STEM Education in Newton Rooms: Students' Learning in Group Work; Process, Content and Social Organisation.

1. Excellence

1.1 State of the Art, Knowledge Needs, and Project Objectives

Recent findings from national and international reports have indicated that Norwegian pupils perform relatively poorly in STEM subjects, particularly when it comes to mathematical reasoning and modelling (Nilsen & Frøyland, 2016; Kunnskapsdepartementet, 2016; Kjærnsli & Jensen, 2016; Bergem, Kaarstein & Nilsen, 2016). Research on Norwegian STEM education has found that teaching is often dominated by the textbook (Lagerstrøm, Moafi & Revold, 2014; Nilsen & Frøyland, 2016), and that teachers lack sufficient materials to support in-depth understanding or to equip students to connect their tasks and learning with larger knowledge and subject contexts (Hodgson, Rønning, & Tomlinson, 2012). In response to this problem, Norwegian educational policy, including in white paper no. 28 and the recently developed national curriculum for primary and secondary education, has vigorously pursued "deep learning" (Kunnskapsdepartementet, 2016; Utdanningsdirektoratet, 2019). Defined in contrast to fragmented learning, surface learning, and instrumental understanding, deep learning has typically been characterized as integrated learning that leads to relational understanding (Hattie & Donoghue, 2016). This approach to education prioritizes a comprehension of the underlying structure of concepts so that students can transfer knowledge between contexts, problems, subjects, and people. The distinctive dynamics and potentialities of deep learning are productively modelled by the Structure of Observed Learning Outcomes (SOLO) taxonomy (Biggs & Collis, 1982; Hattie & Brown, 2004); as opposed to the lower two levels of learning and assessment, which are characterized by quantitative and superficial comprehension, the higher two levels are characterized by complexity, abstraction, and relationality. These 'deeper' levels involve self-monitoring and self-regulating strategies that can produce changes to cognitive function that lead to independent learning. In other words, deep learning involves seeking patterns, meaning, and underlying principles; connecting and extending ideas by critically evaluating evidence and arguments in relation to conclusions; and being actively interested in subject content (Hattie & Donoghue, 2016; Enwistle, 2000). The imperative to inculcate such generative, higher-order thinking and reasoning in students at an early stage of their education has been emphasized at national and international levels, such as in the Common Core State Standards State Initiative Report (CCSSI, 2010) and in the 2015 Norwegian Ministry of Education and Research "School of the Future" Report (Pellegrino & Hilton, 2012; Kunnskapsdepartementet, 2015).

In response to these imperatives, Norway is now pursuing new curricula and technologies to facilitate deep learning, a strategy that has proven promising but still uncertain. In studies of practical implementation from around the world, deep-learning approaches to STEM education have shown a marked improvement over formal methods, enabling students to understand previous contexts and apply them to new ones; for instance, algebraic pictures and non-routine problems in mathematics and discovery-oriented science activities have appeared to foster deep learning (Radford, 2012; Kaput, Carraher, & Blanton, 2008; Bereiter & Scardamalia, 2014). Yet, many of the core workings of deep learning remain insufficiently understood. The exact process of specific transferences—from one concept, field, or context to another—is still relatively understudied (Hattie & Donoghue, 2016), and the burgeoning "flipped classroom" strategy has only been tenuously linked with deep learning. Precisely how interaction affords deep learning has also been largely underexplored, leaving uncertain which social interactional components must be in place for deep learning to be possible. In Norway itself, new educational technologies and innovative classroom spaces have been envisaged as part of a "school of the future" that promotes deep learning practices (Kunnskapsdepartementet, 2015). Newton Rooms (www.newton.no), developed by FIRST Scandinavia but owned by local school owners (i.e. municipalities and county municipalities), are an arm of this strategy; offering quality-controlled education modules and state-of-the-art equipment for STEM activities, these learning arenas (over 30 throughout Norway) have allowed students to work together on curriculum-relevant topics outside of traditional classroom environments and modules. For research purposes, Newton Rooms provide a unique medium for a comprehensive study of deep learning, since their design and technological facilities promise the kind of collaborative, problem-solving, meaning-seeking, and transfer-enabling "flipped classroom" that is essential to this process. Yet, exactly how deep learning emerges in these innovative spaces is insufficiently understood, partly because Newton Rooms have barely been investigated—the subject only of a few Master's theses (Overå, 2010; Moe, 2011; Sæther, 2015). The current project applicants,

in fact, have performed one of the only research studies of the Newton program. This preliminary investigation, funded by Regionalt Forskningsfond Nord (RFF-Nord), discovered that deep learning processes are complicated by the dynamics of group work, which is a far more complex phenomenon than both current Newton-Room modules and larger curricular designs assume (Rusk & Rønning, 2020). The five excerpts analyzed in detail for this preliminary study demonstrated that students approach cooperation, knowledge expression, and the negotiation of shared pedagogical foci in diverse (and potentially heterogeneous or incompatible) ways throughout group work. These findings highlighted a significant knowledge gap: the need for a micro-analytical perspective that could parse how micro-oriented interactional practices affect group work learning outcomes. In particular, issues with cooperation, communication, and problem-solving uncovered by the study indicated that group work is significantly influenced by preparatory activity and pre-existing skills—an important avenue for further study. Deep learning in Newton Rooms depends heavily on group work, but social interaction in this context is still imperfectly understood and arranged.

