents to identify lessons with science content, The list was long and includes words such as Science, practical work, experiments, STEM, STEAM, magnets, electricity, plants, animal.

RESULTS

The school in most year-groups planned the makerspace work in carousel, workstations or themes spanning over several lessons around curricular content such as the ocean, the Vikings, or the human body. The schools also shared ideas between them, so the same tasks were often used in all of them. The lessons described and observed were often in the form of design challenges, digital creation, programming and general making and crafts. A small minority of tasks described had clear aims and competence criteria related to school subjects stated and only in the one school that had year 8-10 (13-16 year old students) were learning science content clearly stated. The tasks often had a focus on building student skills and competences such as designing, creating or solving problems. Also learning to use both digital and analogue tools and resources and the choice was often built on the teachers' strengths and interests.

Articulation of science concepts was rare in observed lessons and lessons. In the focus group interviews it was clear that the teachers were aware of the limited focus on s „you know this was supposed to be an integration of one Icelandic lesson, one social science and one science, but now it is just one meltingpot of, of joy" The teacher recognised that some tasks have close connections to science and that they needed more attention and articulation:

„if they know the concepts?, yes I mean they come across these concepts and do not know they have been working with conduction for example. ……..maybe they have been doing ten experiments with conductivity.

But at the same time some felt they were on the right path, and when asked about connecting makerspace tasks and science said:

> „well they do it sometimes, not direct, well… This of course is often connected to science, may be unintentionally. People are not thinking directly about it [makertasks] as a science lesson if they are working with paths for balls and are exploring gravity, centrifugal force or something. I am not sure they put words to this, it is just like this, playing with it…..But now this is more like STEM-tasks, a bit deeper. They go further and are more creative.“

On the whole science was not prevalent in the makerspace projects and tasks even though many of them, especially the design challenges were based on phenomena that could easily have been connected to learning science concepts and ideas. It seems that the main aim of the work is more tied to skills and competences. with concerts but to create interest through exploring ideas and doing experiments both in designing and actual science experiments. What can also be seen is that there is a big emphasis on working with the language using stories and creating task with the stories that require experimentation and design stories such as the three picks where do the pigs build their different houses from different materials were used in all the schools also the story of Goldilocks where different kinds of pets and chairs were made testing their durance and design.

Discussion

The integration of makerspaces and STEM-related tasks into school curricula offers potential benefits but also raises significant challenges for science education. These activities promote creativity, design thinking, and digital skills, often driven by student choice and active learning. However, their impact on science learning depends heavily on how they are designed, implemented, and assessed.

A primary concern is that while makerspaces can kindle interest in science-related topics, science concepts are often treated as implicit rather than explicit elements of the tasks. Analysis of task descriptions shows that activities frequently emphasize tool use, material manipulation, and creativity, with less focus on clear competence criteria or explicit science content. As a result, opportunities to enhance students' scientific understanding through these activities may be overlooked.

The limited visibility of science in makerspace tasks highlights the need for deliberate efforts to integrate and assess science concepts. Teachers must articulate the scientific principles underpinning these activities, incorporate them into lesson objectives, and design assessments that evaluate students' understanding of these principles. Without such intentional planning, valuable teaching time may be diverted from core science knowledge, leaving its role in the curriculum diminished.

Teacher competence and training play a crucial role in bridging this gap. While teachers often have tacit knowledge (Eraut, 2000) about the science concepts they aim to address, this understanding is not always reflected in task descriptions or assessments. Professional development and reflective practices are essential to help teachers explicitly align makerspace activities with science learning goals. The Icelandic national curriculum emphasizes the importance of teaching science but also values interdisciplinary and creative approaches. This dual mandate creates a tension between fostering broad competencies and ensuring deep subject-specific knowledge.

Furthermore, as schools adopt makerspaces as part of a global trend, it is critical to consider how time is allocated across subjects. In many schools, subjects like Icelandic, mathematics, and physical education have dedicated time slots, while science, social skills, and the arts are taught in carousels or workshops. This raises questions about whether makerspace activities sufficiently address specific science concepts or inadvertently displace essential science teaching.

To maximize the potential of makerspaces, it is necessary to shift the focus toward the underlying science of tasks, make these concepts explicit in planning and assessment, and provide teachers with the tools and training to integrate science meaningfully into these innovative practices.

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POSTER: TEACHING ABOUT DEEP-TIME PERSPECTIVES ON CLIMATE CHANGE– COMBINING ASTRONOMY AND GEOLOGY

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Abstract

Seven student teachers participated in a module on Geology, Cosmology and Astronomy in a teacher training course in the school subject Science. Throughout the module it has been essential to use cosmological and geological time scales. Working with timelines means that students develop their ability in terms of time awareness, regarding past, present and future. This is to understand what are the natural causes of climate change and what are the anthropogenic causes. This study focuses on teaching about natural global climate change over long time scales. This was done by combining geology and astronomy using a holistic approach, and seven themes were developed. The final teaching moment on geology and astronomy in the teacher training course consisted of a group discussion where the students had the opportunity to discuss which points on the timeline from the Big Bang to the present day they consider essential for their science teaching. Through a qualitative descriptive theory-driven thematic analysis, the patterns that are found in the students' different entries in their timelines were analyzed based on the developed seven themes. In this presentation we present the results of the study against the background of the current curriculum for Swedish upper secondary school.

1 Introduktion

Under hösten 2023 deltog sju lärarstudenter i ett moment om geologi, kosmologi och astronomi, omfattande 10 hp. Momentet ingick i en lärarlyftskurs LFB65U (Högskolan Kristianstad, 2021) i Naturkunskap (90 hp) på Högskolan i Kristianstad. Genomgående för hela momentet har det varit väsentligt att använda sig av kosmologiska och geologiska tidskalor. Just begreppet tidslinje saknas i ämnesplanen för naturkunskap, och finns implicit när det gäller evolution i Gy 2011 (Skolverket, 2022). Att arbeta med tidslinjer innebär att studenter utvecklar sin förmåga när det gäller tidsmedvetenhet (Brock et al., 2018; Czajka & McConnell, 2018; Einarsson, 2018; Trend, 2005), avseende dåtid, nutid och framtid. Detta anser författarna är väsentligt för undervisningen, speciellt när det gäller klimatförändringar. Detta för att förstå vad som är naturliga orsaker till klimatförändringar och vilka de antropogena orsakerna är. För att kunna förstå sig på Antropocen måste forskare se tillbaka i tiden för att förstå vad som kan hända i framtiden (Williams et al., 2018). Cervato och Frodeman (2012) argumenterar om vikten av studenters förståelse av geologisk tid som en vägledning för framtida beslutsfattande kring miljömässiga, politiska och ekonomiska frågor relaterade till vår planets hållbarhet. I artikeln Teaching About Climate Change from an Astronomical Perspective (Kay & Fuiten, 2023) beskrivs ett undervisningsupplägg där det inte enbart fokuserades på de klimatförändringar som vi står inför idag på jorden. Klimatförändringar handlar alltså inte bara om det som sker på jorden och inte bara om vår nuvarande tid. Jorden har utvecklats och förändrats som en planet, liksom de andra planeterna i vårt solsystem.

Lärarlyftskursen bestod av tolv moment. Det viktigaste syftet var att ge studenterna möjligheten att utveckla och fördjupa sina kunskaper i skolämnet naturkunskap och få en inblick i naturvetenskapernas didaktik för att bli behöriga att undervisa i gymnasieskolan. Innehållet i kursen tog sin utgångspunkt i gymnasieskolans ämnesplan för naturkunskap enligt Gy 2011 (Skolverket, 2022). Skolämnet naturkunskap färgas av tvärvetenskap, och ligger i tiden eftersom de komplexa problem som samhället står inför (t. ex. hållbarhetsfrågor) måste lösas genom samarbete inom olika vetenskapsområden. Ett av kursen många syften var att ge en inblick i de synsätt och teorier som ligger bakom ämnesinnehållet. Detta syfte var viktigt när det skulle planeras för innehållet i momentet geologi, kosmologi och astronomi. I momentet behandlades universums storskaliga historiska utveckling, liv i universum, jordens komplexa uppbyggnad och utveckling med dess olika utvecklingsfaser, samt processer som påverkar landskapet och klimathistoria. Det ingick också grundläggande meteorologi. Jordens nuvarande klimat hade behandlats i ett tidigare moment. Speciell vikt i undervisningen har också lagts på de vetenskapliga förklaringsmodeller och metoder som vi använder idag inom astronomi och geologi. En strategi i planeringen av momentet var att sammanföra geologi och astronomi genom skriftliga projekt samt användning av tidslinjer.

