TRELIS (Teachers' Research Literacy for Science teaching)

0. Relevance to the call

Science teachers are an important key to achieving a science literate population and a workforce skilled in science and technology. This is essential to secure a sound economy and to meet future challenges related to communication, environment, energy and health. To achieve this, Norway needs a science teacher education preparing teachers to continuously develop their classroom practice, drawing on experience, research, and systematic exploration. Additionally, in-service teachers need opportunities for developing their practice with input from research in collaborative learning communities. Project TRELIS aims, in accordance with the call, to strengthen the research-based foundation for science teacher education.

The call from FINNUT asks for strategic, practice-oriented research in teacher education for the primary and lower secondary level within two thematic areas: (A) learning processes, assessment forms and learning outcomes; and (B) practice, professional practice and competence-development. Furthermore, research in didactics is specifically encouraged. TRELIS answers to all these priorities: It investigates how learning processes, assessment and learning outcomes may be developed in teacher education programmes to promote research literacy. Also, TRELIS aims to prepare student teachers and in-service teachers to use research actively in developing their professional practice within science teaching.

TRELIS is a collaboration between two large teacher education institutions in Norway, Oslo Metropolitan University (**OsloMet**) and Western Norway University of Applied Sciences (**HVL**). The project looks at several phases of science teachers' professional development, starting with investigating the preparation teachers receive through initial teacher education (including school practice). In collaboration with **Lillestrøm** municipality and their schools (Vigernes University School and regular practice schools) and **VilVite** science centre in Bergen, TRELIS will also study and contribute to development of research-rich collaborative learning communities that support in-service teachers' professional development. The project thus aims to enhance 'the capacity to meet the current and future needs for expertise over a teaching career', as requested in the call. The collaboration will build competence in all involved groups and enable teacher education as well as VilVite and Lillestrøm municipality to profit in the long term.

To ensure relevance of the research and strengthen the interaction between research, teacher education and schools, as called for in the FINNUT programme, research-based development of teaching and learning activities will be done in close collaboration between student teachers, teacher educators and the participating municipality and science centre. Student teachers and teachers will be included in an advisory board, and actors in the school sector will take active part in implementing TRELIS. Lillestrøm Municipality has established a centre for science, technology, engineering and mathematics (i.e. STEM-centre), and has unique resources for supporting science education and professional development in its schools. In addition to involvement of current staff at OsloMet and HVL, TRELIS plans for three PhD positions. These will greatly enhance the research capacity in the groups involved. In addition, TRELIS builds collaboration with national and international academic partners, which will enable international exchange and contribute to a robust academic network. The close interaction between researchers and teacher educators, pre- and in-service teachers, a school owner and a science centre will facilitate continuous development of science teachers' professional practice in all stages of their education and career. This interaction also provides multiple channels for communication and dissemination of project outcomes.

1. Excellence

1.1 State of the art, knowledge needs and project objectives

The primary objective of TRELIS is to prepare research literate science teachers who are able to integrate research-based knowledge with classroom experience to develop rich science learning opportunities for pupils. Science in this application refers to the integrated school science subject for years 1 to 11.

Research literacy is recommended as a central competence for teachers. The Norwegian Government's aims for the 5-year teacher education include to 'prepare candidates better for seeking and using research-based knowledge' (Ministry of Education and Research, 2017, p. 31). Similarly, the British Education Research Association suggested research literacy, understood as a capacity to engage with and in research, as one of three main dimensions of teacher effectiveness and teachers' professional identity (BERA, 2014). Studies of teachers' engagement with and in research show strong evidence for a link with significant changes in practice, again leading to a positive impact on pupils' outcomes (Bell et al., 2010). Norwegian surveys, however, show, 'insufficient research taking place in, and centred on, teacher education institutions' (Ministry of Education and Research, 2017, p.12). TRELIS aims to promote research literacy among pre- and in-service science teachers and teacher educators.

In Norway, the teacher education programmes for primary and lower secondary levels are in a process of change from four-year to five-year master's degree programmes (Ministry of Education and Research, 2017). There is a need to prepare the teacher education community for implementing this reform and for developing suitable practices on different levels of teacher education. Teaching and learning activities for students must be based on current science education research, and students need practice in using and contributing to science education research through assignments such as bachelor-level R&D theses and notably the master's thesis. There is to date scarce research carried out on master's theses in teacher education (Skagen et al., 2018). Within the Finnish context, research has shown that student teachers have positive attitudes towards inquiry and reflection; however, they do not perceive a clear relation between the master's thesis and the teaching profession (Eklund, 2018). A knowledge base is needed to study the implementation and outcomes of this important transition in teacher education and to establish best practice examples. TRELIS will specifically focus on developing research-based science teaching and learning activities and on developing the research assignments science student teachers meet at different stages of their education.