Indeed, research on the fundamental interplay of deep learning and group work is inadequate for the growing complexity of educational innovations. Across nearly six hundred studies and over one hundred developmental projects—comparing collaborative, competitive, and individual working methods—throughout the last century, group work has been found to consistently result in better performance, greater productivity, more supportive relationships, enhanced mental health, heightened social competence, stabilized self-perception, and increased capacity to manage adversity and stress (Johnson, Johnson, Haugaløkken & Aakervik, 2006). Evidence from practical classroom research illustrates that the use of group goals and individual accountability significantly shape the learning outcomes of group learning and affect cognitive processes by motivating students to engage in peer modeling, cognitive elaboration, and collaborative practice—activities that make them feel responsible for each other's achievements and thus motivate students to engage in cognitive processes which enhance learning (Slavin, 2014). Research on deep learning, for its part, has promoted a multidimensional approach that locates learning in the interaction between cognitive, social, and emotional skills, such as curiosity, creativity, endurance, tenacity, resilience, and cooperation (Pellegrino & Hilton, 2012). Immersing themselves in subject matter and receiving feedback, students reflect on their own learning and receive assistance with understanding relationships; they are impelled, in this framework, to engage in elaborate explanations and epistemic negotiations with each other in groups (Sporer, Brunstein, & Kieschke, 2009; Webb, 2008). From the position of both fields, then, the relationship between deep learning and group work is often treated as self-evident, but, as our investigations have discovered, the finer workings of this relationship require further study. On one hand, the dynamics and optimal conditions for group work are contested (Rohrbeck, Ginsburg-Block, Fantuzzo, & Miller, 2003; Roseth, Johnson, & Johnson, 2007; Webb, 2008), while, on the other hand, research on the micro-level social organization and structure of group work interaction is limited compared to similar research on teacher-centric activities (Gardner, 2013; Sahlström, 2008). In other words, current research has demonstrated that group work fosters student dynamics that are essential to deep learning, but how these epistemic negotiations are co-constructed and what they 'look like' is still largely unknown.

Based on the issues and needs exposed by our preliminary investigation, and with a plan to carefully record and analyse Newton Room activities, the primary objective of the proposed FINNUT project is to develop knowledge of how group work in an activity-rich and inquiry-based learning environment can be designed to facilitate deep learning in STEM subjects. The secondary objectives of this research are: to understand how roles and knowledge are constructed and negotiated in the social interaction of group work, and how this process affects student-student cooperation and deep-learning opportunities; to identify how content, resources, and tasks in Newton-modules can be best designed to support deep-learning processes; and to determine how school activities, both before and after the Newton-Room visits, can enhance Newton-Room group work and deep-learning potentialities.

1.2 Novelty and ambition

At this intersection of educational technology and policy, we have a unique opportunity to understand social interaction and deep learning; in examining the finer mechanisms of group work in Newton Rooms, this project would be the first of its kind. Serving as the *medium* rather than the *object* of our study, Newton Rooms offer a uniquely optimal (and novel) environment for analysing group work dynamics and deep

learning, particularly the effects of task design and flipped classroom frameworks. Many of the variables that might confound research in traditional classrooms are mitigated by the infrastructure of Newton Rooms. The Newton teachers have received consistent training on the space and learning modules. And the modules themselves, designed by FIRST Scandinavia and Newton teachers, are quality-assured, standardized, and catalogued for use on the Newton website, such that their implementation is relatively uniform. This uniformity provides a ready-made foundation for examining how the same module and activities are engaged by different contingents of students. Additionally, the established pre-work practices that precede Newton Room visits furnish an opportunity to study "flipped classroom" dynamics. At the same time, the unconventional design of the Newton Rooms permits more naturalistic and detailed data collection, as video equipment will be less intrusive and constrained; the open-plan spaces can unobtrusively accommodate 4-6 cameras and several microphones, allowing researchers to analyse classroom interactions at a micro-detail not often possible. Moreover, the integrated layout of the Newton Rooms—connecting amphitheatre, laboratory, group workstations, and open floor—provides an opportunity to discreetly observe multiple class formats along with the important transitions between them.

The data collection and analysis techniques of this project engage and develop the most current methodologies of learning in interaction and conversation analysis (CA) (Rusk, Sahlström & Pörn, 2017; Melander Bowden, 2019; McQuade, Wiggins, Ventura-Medina & Anderson, 2018; Kimura, Malabarba & Hall, 2018). Through a setting-centred approach to studying learning from a CA perspective (Rusk, Pörn, Sahlström, & Slotte-Lüttge, 2014), the project will be able to provide a more in-depth understanding of how the entire class performs and comprehends the teaching and the tasks in the module. Moreover, CA can help to uncover the social practices that participants employ when negotiating knowing and knowledge, thus providing insight into the elemental workings of deep learning. The analysis focuses on what is observable in the data and what the participants in the data orient towards, and it understands cognition as socially shared and situated in social practices and activities. As recent studies have shown, the management of knowledge is the bedrock for dynamics of cooperation, affiliation, and sociality in human interaction (Heritage, 2018). The dynamic relationships between participants' knowledge of oriented-to learning object(s) has been found to be vital in the practices they use to express knowing and understanding and, in turn, to understand each other's expressed knowing and understanding. This management of knowledge becomes important to the interaction in educational institutions between pupils in group work assignments, in which they are given space to express their knowing and thinking (Melander & Sahlström, 2010; Rusk et al., 2017).