2 Teoretisk bakgrund

Denna studie fokuserar på undervisning om naturliga globala klimatförändringar över långa tidsperspektiv. Detta görs genom att kombinera geologi och astronomi med hjälp av ett holistiskt tänkande (se Corrochano & Gómez-Gonçalves, 2020) inom följande tematiska områden:

1. Meteoroider/asteroider i rymden - meteoritnedslag/asteroidnedslag på jorden som orsakar massutdöende.
2. Solaktivitet/solstormar och dess påverkan på jorden (molnbildning, ozon etc.).
3. Milankovitchcykler och glaciationer.
4. Uppkomsten av vårt solsystem - jordens uppbyggnad och endogena processer i bergartscykeln (plattektonik, förändring av havsströmmar och vindar etc.).
5. Förekomsten av liv i andra delar av universum - förutsättningar för liv på jorden.
6. Stjärnornas uppkomst - grundämnen, mineral på jorden.
7. Solens energi – exogena processer i bergartscykeln (som drivs av vattnets kretslopp).

Dessa teman var vår utgångspunkt i vår tematiska analys.

3 Metod

Det avslutande undervisningsmomentet om geologi och astronomi inom lärarlyftskursen bestod av en gruppdiskussion där studenterna fick möjlighet att diskutera fram vilka nedslag på tidslinjen från Big Bang och fram till idag som de anser är väsentliga för deras naturkunskapsundervisning. Studenterna sammanfattade de utvalda nedslagen på tidslinjen skriftligt, se fig. 1 och 2. Teoristyrd (deduktiv) tematisk analys används i syftet att studera huruvida empiri överensstämmer med en given teori. Genom en kvalitativ deskriptiv teoristyrd (deduktiv) tematisk analys (Braun & Clarke, 2006) analyserades vilka mönster som återfinns i studenternas olika nedslag i deras tidslinjer med utgångspunkt i våra egna framtagna sju teman i den teoretiska utgångspunkten. På så sätt kunde vi se på vilka sätt studenterna tangerar naturliga globala klimatförändringar över långa tidsperspektiv genom att med hjälp av den teoretiska utgångspunkten titta på kopplingen mellan geologi och astronomi i studenternas val av väsentliga nedslag i tidslinjen från Big Bang fram tills idag.

Viktig tidspunkt att ta med i undervisningen	Koppling till kursmaterialet och ämnesplanen i NK1:
13,8 mld Big Bang	**När man pratar om ämnetssyfte, framkommer ordet "universum", det är viktigt att eleverna får en uppfattning av vad universumkonceptet betyder för att kunna förstå naturkunskapskursens inriktning och vad vetenskapen undersöker och studerar. Man visar en modell på den accelerande universum. Det är viktigt med visuell framställning av universumkonceptet.**
13,6 mld år sedan	**Man kan koppla läran om atomer och grundämnen till bildandet av de första stjärnorna, varifrån alla grundämnen kommer. I arbetsmoment om energi pratas det om kärnenergi och vad fusion är, man kan koppla diskussion om uranets fission och vätefusion till fusion av de tyngre element i superstjärnor.**
4,6 mld år sedan	**Solen och solsystemets bildande från ett moln av gas och stoft i Vintergatan, medvetandegöra att planeterna (Jorden) skapades i samma process.**
4,5 mld år sedan	**Jorden bildas – viktigt att få en tidsuppfattning för elever hur länge vår planet har funnits och hur planeter som är differentierade med varma kärnor och bergartslager skiljer sig från gasplaneter, planeter/månar med svag eller ingen atmosfär och från stjärnor.**
3,7 mld år sedan	**Tidigt tecken på liv på jorden. Mikrobiella spår har hittats. Detta kopplar vi till diskussionen "Vad är liv?" tillsammans med eleverna. Visa att livet tillkom ganska "snabbt" efter Jordens bildandet. Cyanobakterier som gör att syre ökar i atmosfären och som även idag står för 50% av syreproduktionen på Jorden. Bakteriecellen är den första cellen man studerar med eleverna, eleverna kan få perspektiv på hur de minsta organismerna har påverkat livet på Jorden.**
541 mil år sedan - 252 mil år sedan - 66 mil år sedan 2,6 mil år sedan	**Både när man arbetar med arter, ekologi, ekosystemfrågor och när man går igenom energisystem, fossila bränslen och resursutnyttjande skulle man med fördel kunna koppla till de olika eror och perioder i den geologiska kalendern där man lyfter följande tidspunkter och begrepp: Precambrium slutar och Fanerozoikum (det "visibla" livet) börjar: Paleozoikum – Sverige (Baltica) befinner sig på södra jordklottet – kallt hav – varmt tropiskt hav – vulkanisk aktivitet – bergbildning Fossiler i Skåne, Västra götaland, Öland Mesozoikum – Dinosaurier, fåglar, däggdjur – massutdöende 66 milj år sedan Kenozoikum – stora däggdjur, människa**
	Man kan koppla diskussioner kring människans påverkan på Jorden i Antropocen till grafen där glaciationer, global havsnivå, global medeltemperatur och global CO2-halt i modern tid kopplas till den geologiska skalan. Bra utgångspunkt för diskussion om massutdöende – koppla till idag när vi talar om den sjätte massutdöende av arter.
	Man kan skriva ut Carl Sagans Cosmic Calender eller be eleverna att göra egna kalendrar där de fyller i viktiga händelser på 12-månaders kalenders positioner för att få en relativ uppfattning av hur långt tillbaka i tiden vissa punkter inträffade.

***Figur 1**. Tidslinjen från Big Bang fram tills idag med de, för eleverna i naturkunskapsämnet, väsentligaste nedslagen enligt studentgrupp 1.*

Big Bang	13,8 miljarder år sen	0 km
Första stjärnorna	13,7 miljarder år sen	21 meter efter big bang
Galaxens bildande	13, 6 miljarder år sen	42 meter efter big bang
Solsystemets bildande	4,6 miljarder år sen	2 km
De första encelliga organismerna bildas	3,5 miljarder år en	2,257 km från big bang
Jordskorpan och litosfären, plattektoniken ändrar form. Sverige har funnits på olika platser. den äldsta berggrunden i Lappland bildas	2 800 miljoner år sen	2,392 km från big bang
Allt land på joprden är samlat i kontinenten Rodinia och Sverige ligger vid sydpolen	900 miljoner år sen	2,8 km från Big Bang
Kambriska explosionen Sverige ligger vid Ekvatorn och är täckt av ett hav med lera och sand, och liv utvecklas explosionsartat.	542 miljoner år sen	2,88 km från Big Bang (8 meter från föregående)
Siljaringen. Sverige ligger på land för första gången. En meteorit slår ner	416 miljoner år sen	2,91 km från Big Bang
Rodinia har blivit Pangea, varpå det glider isär igen,	359 miljoner år sen	2,92 km från Big Bang
Trias. Varmt. träsk dinosaurier	251 mijoner år sen	2,95 km från Big Bang
Krita. södra sverige täcks av ett tropiskt hav	145 miljoner år sen	2, 97km från Big Bang
Dinosaurierna dör ut, det blir kallare och kallare	65 mijoner år sen	2,986 från Big Bang (16 meter från föregående)
Istid	2,5 miljoner år sen	2,995 km från Big Bang (en halv meter från föregående)
Nutid		3 km

Figur 2. *Tidslinjen från Big Bang fram tills idag med de, för eleverna i naturkunskapsämnet, väsentligaste nedslagen enligt studentgrupp 2.*

4 Resultat

Grupp 1 fokuserar främst på tema 4, 5 och 6 där de delvis eller helt kombinerar geologi och astronomi. De tangerar även tema 1 då de nämner dinosauriernas massutdöende. Skillnaden mellan naturliga och antropogena klimatförändringar tydliggörs genom fokus på den geologiska tidsperioden Antropocen. Grupp 1 kombinerar därmed geologi och astronomi.

Grupp 2 fokuserar främst på tema 1, 3, 4, 5 samt 6, men kombinerar inte geologi och astronomi. I tema 1 fokuseras geologin med Siljansringen och dinosauriernas utdöende. I tema 3 fokuseras geologin i form av istider. I tema 4 fokuseras astronomin i form av bildandet av solsystemet, men även geologin i form av plattektoniken som en återkommande röd tråd i tidslinjen. Även om både astronomi och geologi nämns inom tema 4 kopplas de inte samman. I tema 5 fokuseras geologin i form av de första encelliga organismerna. I tema 6 fokuseras astronomin i form av bildandet av stjärnor och galaxer. Grupp 2 kombinerar därmed inte geologi och astronomi. Grupp 2 nämner inte heller antropogena klimatförändringar.

Studenternas nedslag på tidslinjen visar att grupp 1 till viss del kombinerar astronomi och geologi medan grupp 2 börjar med astronomin och avslutar med geologin i sin tidslinje. De båda grupperna fokuserar främst på bildandet av stjärnor, solsystemet och jorden samt livets utveckling. När det gäller globala klimatförändringar så tar grupp 1 konkret upp detta i samband med beskrivningen av Antropocen och fokuserar då främst på antropogena klimatförändringar. Grupp 2 tar däremot upp istider/glaciationer och meteoritnedslag, men endast utifrån det geologiska perspektivet utan koppling till astronomin och får därmed inte med kopplingen till globala klimatförändringar över långa tidsperspektiv. Grupp 2 nämner att dinosaurierna dör ut medan grupp 1 nämner massutdöenden i form av dinosauriernas utdöende samt i samband med det nutida massutdöendet i Antropocen, vilket kopplas till klimatförändringar.