Teaching as profession needs both research-based and practical knowledge. The current reform focuses on improving the quality of the pre-service practice by strengthening the collaboration between universities and training schools (Jakhelln, 2015; Ministry of Education and Research, 2017). Pre-service practice should be a 'dialogue between research-based understanding of teaching and learning, and the professional understandings of experienced teachers' (Burn & Mutton, 2015, p. 219). According to Winch et al. (2015), a popular conception of teaching emphasises the value of situated professional knowledge and downplays the role of academic educational research. Within science education, Crawford (2014) pointed to how existing expectations of an individual school or school district could discourage the teachers from innovative teaching (e.g. inquiry-based), since this could be perceived as conflicting with the existing school culture. There is, therefore, a need for research and development on pre-service teacher education, school practice, and in-service participation in research-rich collaborative learning communities in order to promote a teaching culture that includes research-based knowledge. TRELIS will involve central stakeholders in identifying possibilities and limitations for developing such communities involving both pre- and in-service teachers.

To implement a research-rich science teacher education, institutional frames must support a progression through the five-year programme, and teaching staff qualifications must be in place. In a survey in Norway, Munthe and Rogne (2015) found the proportion of teacher educators holding a PhD to be below 1/3 but increasing. Within science teacher education, many educators have a PhD in a science discipline such as chemistry, physics or biology, but lack experience and familiarity with educational research. For teacher education to be equipped to teach research-based and supervise master's and PhD theses, Norwegian science teacher educators must develop their educational research and supervision capacity. Moreover, the structural organisation of teacher education programmes must support suitable teaching and learning activities and assessment throughout the programme. TRELIS aims to map contextual factors and identify strategies for progressively developing student teachers' research literacy for science teaching through the 5-year programme. By documenting and systematically enhancing the quality of the current programmes at the two institutions involved, TRELIS will provide a model for other institutions. Moreover, TRELIS will allow participating teacher educators to develop their competence within research-rich science teacher education.

The national school curricula in Norway are also in a process of renewal, with new curricula to be implemented from 2020. Aspects of science education that will be highlighted include inquiry-based learning (IBL), education for sustainable development, programming and modelling (P&M) in science, as well as digital and computational literacy (The Norwegian Directorate for Education and Training, 2019). IBL has long been promoted as central in science education (Furtak et al., 2012); however, this instructional approach appears to be under-utilised (Rocard et al., 2007), and research is needed on how to successfully implement IBL approaches in Norwegian school science and teacher education. Modelling as a central feature of scientific practices and as a work form in school science has also been extensively discussed in the literature (Pajchel et al., 2020), whereas programming as a way of modelling science phenomena is newer on the educational arena but is receiving increasing attention (Weintrop et al., 2016). TRELIS aims to develop research-based science teaching and teacher education within two areas in the new school curriculum: IBL and P&M. The work in these focus areas will deeply involve TRELIS' collaborating partners to comply with the needs of the user groups. This development will result in concrete teaching and learning material as well as improved scientific understanding of research-based science teacher education.

Practice schools and teacher professional development providers are important local partners in science teacher education. Lillestrøm municipality collaborates with OsloMet both through its practice schools and through its STEM centre. The STEM centre focuses on supporting science teachers' self-reflection and professional development, for instance through the use of lesson study. This form of reflective collaboration and research-driven practice is emphasised in the new school reform (Ministry of Education and Research, 2016). However, it has not been a tradition in the region, and Lillestrøm STEM-centre aims to make research-based teaching a larger part of the professional life of the teachers and to strengthen a culture where teachers will remain consumers of research and constantly seek to update and develop their practice. HVL collaborates with VilVite, which also works with establishing regional networks for teachers. Furthermore, VilVite is partner in *Skaperskolen*, a national project aimed to develop technology and programming activities and resources for school. TRELIS will use these networks to develop and try out P&M for science education. Furthermore, through the collaboration TRELIS will provide models for teacher professional development.