The proposed project will develop new knowledge about how group work is organised by students themselves, and how teachers may or may not influence this group work through situational support, teaching, and task-planning. Novel insights, provided by this research, into how the rooms, the tasks, and the groups are organized pedagogically, interactionally, and semiotically will provide us with a more robust understanding of how deep learning is afforded in group activities on a micro-level. Understanding these complex dynamics will help educators adapt learning environments to the unique needs and possibilities of twenty-first century education; as students take on increasingly active and interactive roles in their learning, group work will become ever more central to teachers aiming to generate deep learning. The proposed project will thus provide the practical, theoretical, and intellectual underpinnings for a responsible and fruitful response to these new conditions.

1.3 Research questions and hypotheses, theoretical approach and methodology

Based on the results from our preparatory project, the proposed research will focus on the concept of deep learning and whether group activities in Newton Rooms afford deep learning outcomes. It will also investigate and support the development of Newton modules (task and lecture design) and the preparatory and follow-up activities in the home school—thus incorporating innovative elements into the project. With reference to the primary and secondary objectives, the following research questions have been defined:

RQ1. How are roles, knowledge, access, strategies, and solutions negotiated, constructed, and applied during group work in Newton Rooms, and how do these processes affect student-student interactions and shape opportunities for deep learning?

RQ2. How does the design of tasks and lessons influence student activity in groups, and how can the exercises, content, and resources be reframed and reconstructed to better facilitate deep learning in Newton Rooms?
RQ3. How is the classroom work preceding and following Newton Room visits understood and implemented by pupils and class teachers, and how may they be framed to support pupils´ learning?

To investigate these RQs, the project will deploy a mixed-method approach (Tashakkori & Teddlie, 2010):

- Video recordings of the activity in Newton Rooms. The data will be studied using Conversation Analysis (CA).
- Video-Stimulated Recall interviews with Newton-teachers.
- Semi-structured interviews with class teachers and selected students to examine classroom activities which precede and proceed Newton room visits and to receive feedback for use in the further development of the selected Newton modules.

Video Recordings and Analysis (RQ1 & RQ2)

The proposed study will employ video recordings and apply a participant's perspective to analyse the social practices of the groups in Newton Rooms. Using conversation analysis (CA), we will focus on social organisation and the organisation of epistemic relationships (Schegloff, 2007; Heritage, 2018) during group work. CA applies an emic participant's perspective, which privileges the participants' understanding of situations and promotes naturally occurring settings as the primary source for systematic empirical findings (Schegloff, 2007). CA studies typically approach learning as social action that participants do in interaction (i.e. "doing learning") (Melander, 2012; Rusk, 2016; Tanner & Sahlström, 2017). In an emic participant's perspective, learning is analysed through a consideration of the learning object as an emergent, shared pedagogical focus that is locally established, co-constructed, and relevant for the participants doing learning as social action (Lee, 2010). For this project, we treat learning as a social practice and we concentrate on how participants (pupils doing group work) demonstrate and negotiate, through their use of verbal and nonverbal resources, their epistemic relationships in the Newton-Room context. CA studies that view learning as social action regularly employ notions of epistemic status and stance, and we will be using these concepts in our analysis of pupils' group work. Issues related to knowledge appear to have a ubiquitous role in social interaction (Heritage, 2018; Stivers, Mondada, & Steensig, 2011). The epistemics framework conveys the epistemic complexity and the epistemic orientations of participants' practices from an emic perspective. In the organisation of epistemic relationships, participants express their "epistemic stance," that is, the expressed reflection of the speaker's "epistemic status" regarding the oriented-to epistemic domain and the co-participants (e.g., Heritage, 2018; Stivers et al., 2011). The epistemic statuses and stances of the involved participants are central, pragmatic resources when participants determine whether an utterance is requesting or asserting information (Heritage, 2013). The primary method of documenting interaction in this line of analysis is video, and the proposed project will correspondingly use several cameras and external microphones to capture both whole-class teaching and group work. Each group will have a dedicated camera and microphone that will record their work throughout the Newton module—an arrangement that will increase the possibility of studying and analysing the situated and contextual social organisation of the groups during the group activities (Rusk et al., 2014). By comprehensively recording all student and teacher activity throughout the module, we will gain a richer perspective of both the whole (the module as a unit of analysis) and the constituent social organisation and interaction (teachers' whole-class teaching and students' group work). The recordings will include videos from three different Newton Rooms teaching one module each to one class of students each (ranging in ages from 11–16 years old) through a maximum of 3 rounds over a period of 4-6 months (cfr. below). The modules will encompass both plenary teaching as well as student group/pair work. The data will be transcribed in accordance with CA conventions for transcription, including details of both what is said and how it is said (e.g. pitch, volume, speed, and/or prosody, see Hepburn & Bolden, 2012; Jefferson, 2004).

Video-Stimulated Recall Interviews with Newton-teachers (RQ2)

Stimulated Recall (SR) is an advanced interview technique that aims to support reflection and dialogue, rather than require participants to reiterate thoughts occasioned in the observed or recorded situation. Developed first in the early 1950s (Bloom, 1953), the technique saw wider use in later research on teacher thinking