Eftersom grupp 2 inte kopplar geologi och astronomi får de inte heller någon koppling till globala klimatförändringar över långa tidsperspektiv. Grupp 1 däremot kopplar delvis ihop geologi och astronomi i flera av teman samt har även en utvecklad del om Antropocen. Detta gör att globala klimatförändringar fokuseras, men beskrivningen av Antropocen gör att antropogena klimatförändringar nämns explicit medan naturliga klimatförändringar blir implicita.

5 Diskussion och slutsatser

Studenterna skulle kunna utveckla en djupare förståelse för globala klimatförändringar över långa tidsperspektiv genom en undervisning som tydligt tar upp kopplingen mellan geologi och astronomi till tidslinjer. Utgångspunkten och avgränsningen i kopplingen mellan geologi och astronomi skulle i första hand kunna vara de olika teman som nämns i teoretisk utgångspunkt. De teman som båda studentgrupperna nämner i tidslinjerna är tema 4, 5 och 6, vilka framförallt anknyter till bildandet av stjärnor, solsystemet och jorden samt livets utveckling. Tema 2 (solaktivitet) och 7 (solens energi och exogena processer) nämns inte i någon av gruppernas tidslinjer.

De teman (4, 5 och 6) som båda studentgrupperna nämner i tidslinjerna skulle kunna vara en startpunkt i undervisningen för att hitta kopplingen mellan astronomi och geologi samt dess samband med globala klimatförändringar över långa tidsperspektiv. De teman (2 och 7) som studenterna inte nämner i tidslinjerna behöver tydliggöras i den grundläggande undervisningen. Massutdöenden som i detta fall endast kopplar till tema 1 och meteoritnedslag, borde vara en del av samtliga teman eftersom massutdöenden oftast är en följd av globala klimatförändringar (Einarsson, 2018). Detta är något som behöver vidareutvecklas och förtydligas.

Sammanfattningsvis är både de kosmologiska och geologiska tidsperspektiven viktiga för att skapa en tidsmedvetenhet (Brock et al., 2018; Czajka & McConnell, 2018; Einarsson, 2018; Trend, 2005). Tidsperspektiven och tidsmedvetenheten är viktiga i naturkunskapsundervisningen för att förstå naturliga och antropogena globala klimatförändringar över långa tidsperspektiv. Det är viktigt att som samhällsmedborgare förstå hur kombinationen av geologi och astronomi kan förklara naturliga globala klimatförändringar över långa tidsperspektiv samt hur de kan påverka jorden och livet på jorden under dåtid, nutid och framtid. Genom kunskap om de naturliga globala klimatförändringarna under långa tidsperspektiv kan vi få värdefulla insikter om de nutida antropogena globala klimatförändringarna.

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SYMPOSIUM: BUILDING RESEARCH LITERACY FOR SCIENCE TEACHING

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Abstract

In this symposium, we explore prerequisites for science teachers' development of research literacy. We present three papers that all contribute with different aspects related to research use for science teaching, both among science teachers and science teacher educators. Even though research-based teaching has long been encouraged in the Nordic countries, there are still challenges left to be solved. The first paper presents the tension between natural science research and science education research. The second paper investigates teachers' development of research literacy during participation in a professional learning community (PLC). The third paper examines teacher educators' reflections on how their own practice as researchers affects their role when they meet student teachers. This symposium will discuss where we are now, but also potential ways forward.

1 Introduction

This symposium consists of three papers relating to science teachers' research literacy and research use for science teaching. Research literacy is defined as the ability to understand, value, and use research for teaching. The concept implicates an *active dimension* when teachers' knowledge from earlier experiences of teaching meets knowledge from science education research (Stolpe, ahead of print). In this symposium, we will explore prerequisites for science teachers and science teacher educators' use of research in their science teaching. Earlier research has suggested that professional learning communities (PLC) could be a way of enhancing this challenging endeavour. One interview study and two PLC studies from three Nordic countries, will be presented as a base for the discussion about how science teachers' research literacy as an activity could be fostered.

2 Biology teachers' conceptions about research use for teaching evolution[1]

In Sweden, the Educational Act states that education should be founded on science and proven experience. The school authorities have agreed that both the content taught, and the methods used in the classroom should rest on research findings. This means that teachers should stay up to date regarding biology content (in this case, evolution) and research in biology education (didactics). Earlier research has indicated that it is challenging for teachers to enact this legal demand (Bergmark & Hansson, 2021). However, little is known about how teachers conceptualise the requirements when it comes to the relationship between science and didactic research, respectively.

This study investigates upper secondary biology teachers' conceptions about research use for teaching evolution. Seven biology teachers from different schools around Sweden have participated in in-depth interviews about what resources they use as they plan, carry out and evaluate their teaching about evolution. A phenomenographic analysis (Sjöström & Dahlgren, 2002) reveals that biology teachers hold four conceptions of the role of research.

Firstly, science has an important role in the classroom in terms of presenting materials that are scientifically correct, but also teaching about the scientific method, a scientific language and writing reports.

Secondly, the teachers stay up to date with resources such as science museums, scientific biology journals, and textbooks from their own university courses. However, most of the teachers explicitly say that they do not search for didactic resources since they know how to teach by experience.

Thirdly, evolution is a content that highlights the importance of being able to separate faith from scientific knowledge. Science has the role of justifying what is "true" from what is faith; but also what is fake news and pseudoscience.

Fourthly, discussions about research in schools are dependent on the collegial culture at the school. The teachers describe that during the teacher meetings, they need to discuss how all students should reach their learning goals and what materials they need to buy for the next semester. These topics consume all the time, so there is no time or engagement for discussing how science and didactics could be enacted in the classrooms.

3 Characteristics of teachers' research literacy and reflection when analysing video of classroom practice[2]

In this study, we investigate how teachers participating in a Professional learning community (PLC) use analytical frameworks for video-analysis in their professional reflection on their own science teaching. The aim is to study the characteristics of the reflective discussion when it is combined with developing research literacy through analysis.

Research-based education is encouraged by policy-makers in Norway (NOKUT, 2020). Yet, implementing research-based education is challenging and requires a degree of research literacy among teachers. Research literacy consists of a range of implicit and explicit skills (Aspfors & Eklund, 2017); for teachers these skills are proposed to aid in making accurate observations and insightful analyses of student learning, and to increase the precision of their reflective professional inquiry (NOKUT, 2020). The reflective inquiry is central to a PLCs contribution to professional development and in turn changes to classroom practice. Two challenges to reflective professional inquiry are lack of concrete examples from practice, and lack of critical dialogue (safe talk).

In our study the teachers discussed concrete examples of classroom practice through video-recordings of teaching and pupils' written work products from inquiry-based science lessons. We used a framework from educational research as a tool to stimulate critical dialogue among the teachers. The framework is adapted from the *Linking Instruction in Science and Student Impact (LISSI)*- project and is designed to analyse the quality of science teaching (Ødegaard & Kjærnsli, 2021). We investigate how the teachers in the PLC utilise the framework in their professional reflective inquiry, whether it supports their professional inquiry, and how they use the framework in their analysis of their own classroom practice.

We observed and videorecorded three science lessons from two science teachers, and two lessons from one science teacher from lower secondary school participating in a PLC. The three teachers convened in a focus group meeting, where they, together with the first author, analysed selected video-sequences and pupil work products using the LISSI-framework. This reflective professional inquiry in the focus group was audio- and videorecorded and analysed using Legitimation Code Theory.

Preliminary findings indicate that the teachers shifted between using experience-based knowledge and research-based knowledge when discussing video-sequences of their own teaching. Additionally, when analysing pupil work products, they primarily relied on experience-based knowledge. Furthermore, prompts and the analysis framework facilitated a more varied use of research-based and experience-based knowledge in their professional reflective inquiry.

4 Professional learning communities for science teacher educators: Researcherly practices and modelling of these for student teachers[3, 4]

The paper presents findings from NAFA, a large-scale initiative to improve science teacher education in Denmark, e.g. by organizing professional learning communities (PLCs) for teacher educators. The PLCs work with 'professional inquiry' positioned between everyday evaluation of teaching and practitioner research (Boyd & White, 2017). Baseline research, using the four domains of teacher educator knowledge from Mork et al. (2021) has shown a large variance in competences related to science education research, partly due to different institutional possibilities. Different possibilities are also emphasised in international research highlighting the hybrid position as ´teacher educator-researcher´ and referring to teacher educators' researcherly disposition (Tack & Vanderlinde, 2016). Based on this, the aim of the present research is to examine how teacher educators reflect on the PLC-work in terms of themselves as producers of research improving their practice and contributing to the knowledge base on teacher education, and the possibilities for modelling of researcherly practices for the student teachers. Data is from the first two cycles (2022-24) following an annual rhytm with local work in the PLC and sharing the findings in the national network. The research design is a sequential mixed methods design with a yearly survey and repeated group interviews with teacher educators, and survey data from student teachers. Findings show a large variance in the PLC-projects in terms of researcherly practices. The institutional differences in research-culture also before NAFA appear to be determent. Furthermore, the possibility to develop a meaningful PLC-organisation locally is important for engagement and value-creation, and the teacher educators emphasize cooperation around developing not only teacher education, but also the knowledge base om subject specific practices in science in schools. Student teachers emphasize professional outcomes from their own minor inquiries developing and trying out science activities at schools or in a microteaching format.