1.2 Novelty and ambition

TRELIS will document, investigate and improve the research component of science teacher education in Norway in a time when teacher education as well as school science curricula are in a process of change. Thus, TRELIS will provide invaluable empirical results and contribute to the development of a future-oriented science teacher education. While research and professional communities as well as educational authorities promote *research literacy* for science teachers, little has been done in a Norwegian context to describe how such literacy can be developed and how teachers, student teachers and teacher educators conceptualise and relate to these competencies. TRELIS will contribute to operationalising *research-based science teacher education* (RBSTE) and provide practical and documented examples of how it can be developed and supported.

TRELIS will develop concrete teaching approaches, learning activities and assessment tasks that support RBSTE with particular focus on IBL and P&M. This will produce validated materials for wide dissemination to teacher education programmes as well as to school science classrooms. In the process, models for collaborative research and development involving practitioners will be developed. Through the science subject as an example, TRELIS will demonstrate how a progression can be designed through teacher education and into professional practice, allowing student teachers and in-service teachers to develop their awareness of how research can be used to improve education in schools.

Concerning the explicit research components in teacher education (notably the master's thesis), TRELIS will provide knowledge of student teachers' and teacher educators' approaches and exemplary ways of organising and supervising work with the masters' thesis in the context of the new teacher education.

1.3 Research questions and hypotheses, theoretical approach and methodology

The objectives of TRELIS will be pursued through six work packages (WPs): Project management and communication (WP 1), Mapping and developing the conditions for RBSTE (WP 2), Explicit RBSTE – The research assignments (WP 3), Implicit RBSTE – Inquiry-based learning (WP 4), Implicit RBSTE – Programming and modelling (WP 5), and Supporting RBSTE in schools through collaborative learning networks (WP 6). Below, theoretical and methodological entry points and data collection strategies are described for each WP. The WPs are further described in terms of research questions, methods and participants in Section 3.2.

Tatto and Furlong (2015) suggest four ways in which research can contribute to teacher education programmes: (1) the *content* can be informed by research-based knowledge; (2) the *design* and *structure* can be informed by research; (3) teachers can be equipped to *engage with* and *become consumers of* research; and (4) teachers can be educated to *do their own* research. This is in line with emphasis on *explicit* and *implicit* research-based approaches (Aspfors & Eklund, 2017). Explicit approaches include student teachers carrying out independent studies, while the implicit approach is related to development of the student teachers' ability to reflect critically and systematically on their daily work through research that permeates the entire programme. TRELIS will take as its theoretical starting point these ways in which science teacher education and professional development can be research-based, and contribute to refining these theoretical perspectives and adapting them to the Norwegian context. **WP 2** will use this as a framework for analysing the conditions for RBST, whereas **WP 3** focuses on the explicit aspects of RBSTE, and **WPs 4 - 6** focus on the implicit aspects with particular attention to IBL and P&M, relevant in the new school science curriculum.

WP 2 provides the background for the project through mapping the conditions for RBSTE. The aim is to identify possibilities and challenges in RBSTE, highlighted with examples from OsloMet and HVL. Document analysis with a hermeneutic approach (Friesen et al., 2012) will be used for describing the education that student teachers receive, e.g. course plans, reading lists, lesson plans, assignments, and school practice placements, with a view to the role of research. Empirical studies of student teachers', teachers' and teacher educators' views of RBSTE will be carried out, conducting individual and focus group interviews (Brinkmann & Kvale, 2018). Special attention will be given to inquiry-based science education and its implications for science teacher education. For interview data, thematic analysis as described by Braun and Clarke (2006) will be used. Results from WP2 will feed back into teacher education to develop and improve RBSTE.

When studying explicit RBSTE in **WP 3,** the focus will be on the research assignments in the teacher education programme (i.e. the R&D assignment and the master's thesis). The aim is to identify ways of organising the assignments in order for them to be recognised as valuable by student teachers and to prepare student teachers for being research literate participants in learning communities when they enter professional practice. Student teachers' experiences of the research assignments before and after they have finished their study will be investigated through essays. The same informants will be studied after working one year, in order to investigate their views on the usefulness of the research assignments for the profession. Interviews with supervisors will also be performed. The study is comparative in its character, since similar Finnish data has been collected at Åbo Akademi.