(Calderhead, 1981; Haglund, 2003), and it is currently most often used in the form of video-stimulated recall (VSR), in which video recordings are utilized to stimulate respondents´ reflections and support the dialogue between interviewer and interviewee (Nind, 2016). The analytical focus of this methodology is not the video itself, but instead the conversations and commentary about the video excerpts (Nind, 2016, p. 176). Moyles, Adams, and Musgrove (2002, p. 470) argue that such conversations can help teachers express underlying ideas and beliefs about teaching and pupils´ learning—ideas and beliefs that tend to remain implicit unless challenged through processes such as VSR. As a result, VSR has the potential to be a catalyst for teachers´ professional learning (Geiger, Muir & Lamb, 2016), which will support the developmental and innovative elements of the current project. With VSR, excerpts from recorded videos will be used to elicit Newton-teachers´ understanding and evaluation of both the pupils´ and their own work in the Newton Rooms. Based on the teachers´ reflections and responses about the observed work, researchers and Newton-teachers will discuss what adaptations are requisite for the Newton-module and what module modifications the Newton-teachers should prepare to use with another group of students. Through a maximum of three such rounds (video recordings of work and VSR interviews) over a period of 4-6 months, the selected modules will be refined and revised to enhance pupils´ learning. This process will enable Newton-teachers to gain specific knowledge about the learning processes undergone by pupils and to develop research-based competences for evaluating and developing their teaching practices. The VSR interviews will also be analysed to study the processes teachers go through: how their understanding of their work develops throughout the period and how this influences their decisions regarding tasks, activities, and learning resources in the modules.

Semi-structured Interviews with class teachers and students (RQ3)
Our approach to interviews about pre- and post-visit activities is based on the recognition that flexible methods are necessary to effectively access student and teacher perceptions and opinions (Kvale, 1996; Robson, 2002). This project will employ hierarchical focusing, a semi-structured interview method developed by Tomlinson (1989) which functions both to provide in-depth access to the participants´ ideas as they frame them and to permit coverage of the researcher's concerns. This approach functions by means of a topic agenda that begins with minimally-framed, general, or concrete questions and then only introduces those increasingly specific topics that the interviewee has not raised spontaneously. The construction of a hierarchically-focused agenda requires a thorough understanding of a researcher's intended topic concerns. The purpose is to design a hierarchically-focused interview agenda for use with teachers and students, and audio record the interviews. These interviews will be conducted and analysed to gather data regarding preparatory (briefing) and follow- up (debriefing) work in schools. For each round (cfr. above), a class teacher and 3-4 students will be selected for interview.

The proposed project is interdisciplinary for both strategic and contextual reasons. As deep learning is, by definition, about transferable competencies between subjects, any approach to the phenomenon must consider a diverse range of fields—both their distinctive features and the relationships between them. And Newton Rooms themselves, both the spaces and the modules, unite disparate STEM-subjects, aiming for a more holistic engagement with these topics. As a result of these interdisciplinary imperatives, a wider research community in teacher education at Nord University and beyond—involving science, mathematics, and pedagogy experts—has been recruited for this project.

This project will be conscientiously conducted in accordance with the principles of respect for participants and ethical treatment of human subjects participating in research (Derry et al., 2010). All the data types (video recordings and interviews) are ethically sensitive, and thus require special care and respect. In addition to the rules that apply to good ethical practice, the project will specifically inform the focus students about their right to withdraw their participation at any time, as well as about how recorded content can be controlled—and deleted—in hindsight. The participants will be clearly informed about their right to stop or request the deletion of recordings at any time, and they will be made aware that all sound is recorded when external microphones are used. They will also be notified of the anonymity protocols and data protection procedures, as well as the use, archiving, and potential reuse of data; all names and locations will be anonymized, and participant rights to privacy and confidentiality will be considered throughout the data-collection process. All participants will sign individual contracts for consent; minors will be advised and assisted with the decision by a parent or guardian. Our experience with similar projects throughout the past

ten years in different countries and contexts has equipped us to collect data in an ethically and scientifically acceptable manner. These guidelines will be strictly and uniformly applied to all picture and video excerpts. And throughout the project, researchers will constantly consider (and reconsider) the ethical imperatives of these recordings (Häggblom, Melander, & Sahlström, 2003).

2. Impact

2.1 Potential impact of the proposed research

The project will have an impact on scientific and social issues at the local, national, and international levels. The new knowledge it will generate on deep learning affordances and group work activities, and more specifically on group work in inquiry-based STEM learning environments, will contribute to research on interaction in group work, and its relation to knowledge negotiations and deep learning. The state-of-the-art methods of video capture and analysis used in this project could serve as a model for other studies, especially those in smart rooms and non-traditional classroom environments. Our micro-analysis of group work should offer a better understanding of the social dynamics of group work and help pinpoint the cooperation and communication skills and strategies that are to be considered as learnables. Our findings on group work dynamics should also impact pedagogy, teacher training, and educational task development. The project will help teachers better support student groups as they work with tasks and determine how and when to assist them. The holistic and developmental perspectives achieved by this research will also allow teachers to make more pre-informed decisions about the design and implementation of group work activities in a variety of instructional settings. Based on the findings of our pilot project (Rusk & Rønning, 2020), teachers may be trained to develop activities that moderate student epistemic stances and, thus, keep inter-student negotiation open to cooperative elaboration and knowledge exchange—inhibiting the conventional imperative to "get the job done" or find the correct answer. For Newton Rooms in particular, this research will provide modules to the growing international network of Newton teachers in Norway, Denmark, Scotland, and the European countries to which the program is rapidly expanding. As deep learning is increasingly considered a desideratum of new professions and careers, this research will have important social and economic ramifications. According to a wide range of sources, "critical thinking and problem-solving skills" will be essential to prepare students for our increasingly complex society and world (Schoenfeld et al, 2016); these higher-order faculties and competencies—"being able to reason and analyse, identify relevant issues and apply relevant strategies to solve problems" (Kunnskapsdepartementet, 2015, p. 10; Kunnskapsdepartementet, 2016, p. 33) are often seen as gatekeepers for intellectual development, continuing studies, and eventual occupational opportunities (Katz, 2007).