5 Discussion and conclusion

In this symposium, we will discuss the possible ways to proceed with the development of research literacy among science teachers and science teacher educators. Although research-based education has been promoted by the authorities in all Nordic countries, there are still challenges that need to be overcome. We believe that one way to overcome these challenges is to share experiences between Nordic countries, which will help foster cumulative research in the area of research use and research literacy in science education.

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SYMPOSIUM: LÆRERMIDDELBRUG OG LITERACYFORSTÅELSER I NATURFAGENE I DANMARK

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Abstract

In this symposium, the ongoing Danish project "Scientific Reading – Learning with Texts in Science Education" (2022-2026) is presented. The symposium focuses on Danish science teachers' use of learning materials as well as their understanding of and approaches to literacy in science. In Denmark, research on literacy and use of learning materials in scienceteaching is scarce, underpinning the significance of this project. Unlike the traditional ‘content area literacy’ approach that has dominated Danish science education, this project adopts a contemporary ‘disciplinary literacy’ framework. The symposium comprises three presentations exploring specific aspects of the project: Presentation 1 delves into a survey study mapping literacy and learning material use in Danish primary and lower secondary science education; Presentation 2 lays forth and discusses preliminary findings from qualitative classroom studies exploring learning with texts in science teaching; Presentation3 offers a comparative analysis of recent trends in disciplinary literacy in science education based on an international research review *and* Danish findings from the survey study introduced in presentation 1, emphasizing among others the prominence of multimodality. The symposium aims to bridge connections between actual trends in literacy research (multimodality and disciplinary literacy) and the increasing emphasis on models and modeling in science education research.

Introduktion (Martin Krabbe Sillasen)

I dette symposium præsenterer vi resultater fra det igangværende danske projekt *Naturfaglig læsning – At lære med tekster i naturfagsundervisningen* (2022 – 2026). Projektet er et landsdækkende praksisudviklende forskningsprojekt organiseret som et samarbejde mellem Nationalt Videncenter for Læsning og de seks danske university colleges.Resultaterne der præsenteres i symposiet, stammer fra projektets første to vidensafdækkende faser med særligt fokus dels på danske naturfagslæreres brug af fagtekster og læremidler i undervisningen og dels på den forståelse af literacy, der er fremherskende blandt lærerne.

I Danmark er viden om naturfagslæreres brug af læremidler og deres literacyforståelser sparsom. En sådan viden er værdifuld af flere grunde. Der er solidt forskningsmæssigt belæg for, at læremidler har en stærk indflydelse på undervisning både generelt (fx Warren, 2000) og specifikt i naturfagene (fx Sanchez & Valcárcel, 1999). Undersøgelser viser ligeledes, at læremiddeltekster i naturfagene stiller særligt store krav til elevernes læsefærdigheder på grund af deres sproglige og multimodale kompleksitet (fx Bremholm, 2014). Endvidere har dansk naturfagsdidaktik – hvad angår tekstbrug og læsning – gennem de seneste 20 år været domineret af en traditionel ’content area literacy’ tilgang, på dansk betegnet som ’faglig læsning’ (fx Moss, 2005). I modsætning hertil baserer projektet *Naturfaglig læsning* sig på en nyere forståelse af literacy betegnet ’disciplinary literacy’ som sit teoretiske grundlag (fx Moje 2012; Shanahan & Shanahan, 2008). Disciplinary literacy kan på dansk oversættes til ’fagspecifik literacy’, og et aspekt af projektet retter sig således også mod at undersøge, hvorvidt denne nyere forståelse af literacy har vundet indpas blandt lærerne og i læremidlerne i naturfagene i grundskolen såvel som på læreruddannelsen.

Symposiet består af tre oplæg, der hver især er knyttet til delundersøgelser inden for det overordnede projekt, henholdsvis en spørgeskemaundersøgelse af læremiddelbrug blandt danske naturfagslærere, etnografiske klasserumsstudier af naturfagsundervisning på udvalgte skoler og et litteraturreview.

Oplæg 1: Kortlægning af literacy og læremiddelbrug i naturfag i den danske grundskole

Oplæg 2: At lære med tekster i naturfaglig undervisningspraksis

Oplæg 3: Nyere trends i literacy i naturfagene i Danmark – en komparativ analyse med etinternationalt review om 'Fagspecifik literacy'

Oplæg 1 (Jesper Bremholm & Bettina Buch): Kortlægning af literacy og læremiddelbrug i naturfag i den danske grundskole

I dette oplæg præsenterer vi en nyligt afsluttet undersøgelse, der bidrager med systematisk viden om naturfagslæreres brug af læremidler i deres undervisning i grundskolen i Danmark (Bremholm et al., 2023). Undersøgelsen blev gennemført som en spørgeskemaundersøgelse blandt naturfagslærere i den danske grundskole (1.-9. klasse) i december 2022. Formålet med undersøgelsen var at kortlægge naturfagslærernes brug af læremidler, herunder hvilke læremidler lærerne anvender, hvor meget de anvendes, samt hvordan lærerne anvender dem i undervisningen. Desuden har der i undersøgelsen været et specielt fokus på lærernes forståelse af literacy og deres didaktiske tilgange til at støtte elevernes tekstarbejde i undervisningen.

Metodisk er undersøgelsen en stikprøveundersøgelse, der anvender et stratificeret klyngedesign (Lehtonen & Djerf, 2008). Det endelige udvalg omfattede i alt 92 skoler og 707 naturfagslærere. I den danske grundskole er naturfag opdelt i fire forskellige fag: natur/teknologi (1.-6. klasse), fysik/kemi, biologi og geografi (7.-9. klasse). For at styrke både validiteten og repræsentativiteten i undersøgelsen har vi anvendt et distribueret design, hvor hver deltagende lærer modtog et individualiseret spørgeskema rettet mod et specifikt naturfag og klassetrin.

Spørgeskemaundersøgelsen viser blandt andet, at danske naturfagslærere har et bredt, multimodalt syn på hvad tekster og læsning af læremiddeltekster er. Samtidig indikerer undersøgelsens resultater imidlertid også, at lærerne, hvad angår tekstdidaktiske arbejdsformer, overvejende gør brug af mundtlige og lærercentrerede undervisningspraksisser.

I præsentationen vil vi kort beskrive det metodiske design samt præsentere og udfolde udvalgte resultater fra undersøgelsen med særlig fokus på naturfagslærernes forståelse af literacy og deres didaktiske tilgange til arbejdet med fagtekster i undervisningen.

Oplæg 2 (Therese Malene Nielsen, Marianne Oksbjerg, Ditte Marie Pagaard & Stine Kragholm Knudsen): At lære med tekster i naturfaglig undervisningspraksis

I dette oplæg præsenteres resultater fra den kvalitative del af projektet. Resultaterne er baseret på analyser af cases fra naturfagsundervisningen i udvalgte udskolingsklasser på forskellige skoler. Hver af de deltagende læreres naturfagsundervisning med læremidler betragtes som en case, hvor vi fokuserer på de literacypraksisser, som udfolder sig i casen, men også på mønstre, som eventuelt fremtræder på tværs af cases (Yin, 2018). Vi vil i oplægget vise eksemplariske nedslag i naturfaglig literacypraksis, som den udfolder sig i treaf studiets cases:

Case 1

I denne case har vi set en tendens til, at elevernes læsning af multimodale fagtekster udfordres af manglende stilladsering i undervisningen. Fagtekster læses uden foregående aktivering af forforståelser, præcisering af læseformål og læsemåde, og vi ser manglende sammenhæng mellem den faglige læsning og undervisningens øvrige aktiviteter.

Case 2

I en anden case har vi observeret sekvenser af undervisning, hvor viden og fagsprog danner en sammenhængende rød tråd mellem de enkelte aktiviteter. Eleverne anvender her fagsprog og ser i passager af undervisningen ud til at udvikle begrebsforståelser i tilknytningtil det fagområde, de arbejder med.

Case 3

Vi vil på baggrund af observationer i naturfag vise sammenhænge mellem undervisningsformer og elevernes mulighed for sproglig og faglig udvikling. Yderpunkterneer en traditionel, lærerstyret tavleundervisning præget af monolog sat over for projektundervisning med en vejledende lærer, der fokuserer på krav til prøve og mindre påat støtte elevernes skriftsprogstilegnelse i naturfag.