WPs 4 and 5 focus on the implicit aspects of RBSTE with specific attention to implementation of IBL (WP4) and P&M (WP5). Through these WPs, the science teacher education at OsloMet and HVL will be developed iteratively through design-based research (DBR) (Anderson & Shattuck, 2012). DBR aims to develop and validate suitable teaching and learning activities, while simultaneously supporting research on participants' experiences, attitudes, and learning. A central aim will be to develop new knowledge and best-practice examples of research-based education within these two important areas of science education. This development will be done in close collaboration with Lillestrøm municipality and VilVite.

In **WP 4,** IBL is understood as an educational strategy where learners use *practices* similar to those of professional scientists to build their understanding (Crawford, 2014). The K-12 Framework (National Research Council, 2012) described eight such practices, amongst them *developing and using models*, a*nalysing and interpreting data* and *engaging in argument from evidence*. This involves writing, talking and reading, and IBL and literacy activities are thus fundamentally integrated (Osborne, 2014; Ødegaard, Haug, Mork, & Sørvik, 2014). By using research about IBL to develop novel learning activities as part of the teacher education, TRELIS aims to equip future science teachers with suitable learning activities for the new school science curriculum and give them practice in designing and evaluating teaching and learning activities in light of curricular aims. WP 4 involves three cases, building on and extending ongoing research and development at OsloMet and HVL. One case will look at IBL in the 1-7 teacher education at OsloMet (in particular Years 1-4). The second and third cases will involve IBL in the 5-10 educations at OsloMet and HVL, giving opportunities for collaborative knowledge building across the institutions and a richer data set regarding ways of implementing research perspectives in science teacher education. Both individual and focus group interviews, will be carried out with student teachers, teachers and teacher educators. Further, participant- and direct observations of meetings and teaching activities in teacher education will be conducted. Sound- and video recordings of student discussions while engaging in learning activities will also be made.

In **WP 5**, researchers at OsloMet will investigate how educational research on P&M in school science can be implemented in teacher education for years 5-10. This WP will apply similar methodology as WP 4, and study different ways of implementing P&M in science teacher education, integrating perspectives from research to design activities while also producing new knowledge. Particularly, the introduction, implementation and reception of programming in school science is an under-researched area. *Computational thinking* is a muchused term for the competence that pupils are expected to develop while working with programming tasks (e.g. Weintrop et al., 2016). Shute et al. (2017) categorized computational thinking into six main facets: decomposition, abstraction, algorithm design, debugging, iteration, and generalisation. This framework provides a starting point for TRELIS to investigate how student teachers and in-service teachers work with programming activities for use in school science and what challenges they meet. This WP also draws on theoretical approaches to modelling in science education more generally (Pajchel et al., 2020).

WP 6 investigates how research-based teaching approaches, in particular those developed in WPs 4 and 5, can be implemented in schools. This will be done in collaboration with providers of teacher professional development and be a two-way relationship; observation of the collaborative learning networks will feed into WPs 4 and 5 – and findings from WPs 2-5 will inform the development of the collaborative learning networks in WP 6. The WP involves two cases, Lillestrøm and VilVite, and uses DBR, observation and interviews. Research literature has identified success criteria and best-practice models for professional development aimed at in-service teachers (Capps et al., 2012; Stadler & Jorde, 2012). In TRELIS, these will be considered when developing research-rich collaborative communities and when implementing research-based science teaching and learning activities developed in the project.

Inclusion and utilisation of stakeholder knowledge: The partnerships with Lillestrøm and VilVite will contribute to collaborative learning communities. Furthermore, through the studies in WP 6 and participation in the advisory board, stakeholders will have active roles in providing feedback to WPs 4 and 5. The knowledge and experiences of student teachers will be utilised in particular in WPs 2 and 3, by focusing on making research assignments valuable for their development and future practice.

Interdisciplinarity: The researchers working in TRELIS are from science backgrounds as well as science education and general education backgrounds, allowing exchange of research knowledge and practices. Furthermore, interdisciplinarity is a natural part of WPs 4-6; IBL frequently includes knowledge from both natural- and social sciences, and P&M includes mathematics, computer sciences and natural sciences.

Possible risks: Recruitment of informants will be one of the risks in TRELIS. However, since both Lillestrøm and VilVite have established collaborative learning networks, and participation in the network is mandatory for all teachers in Lillestrøm, the process of recruitment is less complex. Moreover, the renewal of the curricula with new demands for science teachers will probably make the knowledge and resources produced in TRELIS desirable and simplify recruitment. At HVL and OsloMet, some researchers will be doing research on their own organisation. The benefit is that it is easier to get access, while a challenge is to miss out on critical questions that could have given new perspectives. However, the project also includes outsiders who will have a particular responsibility for keeping an objective distance.