2.2 Measures for Communication and Exploitation

In laying the groundwork for this project, Wenche Rønning and Fredrik Rusk have begun to generate wider interest for and anticipation of this proposed study; they have already presented two papers based on the findings of the preliminary project at the ECER 2018 and AARE 2018 international conferences, and they have published an article about this preparatory work (2020) to the level 1 journal *Education Inquiry.* Throughout the proposed project period, members will present their research at international conferences, prioritizing the European Conference on Educational Research (ECER), the American Educational Research Association (AERA) conference, the European Association for Research on Learning and Instruction (EARLI) bi-annual conference, and the Nordic Educational Research Association (NERA) conference for mathematics and science education. From 2022 onwards, members will be submitting project-specific scientific papers for publication in academic journals. The two PhD candidates recruited for this project will be expected to publish a minimum of six articles in academic journals (NSD level 1 and 2), alone or in cooperation with research staff in the project. Nord University staff will also publish a minimum of six articles (two for each RQ). Specific journals will be targeted for their relevance to the project and distinction in the field: *Teaching and Teacher Education, Scandinavian Journal of Educational Research, Classroom Discourse*, *Studies in Science Education*, and *International Journal of STEM Education* among others. The primary stakeholders for this project are FIRST Scandinavia and the Newton network. However, since this project aims to address core pedagogical issues that extend beyond the purview of Newton Rooms—about deep learning, group work, and technology—researchers will also endeavour, where possible, to present their findings to a wider education community. Dissemination to the Newton network will be facilitated by the Newton seminars arranged annually by FIRST Scandinavia. Seminar participants include Newton teachers from Norway and

Denmark, representatives from FIRST Scandinavia, and a selection of other partners. Among the latter group are affiliates of the School Laboratory (Skolelaboratoriet) at NTNU, and, occasionally, representatives from other national centres for mathematics and science. For dissemination to the broader education community, digital resources on the project webpage as well as presentations at national or regional seminars and conferences will be promoted.

3. Implementation

3.1 Project Manager and Project Group

Project Manager

Associate Professor Wenche Rønning has nearly twenty years of experience in research project management. Her methodological expertise includes classroom video analysis and hierarchical focusing, both techniques central to this project. Thematically, she has studied teacher thinking, active learning, and immersive Place-Based Learning. Recently, her work has concentrated on linking teacher thinking and teacher practice through video observations and interviews.

Project Partners

Associate Professor Fredrik Rusk is trained in conversation analysis and interactional analysis, with especial proficiency investigating video recordings of diverse educational environments—both formal and informal—and considering the social organization of such settings. He is also interested in the development of an empirical analysis of learning as identifiable interactional practices, ones that participants use to perform learning as action, and which traverse the traditional institutional/personal divide.

Associate Professor Arne Næsheim Fjalstad has, through twelve years as Dean, been responsible for research in the Faculty of Professional Studies at the prior University of Nordland and for the creation of a PhD-program in professional studies. As Associate Professor in science education, he specializes in experience-based and outdoor learning.

Professor Marja van den Heuvel-Panhuizen has worked for over thirty years at research institutes and universities across the Netherlands, Germany, and Norway. She has a strong record of PhD supervision and has both participated in and organized multiple national and international projects and conferences. Her background formulating instructional materials and studying mathematics learning, assessment, and instruction in primary school and special education will be indispensable to this project.

The project will cooperate nationally with FIRST Scandinavia and its Newton-network while also collaborating with a constellation of international disciplinary experts. Nord University has established productive relationships with two international partners that specialize in science and mathematics education. These partners will be consulted for methodological and theoretical advice and will take part in the planned project workshops to discuss findings and assist with the design and redesign of Newton modules. Additionally, the international partners will share relevant research findings from their own learning laboratories.

The Leibniz Institute for Science and Mathematics Education (IPN) at Kiel University has a resolute research commitment to the development of both student and professional competencies in the fields of science and mathematics. Most importantly, however, they have established *The Kieler Forschungswerkstatt (The Kiel Science Factory)* which promotes exploratory scientific learning for school students and teacher education students. This lab environment, like the Newton Rooms, has consequently provided a rich venue for several research projects, such as investigations into student expectations and outcomes, or studies of particular learning apparatuses, such as hands-on-experiments, videos, or simulations. The IPN will ultimately combine such studies with other longitudinal data on student participation in enrichment programs, such as Science Olympiads. Our cooperation with the IPN will not only offer us beneficial data for our study, but our novel analysis of group work should, in turn, provide a productive additional focal point for their research. Additionally, since the Kieler Forschungswerkstatt is visited by school classes, by students in afternoon programs, and by summer school participants, this range of formal and less-formal groups could introduce compelling categories for future comparative studies as the projects develop.

The Institute of Teacher Education at University College Copenhagen (UCC) is comprised of experienced staff in science and mathematics education, many of whom are familiarized with the Newton Room concept through the established space in Hvidovre (outside of Copenhagen). Members of the institute will be undertaking their own Newton room research with aims that are complementary to this project. Collaboration with our Danish colleagues will allow for a uniquely comparative perspective in this burgeoning field.

3.2 Project organisation and management

Through the preparatory research we have gathered data that will inform the proposed research, and we have gained experience that will enable us to design and implement a research project that productively includes relevant stakeholders: FIRST Scandinavia representatives, school owners, Newton-Room teachers, and teachers from participating schools. In close cooperation with these stakeholders, we will begin by selecting three modules, and these modules will be redesigned to realize the aims of the new 2019 curriculum. The project will be organised through a project group and two working groups – one for WPs 3-5 and one for WP6.