Oplæg 3 (Tine Ejdrup & Martin Krabbe Sillasen): Nyere trends i literacy i naturfagene i Danmark – en komparativ analyse med et internationalt review om 'Fagspecifik literacy'

I dette oplæg vil vi med udgangspunkt i et internationalt litteraturreview om fagspecifikliteracy i naturfagene *og* resultater fra kortlægningen om literacyforståelser og læremiddelbrug i den danske grundskole (jf. oplæg 1) udpege nye trends i forståelsen afliteracy blandt danske naturfaglærere.

Litteraturreviewet er udført som et scopingreview (Arksey & O'Malley, 2005). Søgningen er tidsmæssigt afgrænset til 2015-2023 i nordiske og engelsksprogede databaser, hvilket gav en bruttoliste på 557 resultater. Ved hjælp af inklusionskriterier som *fagspecifik literacy*, *fokus på* *naturfag* og *fokus på grundskole eller ungdomsuddannelse* blev antallet af artikler reduceret til 32 omhandlende fagspecifik literacy i naturfagene.

Reviewet viser: 1) At der i mange studier særligt er fokus på, hvordan læsning og skrivning påvirkes og evt. kan forbedres med digitale muligheder; 2) At multimodalitet står frem som en dominerende trend, der har udviklet sig nærmest eksplosivt de sidste femten år. Specielt brugen af forskellige former for digitale og analoge modeller samt modelleringsprocessers indvirkning på elevers læring i naturfag har været et dominerende fokus; 3) At arbejde med stilladsering af elevers sproglige bevidsthed i både produktive og receptive skrive- og læseprocesser er et fokuspunkt i mange studier; 4) At fagspecifik literacy i naturfag omfatteret fokus på naturvidenskabelige arbejdsmetoder tilpasset en skolekontekst, som eleverne får erfaringer med under temaet ”act-like-a-scientist”.

I præsentationen vil vi kort præsentere det metodiske design, præsentere og udfolde hovedtematikkerne i reviewet samt relatere dem til udvalgte resultater fra kortlægningen af literacyforståelser. Et særligt fokus vil være den centrale plads, som multimodalitet har bådei litteraturreviewet og kortlægningen.

Den efterfølgende diskussion vil bl.a. lægge op til at drøfte forbindelseslinjer mellem multimodalitet i literacyforskningen, og et stigende fokus på modeller og modellering i naturfagsdidaktisk forskning.

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SYMPOSIUM: NFSUN 40 YEARS - 1984-2024 – A HISTORIC REVIEW AND AN ANALYSIS OF CONTENT IN AN INTERNATIONAL PERSPECTIVE

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Abstract

This symposium focuses on the development of science education and science education research in the Nordic countries during the forty years NFSUN has existed. In the first part of the symposium, we summarize the thirteen symposia. The titles of the presentations illustrate that NFSUN has developed from the start with physics education to include all disciplines in the integrated science subject. Other trends are the move towards presentations having several authors and increased use of English, which reflect the growth and diversification of the field. In the second part of the symposium, we investigate which trends in science education research. We find that words connected to didactical theories generally increase in frequency and that words describing science content knowledge decrease. The first appearance and then increase of some common themes in present research through the years of NFSUN are indicators of some broad trends in Nordic research. How these Nordic trends correlate with broader international trends are the main theme of the final part of the symposium. In the last part we use some recent reviews as guides of international trends and investigate how our findings from the Nordic countries correspond to these.

1 Introduction

Autumn 2024 - 40 years since the first Nordic Research Symposium on physics in school. Three years later, 1987, the symposium included the whole field of natural science in school, and from 1996 the name was changed from Nordic Research Symposium to Nordic Research Symposium on Science Education. The triennial venue has since rotated between the Nordic countries.

Our symposium will try to answer some questions on how the content of the NFSUN symposia have developed through these 40 years and correlate these finds to some international trends in science education research.

First, we will present a brief overview of the symposia: locations, formats, size, number of presentations, and communication of outcomes. The second presentation dives into the content from all the symposia by means of the presentation titles. In addition, we will look for trends in the strands/themes/titles/aims. In the final presentation we position our findings in the context of contemporary international trends in science education, and research on science education. This analysis will, as far as possible, include the same categories as the analysis of the NFSUN development.

By looking back on NFSUN history, we want to stimulate to a discussion on the future: what should NFSUN be, and how can the symposium (continue to) be a dynamic arena for discussions on science education research in an international context while caring for the Nordic research tradition and the Nordic school context, as discussed by Dolin (2021).

2 The history of NFSUN, and the diversity of science education research

In the opening speech from the first symposium on physics in Ebeltoft, 1984, Henry Nielsen and Poul V. Thomson said:

> "…… It is our hope that the symposium will be a fruitful meeting between researchers and school staff, and that it will be the start of a constructive Nordic cooperation going forward - also in this new area"[15] (Nielsen & Thomsen, 1984).

From the 1987-symposium the scope was expanded to include all science disciplines that constitute the integrated Nordic school subject Science ("naturfag"). The first symposiums also seem to have a focus on keynotes presenting the school systems in the Nordic countries, while presentations covered diverse topics, for example: teaching methods, teachers' and students' attitudes as well as students' conceptions/misconceptions. This was in a period where concepts such as "Science Didactics" (Sjøberg, 2012) and "Pedagogical Content Knowledge" (PCK) (Schulman, 1986) were rarely used. In the NFSUN context the concept Science Didactics ("naturfagenes didaktikk") was first explicitly stated in 2003, as the title of the symposium (Sjøberg, 2012). Between 1984 and 2003 the science education research environment was seeking for appropriate designations for this field of science/science didactics/science pedagogic/science education, that finally seem to end up with a diversity of concepts rather than one universal. Sjøberg (2012) and Sørensen (2006) are both discussing this journey, with different reflections and conclusions on how to define and frame this new science education research (science didactics) discipline in-between natural science and social science.

The concluding part of this symposium present some science education trends based on themes, strands, and titles of presentations from NFSUN symposia, and offer reflections on these findings in an international perspective based on some recent reviews, e.g., Treagust & Won (2023), Lee et al. (2009), Lin et al. (2018).

3 Research methods

Our study is based on written material from all the symposia 1984-2021, including program booklets, symposia booklets with abstracts, physical or digital proceedings with selected contributions, and special editions of journals (NorDiNa and Lumat). The written material was scanned and included with digital material from the later symposia, into a database (Figure 1 for an overview).