Ethical issues: The study follows the general ethical standards approved by the Norwegian National Research Ethics Committees. All informants will be thoroughly informed according to the guidelines of the Norwegian Centre for Research Data, NSD. Data will be stored and treated in accordance with GDPR and particular care will be taken when storing video data (Derry et al., 2010). Access to non-anonymised data will be restricted to the researchers connected to the project. When reporting findings, no individuals will be identifiable. Measures will be taken to prevent possible power relationships between teacher educators, in-service teachers and student teachers from affecting the outcomes of the research.

Gender issues: The research group is composed of both genders, and gender balance will also be a criterion when selecting informants. Gender perspectives will also be considered when developing learning resources in WPs 4-6 so as to meet the interests and learning preferences of both genders (Kjærnsli & Jensen, 2016). Females are in majority among teacher educators and teachers in Norway, and in a newly released report investigating gender differences in Norwegian schools, boys were found to be falling behind and attention was brought to support and include boys in the learning activities (Ministry of Education and Research, 2019). On the other hand, science traditionally has male connotations, and it is therefore important to keep girls interested in school science in order for them to consider post-compulsory education in science (Henriksen et al., 2015). Thus, research-based strategies for an inclusive science education where a diversity of students feel at home will be prioritised in TRELIS.

2. Impact

2.1 Potential impact of the proposed research

TRELIS' focus on collaborative learnings network and on preparing research literate teachers through explicit and implicit engagement with research, place the project within highly relevant and active areas of research and development. The project collaborates closely with different groups of stakeholders. The theoretical and empirical insights about how to interpret and implement research as a central component of teacher competence will be developed in collaboration with some of the main agents of change in science education.

TRELIS will provide concrete and systematically tested research-based teaching resources. Such new knowledge of implementing IBL and P&M approaches in school science and teacher education is frequently requested by national and international research. It is particularly relevant in the new school curriculum, and closely followed by educational authorities and institutions. In the short term, the project results will feed back into the two large science teacher education institutions, OsloMet and HVL. The numerous student teachers and in-service teachers that pass through these institutions will have a substantial impact on school science in Norway. Through collaboration with Lillestrøm and VilVite, TRELIS will also provide new knowledge on development of professional practice among in-service teachers. On the longer term, the partnerships developed through the project will influence the research and the student teachers' research assignments, in order to make them more relevant to the field.

TRELIS will support and strengthen the science education research groups in two prominent Norwegian teacher education institutions, thus contributing to research-based discussions and development nationally on the implementation of RBSTE. Science education in Norway is in great need of candidates with didactical degrees; the three PhD candidates of TRELIS will provide new competence to Norwegian teacher education. Development of research competence among the teacher educators is highly prioritised and supported by the leadership in the involved institutions. TRELIS involves research groups which are relatively young and include both experienced researchers and researchers who are new to science education. The project will contribute to building national and international research networks. It will also provide important experience with PhD-supervision and project management. In the longer term, the national capacity of science teacher education, which currently is in great need of professors and associate professors, will improve.

Scientific knowledge is crucial in understanding and solving the sustainability issues the world is facing, emphasising the need to improve science education. TRELIS addresses UN sustainable development goal no 4, *quality education*. New technology and active learning processes (such as IBL) are widely applied in education for sustainable development since it allows learners to develop competences for a sustainable future (Jegstad et al., 2018). This is also in line with Education 2030 and the focus on 21st century skills (OECD, 2018). TRELIS also contributes to other goals, through science education addressing research on climate, oceans and plant life (goals 13-15), clean water and sanitation (goal 6), affordable and clean energy (goal 7).

2.2 Measures for communication and exploitation

The overall responsibility of communication in TRELIS, notably web pages, social media channels and larger seminars, lies in WP1, whereas other communication and dissemination lies in the other WPs. Primary target groups are: 1) science teacher education programmes, including teacher educators and student teachers; 2) schools, in-service teachers, school owners and educational authorities; 3) science teacher education researchers. In the short term, project results will feed back into the science teacher education programs at OsloMet and HVL. The advisory board represents both research and stakeholder groups, facilitating discussion and dissemination of results. Communication with the user groups in the school sector is an integral part of project design, and the collaboration with Lillestrøm municipality and VilVite ensures dissemination and field-testing of learning activities. Project results will be communicated to and discussed with a broader national and international scientific community through publications and conferences.