Project Group: Associate Professor Wenche Rønning will serve as the daily manager of the project, coordinating the activity between the different working groups and collaborating with FIRST Scandinavia, Newton-teachers, participating schools, international partners, and other educational staff (WP1-2). Associate Professor Fredrik Rusk will have main responsibility for WP3-5 while Wenche Rønning will coordinate and lead on WP6 together with Associate Professor Arne Fjalstad. The project group will meet regularly to discuss project progress and agree on possible amendments to the work plan. Professor Marja van den Heuvel-Panhuizen will serve as an advisor to the core research management group.

Working Groups: In addition to the project partners described above, each working group will comprehend 3-5 staff members, two PhD students, and a selection of Master's students. The Master's students will participate in the project both when they are enrolled in specialized graduate courses and when they are formulating their theses; we estimate 2-3 Master's students from each discipline will draw on project data for their theses.

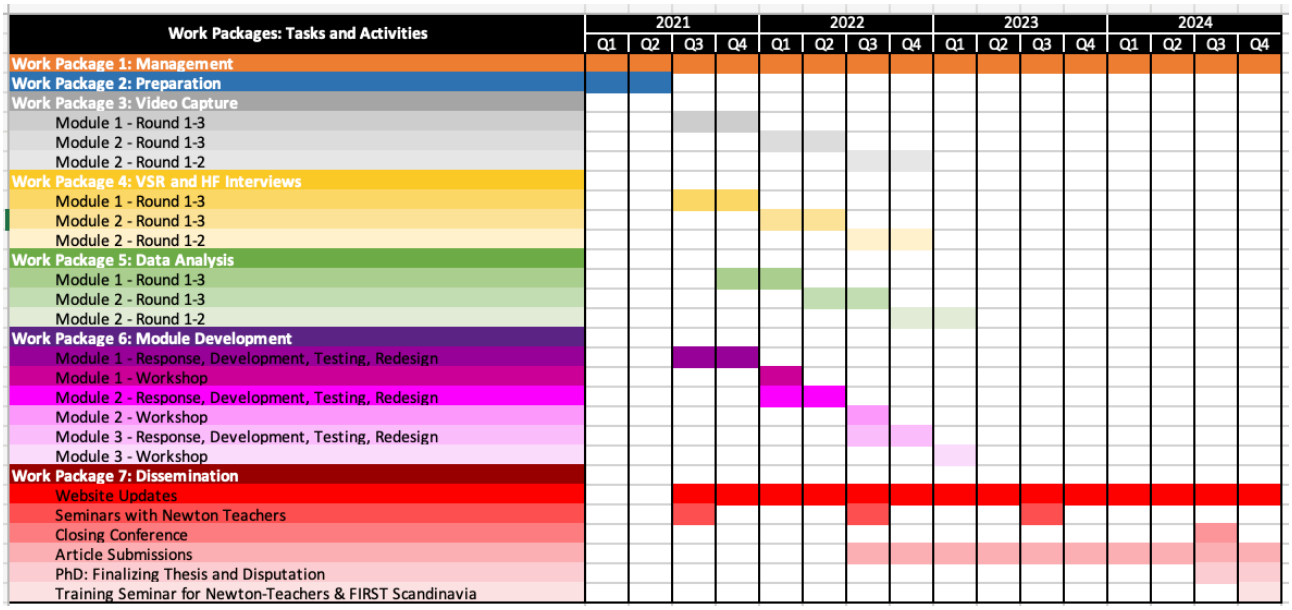
Workshops: A workshop framework, focused on the examination of research findings and the development of Newton modules, will constitute a core component of the project; workshop sessions will alternate between full-group meetings to address common issues and more concentrated roundtables specific to the modules researched. International experts will be invited in to contribute to these workshops.

Seminars: Seminar participation will extend beyond working groups and international experts, incorporating other important participants and stakeholders, such as staff from FIRST Scandinavia and Newton-teachers not involved in the research. The project will schedule four seminars in total, three aimed at disseminating results from the redesign of three existing Newton modules, and one training seminar to instruct Newton-teachers how to redeploy the approach from the current project to form new modules or to redesign existing modules.

Infrastructure: At the Nord University Bodø campus, the Faculty of Education and Arts features a state-of-the-art video laboratory in possession of some of the most advanced equipment for video recording and analysis. Currently, the space is shared between the preliminary Newton-room research project (mentioned above) and the Learning in Interaction Research Group, led by Fredrik Rusk and comprised of many of the researchers who will be involved in the proposed project. Since the laboratory includes teaching facilities which can host 10-15 students, it is also utilized for Master's courses in pedagogy and mathematics to train students in data analysis through materials from the preparatory investigation. The proposed project will continue to develop the lab as a central hub for research and for video-analysis training of academic staff and teacher education students.

PhDs: The proposed project will involve two doctoral candidates—one financed by the Norwegian Research Council and one financed by Nord University. Having already supervised three candidates in the PhD

Programme for the Study of Professional Praxis, the Project Manager is well equipped to undertake this mentorship role.



References

Bereiter, C., & Scardamalia, M. (2014). Knowledge building and knowledge creation: One concept, two hills to climb. In S.C. Tan, H.J. So, & J. Yeo (Eds.), *Knowledge creation in education* (pp. 35–52). Singapore: Springer.