[15] Translated from Danish by the authors

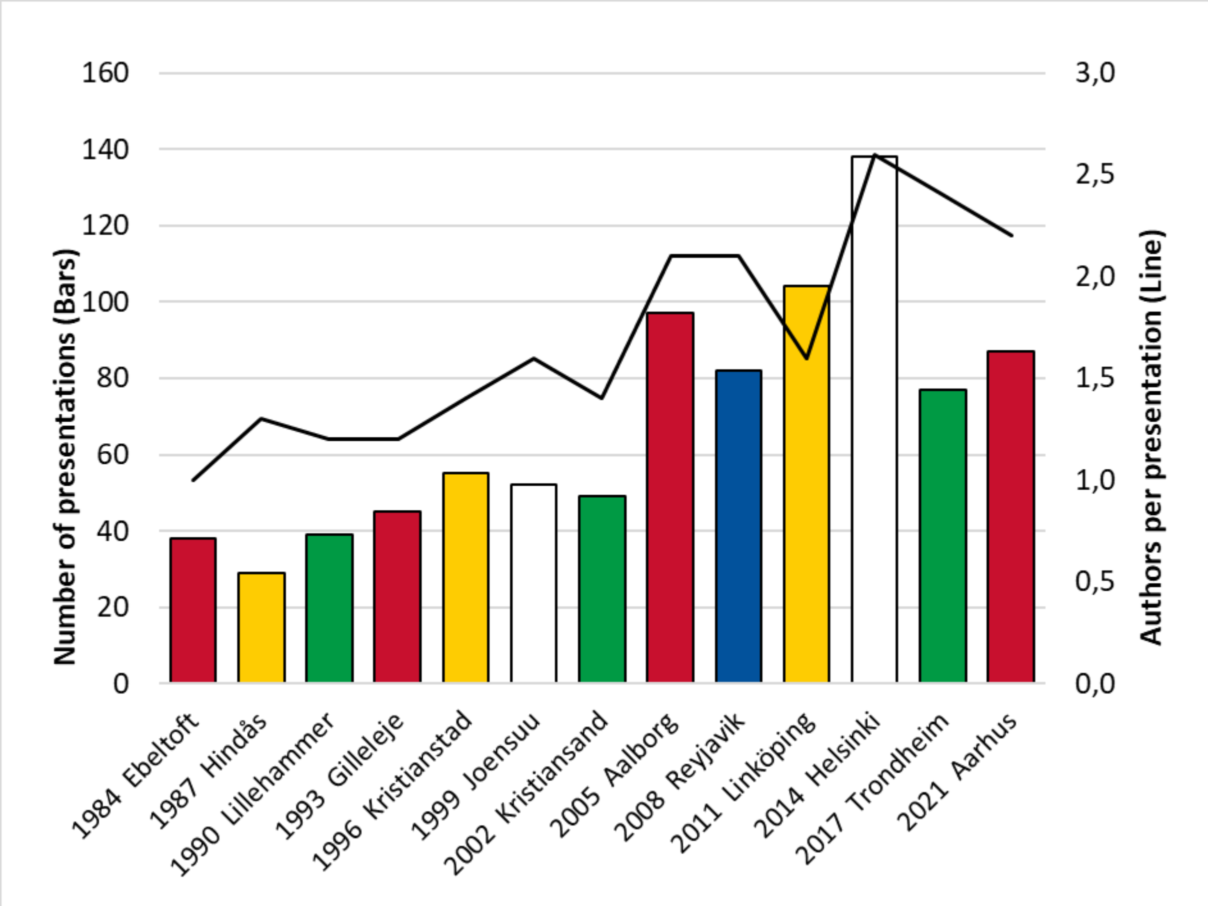

***Figure 1**: Overview of the material from 1984-2021.*

From the database we have extracted the information presented in part 1, and this has been the source for the analyses presented in part 2. The analyses are done as a content analysis, with a mix of inductive/deductive as well as quantitative and qualitative approaches (Cohen, 2018). In this proposal we have focused on trends from different decades.

4 Results

Part 1

The symposia have evolved from a symposium on physics education, to include all science disciplines and an increasing focus on didactics. From approximately 50 presentations per symposium until 2002, it has grown to around 100 from 2005. Another trend is increasing number of authors per presentation (Figure 1). Presentation language has changed from 90 % Scandinavian until 1996, to more than 70 % English from 2008 (Figure 2).

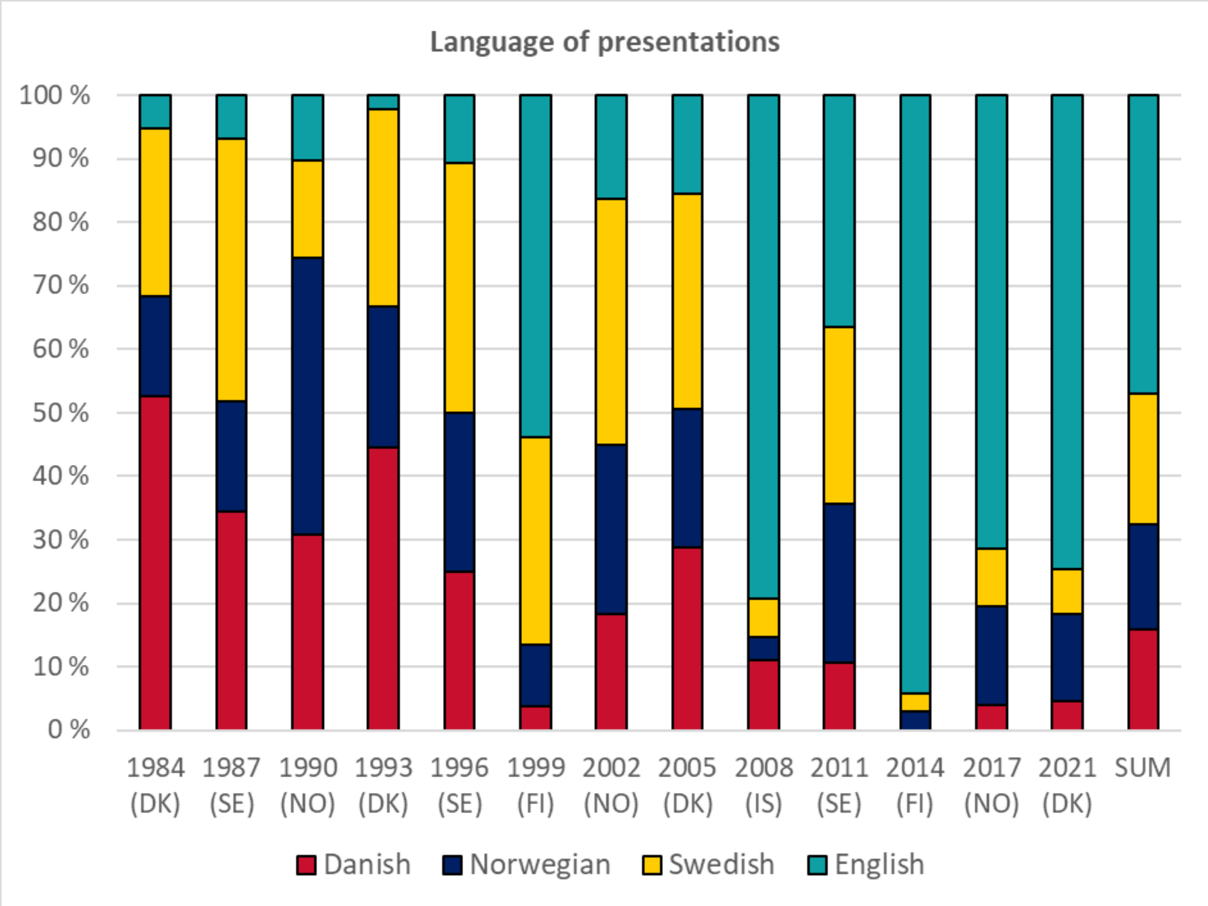

Figure 2. *Language of presentations, NFSUN symposia from 1984-2021*

Part 2:

The presentation titles indicate a considerable diversity in themes: CK, PCK and PK presentations on students learning and knowledge as well as teacher and teacher education knowledge. All Nordic countries are represented, and from all STEM disciplines, in total 892 presentations. Some overall trends are that more "advanced" concepts from pedagogical and science didactical research fields such as SSI, literacy, PCK and argumentation were absent before the 2002 symposium, while science content knowledge words like evolution, CO_2, and electricity are more frequently used in this first period than the last 20 years. The concept "inquiry based" has been used in presentations the last 20 years, with an increase the last 10 years. The concepts: environment, sustainability, and climate change, were analysed separately and we find them used through the whole NFSUN-period with a slight shift from "environment" towards "sustainability" in later years.

Part 3

Our findings are viewed in perspective to some international trends from recent reviews e.g., Treagust et al. (2023), Lee et al. (2009), Lin et al. (2018), combined with time-specific coverage from selected journals such as IJSE. We will show the different weight given to learning of science, teaching in science, science curriculum, and research methods through some loosely defined periods, the 1960s, mid-1970s and the 1980s, the 1990s to mid-2000s, and the mid-2000s to the 2020s. Development in one of these areas causes changes in one or more of the others, etc. As part of this process, we trace the different use of concepts and content. Two examples from our findings correlating to international trends is the decline in research on "Learning-Conceptions", in the period after 2000 (Lin et al. 2018) and to some degree "the shift of focus from content knowledge alone to knowledge along with practices, skills and attitudes" (Karampelas, 2021).

5 Discussion and conclusion

At the end of the symposium, we will invite to a discussion of our findings on how the content of the NFSUN symposia have developed through 40 years, and how these findings are in line with international trends. We also want to discuss the findings in the light of the three paradigms of science education research described by Treagust & Won (2023): post-positivistic, interpretivist and critical theory research paradigm, as we can see clear examples of all these paradigms in the material from the NFSUN symposia. A lot of intervention studies trying to measure outcomes, mostly from the early period of NFSUN (post-positivist), many observations and interview studies (interpretivist) from later years, examples of research representing the more critical theory research paradigm as well as several examples from the last introduced mixed methods research paradigm (Treagust & Won, 2023).

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WORKSHOP: LOW-COST VR-TOOLS SUITABLE FOR SCIENCE TEACHING AND LEARNING

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Abstract

The themes investigated in this workshop are the use of VR-tools in science education, mainly for out-of-classroom education. The workshop will be built on examples from place-based information, and we will use 360-degree photos as a tool for documentation and presentation of information obtained from an excursion. These practical examples will be used to discuss how best to prepare and execute out-of-classroom education for students in science. Much literature exists supporting the use of outdoor learning as this may give learners unique opportunities to develop skills and knowledge that may be difficult to obtain otherwise. However, outdoor education needs to be properly planned and implemented if learners are to be given best possibilities to reach the aims set out. This workshop offers hands-on experiences from using VR technology as a tool that may enrich the experience of outdoor education, in all the phases: preparation, execution and post-fieldwork follow-up. The values of such tools will be discussed based on literature, prior experience and participants' impressions from their use in the given examples.