Bergem, O.K., Kaarstein, H., & Nilsen, T. (2016). *Vi kan lykkes med realfag. Resultater og analyser fra TIMSS 2015*. Oslo: Universitetsforlaget.

Biggs, J. B., & Collis, K. F. (1982). *Evaluating the Quality of Learning: The SOLO Taxonomy* (1st ed.). New York: Academic Press.

Bloom, B. S. (1953). Thought-processes in lectures and discussions. *Journal of General Education*, 7(3), 160–169.

Calderhead, J. (1981). Stimulated recall: A method for research on teachers. *British Journal of Educational Psychology*, 51(2), 211-217.

Common Core State Standards State Initiative (CCSSI) (2010). *Preparing America's students for college and career*. Washington, DC: National Governors Association Center for Best Practices and the Council of Chief State School Officers.

Enwistle, N. J (2000). Approaches to studying and levels of understanding: The influences of teaching and assessment. In J.C. Smart, & W.G. Tierney (Eds.), *Higher Education: Handbook of Theory and* Research (Vol. XV)(pp. 156-218). New York, NY: Agathon Press.

Gardner, R. (2013). Conversation analysis in the classroom. In J. Sidnell & T. Stivers (Eds.), *The Handbook of Conversation Analysis* (pp. 593– 611). West Sussex: Wiley-Blackwell.

Geiger, V., Muir, T., & Lamb, J. (2016). Video-stimulated recall as a catalyst for teacher professional learning. *Journal of Mathematics Teacher Education*, 19(5), 457-475.

Häggblom, J., Melander, H., & Sahlström, F. (2003). En kort beskrivning av fältarbetet i FISK-projektet. In H. Pérez Prieto & F. Sahlström (Eds.), *Från förskola till skola – berättelser från ett forskningsprojekt* (pp. 192- 208). Uppsala: Pedagogisk Forskning i Uppsala 149.

Haglund, B. (2003). Stimulated Recall. Några anteckningar om en metod att generera data. *Pedagogisk Forskning i Sverige*, 8,(3), 145-157.

Hattie, J.A.C., & Donoghue, G.M. (2016). Learning strategies: A synthesis and conceptual model. *Science of Learning,* 1. doi: 10.1038/npjscilearn.2016.13

Hattie, J. A. C., & Brown, G. T. L. (2004). *Cognitive processes in asTTle: the SOLO taxonomy. asTTle Technical Report* (No. 43). Auckland: University of Auckland and the Ministry of Education.

Hepburn, A., & Bolden, G. B. (2012). The Conversation Analytic Approach to Transcription. In J. Sidnell & T. Stivers (Eds.), *The Handbook of Conversation Analysis* (pp. 57-76). Wiley-Blackwell.

Heritage, J. (2018). The ubiquity of epistemics: A rebuttal to the 'epistemics of epistemics' group. *Discourse Studies*, 20(1), 14-56.

Hodgson, J., Rønning, W., & Tomlinson, P. (2012). *Sammenhengen mellom undervisning og læring. En studie av læreres praksis og deres tenkning under Kunnskapsløftet - Sluttrapport* (NF-rapport nr. 4/2012). Bodø: Nordlandsforskning.

Jefferson, G. (2004). Glossary of transcript symbols with an introduction. In G. Lerner (Ed.), *Conversation Analysis: Studies from the First Generation* (pp. 13-31). Amsterdam/Philadelphia: John Benjamins.

Johnson, D.W., Johnson, R.T., Haugaløkken, O.Kr., & Aakervik, A.Osv. (2006). *Samarbeid I skolen - pedagogisk utviklingsarbeid, samspill mellom mennesker.* 4. utg. Namsos: Pedagogisk Psykologisk Forlag AS

Kaput, J. J., Carraher, D. W., & Blanton, M. L. (Eds.). (2008). *Algebra in the early grades.* New York, NY: Lawrence Erlbaum Associates.

Katz, V. (Ed.). (2007). *Algebra: Gateway to a technological future*. Washington, DC: Mathematical Association of America.

Kimura, D., Malabarba, T. & Hall, J.K. (2018). Data collection considerations for classroom interaction research: A conversation analytic perspective. *Classroom Discourse*, 9(3), 185-204.

Kjærnsli, M., & Jensen, F. (2016). *Stø kurs: Norske elevers kompetanse i naturfag, matematikk og lesing i PISA 2015.* Oslo: Universitetsforlaget.