Indented audience: Teachers in HE and secondary school
Educational context: Learn to use low-cost VR tools as a teacher tool, and as a learning tool for students. Suitable for STEM subjects, and other subjects visualizing place-based info.
Language: English
What to bring to the workshop: Laptop and smartphone

Introduction/background

There is lots of evidence supporting "out of school teaching" (e.g. Dillon et al. 2006). Through several projects in the last 20 years Remmen and Frøyland (2014, 2015 & 2017) have accumulated evidence for how to plan and perform fieldwork to optimize students' acquirement of subject matter knowledge. Essential findings are the importance of well-prepared prework, well organized fieldwork, and enough time for reflections and post-work (Remmen & Frøyland 2015). Their findings are summed up in a tool for designing outdoor science activities, called "Extended classroom", where they propose 6 recommendations, or steps, for the design of teaching outside the classroom.

The last six years we have taught, developed and researched on the use of digital placebased tools and apps for outdoor activities in science for preservice students and continuous education for science teachers, and in Erasmus+ projects with students from several European countries (e.g. Cyvin et al., 2022; Favier & Cyvin, 2022). This includes a wide range of arenas outside the classroom, including nature sites, city centers, science centers, and museums. In this workshop we will share experiences from this work, with a focus on low-cost VR cameras and software to process and use 360-degree pictures and films to produce teaching material.

Workshop structure (duration: 1,5 hour)

The workshop is designed as follows: After a short introduction to the theoretical framework for how to design teaching outside the classroom, we will present some examples of teaching material based on 360-degree photos, from Spitsbergen and from the Trondheim city center. We will also demonstrate examples of students' results from a two to three-hour workshop with the same tools as in this workshop. The thematic content will be from biology and geography. In the main part of the workshop, you will (in groups) take a couple of 360-degree photos (we bring special cameras), and then learn to use a special software to put them together with other material as texts, 2D photos, internet links, soundtracks etc. The participants will try out/playtest the digital tools and be able to collect and present the data. At the end of the workshop, we will facilitate a discussion about the pros and cons of the demonstrated tools and how they can be used in teaching to promote science subject matter knowledge. In addition, we will invite to a discussion on how and to what degree Remmen & Frøyland's (2017) tool for designing of teaching activities in "the extended classroom" is useful when you plan to use placebased tools and apps in science education.

Tools to be demonstrated and tested

360-degrees cameras & Google Cardboards (we will provide these). Software to make teaching material out of 360 photos/film: For example, Thinglink and a new software tool developed by the VR-learn-project at NTNU: https://www.ntnu.no/geografi/vr-learn

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WORKSSHOP: RESPONDING TO THE ENVIRONMENTAL CRISIS: ATTNTIVE LISTENING TO SOIL

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Intended audience: teacher educators, educational researchers, PhD students, teachers. Educational context: all levels
Language: English
What to bring to the workshop: coloured pens and paper.
Workshop time: 1 hour.

Abstract

This is a reflection on an experiential contribution advancing the ongoing discussion about STEAM education and its role in sustainability education. By choosing to define the 'A' in STEAM as a practice of 'attentiveness', we draw upon the dual aesthetic power of the arts to bring phenomena of the natural world 'out there' into the present realm of sensorial experience, thus bringing knowing into a new form, weaving together theory and practice as part of conference presentations. In this 1 hour contribution, we both describe the experience and exemplify it through direct engagement with participants. By following a 3-stage approach, each time re-proposing the sound of soil and inviting participants to respond. We suggest that this modality of conducting STEAM inquiry is more easily understood as the attempt to understand one's way of entering in relation to the world and coming to know. Subjective experiences are taken as points of departure to understand one's own values, choices and beliefs – a central competence for sustainability education.

Background. On STEAM and environmental awareness

In this experiential contribution we advance the ongoing discussion about STEAM education and its role in sustainability education (Burnard & Colucci-Gray, 2020). By choosing to define the 'A' in STEAM as a practice of 'attentiveness', we draw upon the dual aesthetic power of the arts to bring phenomena of the natural world 'out there' into the present realm of sensorial experience, and to harness imaginative potential to make sense of subjective experiences within a wider socio-environmental context. The practice of attentiveness acts both as an entry point of paying attention to something and someone and as a disposition of 'attending to' a phenomenon and letting it unfold. In this dual capacity, attentiveness brings a relational and ethical quality to the process of knowing another subject which may be different, distant or alien to oneself. And crucially, such knowing involves a form of 'radical implication' in the life of another, as relational approaches to ethics take human subjectivity and materiality as interdependent with that of non-human others (see Lorimer, 2012). In this view, human bodies and environments are seen as porous and permeated with, as well as dependent on, non-human forms of life. Weaving together theory with practice, we will invite participants to explore the experience of attentiveness through listening to soil. We understand 'listening' as auditory awareness (Østergaard, 2019b), including both modalities of listening as a sensory process and listening as grounding in the world. For example, the gesture of bringing a shell closer to one's ear contains both the potential to perceive the sound of the air circling in the spiral shape of the shell, but also the affective and ethical gesture of bringing something into closer contact with oneself. Hence, attending to an unknown sound phenomenon in this manner poses three questions that relate to each other. First, the ontological question concerning how nature expresses itself; second, the aesthetic question concerning the character of attentive listening; and third, the question concerning specifically how science education deals with the increasing problem of inattention deriving from the fragmentation of knowledge and separation of subject and object, both in scientific research and in educational practice. We will illustrate attentive listening by using excerpts from "Sounding Soil" to introduce participants to the experience and practice of listening and reflect on its potential in STEAM education.

On *Sounding Soil*

"Sounding Soil" is an interdisciplinary research and art project in which the sounds of soil ecosystems are recorded and analyzed (https://www.soundingsoil.ch/). The aim of the project is to bring sounds from below ground to the surface to experience soil life and to build awareness of this complex and important ecosystem and its processes. By using acoustic sensors in the soil, our ears become extended sensory organs that allow us to listen to the soil and hear the crawling, scratching, communication sounds and eating noises of the animals underground (Maeder et al., 2022). Drawing on the interdisciplinary field of ecoacoustics, audio recordings are used to analyse ecological relationships in different soils. Almost every organism produces sound waves, and the soil is a communication medium and a complex soundscape. Thus, "the acoustic richness of a local soil animal community may serve as an indicator of the functioning of a soil composition" (Maeder et al., 2019, p. 5).

The educational aspect of bringing soil into consciousness concerns the practice of listening itself, interrupting the flow of nominal language and explanations to invite the experience of the unknown, the unexpected or that which is different from oneself. In this condition, the experience becomes educational to the extent to which it builds awareness of different ways of listening to something, but also of our capacity to attend to the sound openly. We distinguish between three listening modalities, each posing different questions, as we play a sound recording three times and ask participants to respond through writing or drawing:

- *First time* audio sample, without knowing what the sound is, the question is: "Try to describe as accurately as possible what you hear". Further questions: "What is the value of doing this? Is there any value for sustainability of listening to something without knowing what it is?"

Second time audio sample, now knowing that the sound is soil, the question is: "Listen attentively and like before, try to describe the sound you hear". Further questions: "Knowing what it is, how does it change your experience of listening? And how does it feel to listen to it? What else do you want to know about what you hear?"

- *Third time* audio sample, with further knowledge of the source and the subject matter of the recording, the final the question is: "I will now play this sound sample again adding further detail about the origin, location and uses of this soil. Related to the two previous exercises, what else are you able to imagine about the subject in the recording? Do you see any new connections to your subject/the subject you are teaching?"

These three stages of listening are organized according to a phenomenological approach to the sounding soil which unfolds progressively both through attentive listening and the experience of coming to know the phenomenon through different ways of relating to it. In a STEAM setting, the phenomenon soil is not being 'discovered' as in the more conventional manner of scientific inquiry, but it unfolds through first person inquiry along three stages: First attentive listening to just sound, then relating the described phenomenon to knowing that the sound *is* soil, sounding itself through particular conditions, characteristics and uses, and finally connecting the sound to potential school subjects.

The challenge concerning STEAM education and environmental awareness

When considering attentive listening as the A in STEAM education, the question that arises in the exercises is not concerned with how to use the arts to illustrate or describe a concept in a more visual or accessible manner, but it is the benefit of openly attending to the phenomenon before knowing what is producing the sound. Which STEAM relevance does this approach have? The aim of introducing the auditory expression of soil in education is related to "sound pedagogy" with its intention of affecting "the listener beyond the domain of art" (Tinkle, 2015, p. 223). The epistemological value of this practice lies in dislodging natural phenomena from their established definitions to invite an extended working through, or search for possibilities by means of metaphors or analogies (Cazeaux, 2015), which illuminate the relation between signifier and signified mediated by language. Returning to the opportunities for STEAM education to orient our educational inquiry practices towards sustainability, we will then discuss the questions concerning specifically how science education deals with the increasing problem of inattention deriving from the excessive reliance on descriptions and explanations at the expense of sensory experience. Such inattention may also be part of how education generally addresses the fragmentation of knowledge and the question concerning interdisciplinary cooperation in school teaching, e.g., between music and science (Østergaard, 2019a).