Kunnskapsdepartementet. (2015). *Fremtidens skole.* (NOU 2015: 8). Oslo: Kunnskapsdepartementet.
Kunnskapsdepartementet. (2016). *Fag – Fordypning – Forståelse — En fornyelse av Kunnskapsløftet.* (Meld. St. 28 2015– 2016). Oslo: Kunnskapsdepartementet.
Kvale, S. (1996). *InterViews. An Introduction to Qualitative Research Interviewing.* Thousand Oaks, CA: SAGE Publications Inc.
Lagerstrøm, B.O., Moafi, H., & Revold, M.K. (2014). *Kompetanseprofil i grunnskolen: Hovedresultater 2013/2014*. Oslo: Statistisk sentralbyrå.
McQuade, R., Wiggins, S., Ventura-Medina, E., & Anderson, T. (2018). Knowledge disagreement formulations in problem-based learning tutorials: Balancing pedagogical demands with 'saving face.' *Classroom Discourse*, 9, 227-243.
Melander, H., & Sahlström, F. (2010). *Lärande i interaktion.* Stockholm: Liber.
Melander Bowden, H. (2019). Problem-solving in collaborative game design practices: Epistemic stance, affect, and engagement. *Learning, Media and Technology.* doi: 10.1080/17439884.2018.1563106.
Melander, H. (2012). Transformations of knowledge within a peer group: Knowing and learning in interaction. *Learning, Culture and Social Interaction*, 1(3–4), 232-248. doi:10.1016/j.lcsi.2012.09.003.
Moe, C. A. (2011). *Newtonrommet som læringsarena i naturfag: Elevers læringsutbytte av undervisning i elektrisitet og energi.* (Unpublished master's thesis). NTNU, Trondheim.
Moyles, J. L., Adams, S. & Musgrove, A. (2002). Using Reflective Dialogues as a Tool for Engaging with Challenges of Defining Effective Pedagogy. *Early Childhood Development and Care,* 172 (5), 463-478.
Nilsen, T., & Frøyland, M. (2016). Undervisning i naturfag. In O.K. Bergem, H. Kaarstein, & T. Nilsen (Eds.), *Vi kan lykkes med realfag: Resultater og analyser fra TIMSS 2015* (pp. 137-157). Oslo: Universitetsforlaget.
Nind, M., Curtin, A., & Hall, K. (2016). *Research Methods for Pedagogy*. London: Bloomsbury.
Overå, K. M. L. (2010). *Elevenes læringsutbytte av et skolebesøk på Newton energirom*. (Unpublished master's thesis). NTNU, Trondheim.
Pellegrino, J. W., & Hilton, M. L. (Eds.). (2012). *Education for life and work: Developing transferable knowledge and skills in the 21st century.* Washington, DC: The National Academies Press.
Radford, L. (2012). Early algebraic thinking: Epistemological, semiotic, and developmental issues. Regular Lecture at 12th International Congress on Mathematical Education, Seoul, Korea.
Robson, C. (2002). *Real World Research: A Resource for Social Scientists and Practitioner-Researchers* (2nd ed.). Oxford: Blackwell.
Rohrbeck, C.A., Ginsburg-Block, M.D., Fantuzza, J.W., & Miller, Traci R. (2003). Peer-assisted learning interventions with elementary school students: A meta-analytic review. *Journal of Educational Psychology*, 95(2), 240-257.
Roseth, C.J., Pellegrini, A.D., Bohn, C.M. Van Ryzin, M., & Vance, N. (2007). Preschoolers' aggression, affiliation, and social dominance relationships: An observational, longitudinal study. *Journal of School Psychology*, 45(5), 479-497.
Rusk, F., & Rønning, W. (2020). Group work as an arena for learning in STEM education: Negotiations of epistemic relationships. *Education Inquiry,* 11(2), pp. 36-53.
Rusk, F. (2016). *Doing second language learning: A CA study of learning practices in Finnish-Swedish bilingual educational settings* (Unpublished doctoral dissertation). Åbo Akademi University, Vasa.
Rusk, F., Sahlström, F., & Pörn, M. (2017). Initiating and carrying out L2 instruction by asking known-answer questions: Incongruent interrogative-practices in bi- and multilingual peer interaction. *Linguistics and Education,* 38, 55–67.
Rusk, F., Pörn, M., Sahlström, F., & Slotte-Lüttge, A. (2014). Perspectives on using video recordings in conversation analytical studies on learning in interaction. *International Journal of Research & Method in Education,* 38(1), 39–55.
Sahlström, F. (2008). *Från lärare till elever, från undervisning till lärande: utvecklingslinjer i svensk, nordisk och internationell klassrumsforskning*. (Vetenskapsrådets rapportserie; Nro 9). Stockholm: Vetenskapsrådet.
Schegloff, E.A. (2007). *Sequence Organization in Interaction: A Primer in Conversation Analysis* (Vol. 1). Cambridge: Cambridge University Press.
Schoenfeld, A. H., & the Teaching for Robust Understanding Project. (2016). *An Introduction to the Teaching for Robust Understanding (TRU) Framework*. Berkeley, CA: Graduate School of Education.
Seedhouse, P. (2004). *The Interactional Architecture of the Language Classroom.* Malden, MA: Blackwell.
Slavin, R. E. (2014). Cooperative Learning and Academic Achievement: Why Does Groupwork Work? *Annals of Psychology*, 30(3).
Sporer, N., Brunstein, J.C., & Kieschke, U. (2009). Improving students' reading comprehension skills: Effects of strategy instruction and reciprocal teaching. *Learning and Instruction*, 19, 272-286.
Stivers, T., Mondada L., & Steensig, J. (Eds.). (2011). *The Morality of Knowledge in Conversation.* Cambridge: Cambridge University Press.
Sæther, P. (2015). *Newton energirom, en læringsarena utenfor skolen - Begrepenes betydning i elevenes læringsutbytte* (Unpublished master's thesis). NTNU, Trondheim.
Tashakkori, A., & Teddlie, C. (Eds.). (2010). *SAGE Handbook of Mixed Methods in Social & Behavioral Research* (2nd Ed.). Thousand Oaks, CA: SAGE Publications Inc.
Tomlinson, P.D. (1989): Having it both ways: Hierarchical focussing as research interview method. *British Educational Research Journal*, 15(2), 155-176.
Utdanningsdirektoratet (2019). https://www.udir.no/laring-og-trivsel/lareplanverket/fagfornyelsen/horing-nye-lareplaner Accessed 02.04.19
Webb, N. M. (2008). Learning in small groups. In T. L. Good (Ed.), *21st Century Education: A Reference Handbook* (pp. 203-211). Los Angeles: Sage.