By listening attentively to the sound of soil and reflecting on the potential of this exercise in STEAM education, we conclude that the experience of listening carries considerable affective power, positive interest and even enchantment. However, the process of describing sounds is not well-practiced and requires more regular exposure and continuous practice. And similarly, the disposition towards listening calls for an upturning of educational aesthetics. In addition to the call for expertise and sound management of soil, with its questions about users and uses, the sounding of soils can only be heard in a space of human silence and ability for extended listening. Thus, the gesture of attentive listening is not one of tending forward but the more difficult one of stepping backward and let the other in. We suggest that this modality of conducting STEAM inquiry is more easily understood as the attempt to understand one's way of entering in relation to the world, as coming to know, valuing subjective experiences as points of departure to understand one's own values, choices and beliefs – a central competence for sustainability education.

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WORKSHOP: BREAKING BORDERS - SHARING OWNERSHIP OF DRAWING IN SCIENCE

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Abstract

In this workshop, we focus on the process of drawing, rather than on drawing as product of learning. The workshop offers participants opportunities to experience drawing in science in different new ways. We take a starting point in drawing to deepen individual perception and observation and to construct knowledge of biological objects. From there we proceed to interact with each other's drawing, by changing places and picking up where another person has left their drawing.

Our intention is to challenge the burden of individual prestige, which is often associated with drawing, by immersing participants in personal and interpersonal experiences of drawing with different materials. During the workshop, we seek to co-create artifacts in a manner that may spark discussions about ownership, peer-interaction and perspective. We also want to engage participants in discussion about how the design of drawing activities can serve pedagogical and research purposes in science and beyond.

Indented audience: All
Educational context: Relevant for secondary and upward; biology and integrated science
Language: English
What to bring to the workshop: Necessary materials will be provided

Introduction/background

There is consensus that drawing continues to be relevant for promoting learning processes and creativity across disciplines in a world flooded with technology (Masi,2021). Among the studied learning mechanisms, abilities and skills that drawing process can enhance are visual thinking, connecting ideas, intuition, focus, embodiment, translating experience, perceiving and ideation (Masi, 2021).

In this workshop[16], we focus on the process of drawing, rather than on drawing as product of learning. We consider the question of "what the drawing is *for?"* rather than what "the drawing is *of"* (Adams, 2022), taking a performative perspective on learning. Performative perspectives highlight that learning and knowledge is created, expressed, and shared through language, gesture and other modes of expression with the help of different materials, in a process that is relational in its essence (Østern et al., 2023). During the workshop, attending to the assemblage of humans, materials, ideas and modes of interaction, becomes prominent, and sets the stage for collective exploration of ways of drawing. Arts-based education that

[16] This workshop, with changes, has been presented earlier: FND 2022, Umeä, 2022; and ETE- Educating the Educators, in Leiden May 2023. Its development was partially supported by the EU Erasmus+ program through the project: "Yard4All ", Grant agreement KA201-8A5F302D.

combines artistic practices with learning about the natural world, using experiential reflexive workshops (Van Boeckel, 2020) constitutes an important precedent for our approach.

Over the last years, we have gained valuable experiences from organizing workshops in science and drawing, within professional communities in the context of Yard4All, an Erasmus+ project (https://www.yard4all-project.org/) focusing on developing innovative methodologies to enable the success of all learners and establishing a sense of belonging. From these experiences, targeting teacher students, researchers and educators, have emerged some strengths and potentials embedded within applying drawing as a method in science education practice and research. In both cases, previous experience with art affects how well learners, participants and researchers are able to engage in art-based activities, as noted by Hoppe & Holmegaard (2022) in their review of arts-based methods in science education.

We invite the participants to embark on a drawing experience of slow looking and drawing, followed by interaction, asking the question, "what this leads us to? In our practice and or research". By immersing participants in a personal and interpersonal experience of drawing, we seek to spark discussions about ownership, collaboration, peer interaction and perspective. We also want to engage participants in discussions about how arts-based methods can serve research and pedagogical purposes in science, sustainability education and beyond.

Workshop structure

The workshop offers participants opportunities to experience drawing in science in ways involving different material-human assemblages and interactions. We use drawing as a starting point to deepen individual observation and construct knowledge about biological objects. Participants are then encouraged to interact with each other's drawings, by changing places and picking up where another person has left their drawing. Our intention is to challenge feelings of individual ownership and prestige, often connected to drawing and enhance collaborative perspectives.

The workshop is designed for 15 participants (max. 20) and a duration of 90 minutes. Approx. timeline: Introduction – 10 min.; warm-up - 10 min.; drawing your object – 20 min.; drawing "around" the table – 25 min., reflection and discussion – 20 min. (NB! The participants do not have to be good at drawing to attend the workshop. In fact, in a best-case scenario, participants have diverse feelings towards, and experiences of, drawing).

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WORKSHOP: DRAWING IN SQUARES: INVESTIGATING SCIENCE CONCEPTS IN THE CLASSROOM

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Abstract

In this workshop, the participants are invited to draw and, through the draw-and-write technique, to explore possibilities afforded by visual methods for investigating topics and concepts relevant to science and science education.

The participants draw and write in response to the prompt "what is…", followed by the concept to explore and are then guided through a rudimentary analysis of the set of drawings generated by the group, performed in a collective and embodied way. The workshop is directly inspired by the iSquare research program (http://www.isquares.info/, Hartel, et al. 2018), and by a collaborative and dialogic strategy for guiding participants through varied forms of visual analysis - the "iSquare Dancing"(Hartel & Nguyen, 2018).

The participants are offered an opportunity to experience an innovative arts-informed method, that utilizes drawing and visual methods of analysis. All are invited to engage in exploring the specific qualities of these activities, and their resulting artifacts, for generating innovative approaches to teaching and learning of topics central to science, education for sustainability and beyond.

Indented audience: Researchers, educators, students, teachers

Educational context: Relevant for a broad scope of age, level and subject

Language: English

What to bring to the workshop: necessary material is provided

Introduction/background

I am a biologist and science educator, who has done her bit of drawing and illustration. I have for years known about the power of drawing, and in the last years I have also explored drawing in science with students, teachers and colleagues, in different contexts. With this workshop, I am excited to share this passion and knowledge with the science education community. The workshop is inspired by a standardized draw-and-write task (www.isquares.info), that has been used to investigate the concept of *information,* as well as a pedagogical tool to engage students of information science with the concept (see e.g. Hartel et al., 2018).

The draw-and-write technique is an empirical visual research technique, which has gained popularity across the social sciences research, partially due to its relatively easy and inexpensive way of generating large and evocative visual data sets (Hartel, 2020). However, the method also has a great potential for pedagogical use in the classroom (Hartel et al., 2018), including in knowledge co-construction and group negotiation processes. In the draw-and-write technique participants are asked to answer a question by drawing and by writing or speaking about their drawing, within a limited amount of time. In this way a data-set consisting of visual and textual data is produced, which can be analysed in various ways (Hartel, 2020).

I have adapted the iSquare protocol to situations of which not all qualify as research *per se,* but sought to inspire discovery at the personal and group level, in collaborative contexts. For example, in the "Yard4All" project (Eramus+ project - https://www.yard4all-project.org/) the activity served as a facilitator of collaborative reflection about themes like 'inclusion' in a multinational setting. In my teaching, I have used it to engage teacher students with social scientific concepts (e.g. sustainability) and central science topics (e.g. evolution and biodiversity), and also for research purposes (pilot study).

While providing a first-hand experience for the participants, the workshop also aims to inspire and give rise to discovery about applications of the methods, and to stir discussion about their value for science education research, for pedagogical purposes and beyond.

Workshop structure

At the beginning a short introduction to visual research and the draw-and-write technique is given, making use of short videos (https://www.youtube.com/watch?v=PxZZYabSZGY), and the iSquares protocol is introduced. Participants are then invited to draw and write in response to the prompts 'what is' (followed by the concept to explore), in a 10x10 piece of paper, with standardized material (ink pen) and time constrains (5-7 min). In this way the participants produce unique drawings, generating the data-sets which will be further examined in a following group activity. After a short introduction to the "iSquare dancing" (Hartel & Nguyen, 2018), the participants are invited to engage in a rudimentary analysis of the data-set, that is actually embodied! We will all stand, point, reach, move, talk and engage with the visual data like in a dance. The analysis is prompted by questions about the images themselves. Relevant aspects can be the nature of the graphic representations, the emergence of themes and motives, pictorial metaphors or shared perspectives. Constrains and possibilities, can also be discussed. The exercise is intended to be dynamic, collaborative, dialogic and multidisciplinary.

Note that you do not have to be good at drawing to attend. You just need to be curious about visual approaches to research and teaching. It is more fun if we are many. Instructions in a handout will be provided to all participants, to take home to their own classrooms or research, including a short bibliography of sources related to the draw and write technique.

The workshop is designed to last 90 minutes (can be shortened to 60 minutes). The approximate timeline is: Introduction to the protocol – 10 min.; Drawing – 3 x 10 min.; Introduction to the analysis - 10 min.; analysis exercises – 3 x 10 min. Discussion – 10 min.

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