3. Implementation

3.1 Project manager and project group

Project TRELIS is founded in **OsloMet** and **HVL**, two of the largest teacher education institutions for primary and lower secondary levels in Norway. Both institutions have a strong science education environment in rapid growth. Project leader Henriksen (OsloMet and UiO) is an experienced science education researcher and teacher educator. She currently leads the Research Section for Physics Education at UiO and recently led the FINNUT-funded project 'ReleQuant', which used DBR and interview methods. Eklund (OsloMet and Åbo Akademi University) has 20 years' experience of working in research-based teacher education and leads a research project at Åbo Akademi, aiming to further develop the research-based teacher education. Pajchel has a background in physics, and has considerable experience with leadership, teaching and outreach, in addition to international collaboration through research related to CERN and an EU-project. Jegstad has a PhD in science education and brings experience on conducting case studies in teacher education. Brevik has a PhD on the use of LEGO robotics as a teaching tool in vocational education and Sollid is project leader of *Skaperskolen,* and they thus bring valuable experience in programming. In the HVL group, Schulze and Mestad both have PhDs in science/physics education and extensive research experience. Pilskog has a PhD in physics, international research experience and teaching experience from school and teacher education.

Collaborative partners in the project are:

- **Nord University** (WP 2) and Professor Aspfors, who is project manager for a research project aiming to investigate teacher educators' experiences and understanding of research-based teacher education.
- **Lillestrøm** Municipality (WPs 4-6) is a suburban area with a population of 87 500 and has established a STEM-centre with professional learning networks for teachers. Høiby, a science educator working at the STEM-centre, will contribute in WPs 4-6 and representatives from the municipality will be in the advisory board in order to secure user involvement throughout the project.
- **VilVite** (WP 6) is a science centre of international format located in Bergen. It is partner in Skaperskolen. It will also establish regional networks and courses for teachers. TRELIS will use network and courses at VilVite to involve teachers in trying out programming activities.
- **University** College Copenhagen (**KP**) is one of Denmark's main providers of teacher education. Docents Krog Skott will be member of TRELIS' advisory board with competence on newly qualified teachers.
- **Durham** University has a rich science education research activity in which Dr. Kind is the lead investigator in a number of projects. The Durham group, through Dr. Kind, will be an important international contact and contribute with expertise in research design, teacher competence, publication writing, and more.
- The **University of Oslo (UiO)** (WP 5) provides science teacher education for the 8-13 levels and hosts the Centre for Computing in Science Education, which develops programming courses for teachers 8-10.

The TRELIS project team is in a unique position to attain the aims set forth in the project and in the FINNUT call for proposals: The team includes experienced researchers in science education from several institutions in Norway and abroad; this will ensure the scientific quality of the project. The team also includes highly qualified staff members at the two teacher education institutions These will strengthen their competence in educational research through participation in TRELIS. This will in turn improve the teacher education programmes at the two institutions. With two large teacher education institutions, Lillestrøm municipality and VilVite involved, good data collection opportunities and an extensive national network are ensured. Thus, the partnership will have a strong position in the future Norwegian science education environment. Our international partners in Denmark, Finland and the UK will contribute with scientific support as well as valuable outside perspectives that may inform both the research- and development components of TRELIS.

3.2 Project organisation and management

WP 1 will provide the overall leadership of TRELIS, coordinate activities in the WPs and organise larger dissemination events. The project will have a dual leadership; Henriksen will act as overall scientific project leader and Jegstad will act as co-leader, following up on practical management of the project. The project leaders and WP-leaders will make up the project steering group. This group will meet on a regular basis to discuss progress and project strategy. Once a year, an advisory board, consisting of representatives of national stakeholder groups and national and international experts in the field, will meet. The representatives from the stakeholder groups include a student teacher, a school leader and a teacher from a university training school in Lillestrøm, and a representative from VilVite. The group of experts includes Professor Jorde (ProTed), Aspfors (Nord), Krog Skott (KP), and Kind (Durham). The WPs are described according to work plan in Figure 1, and according to research questions, methods and participants in Table 1 below.

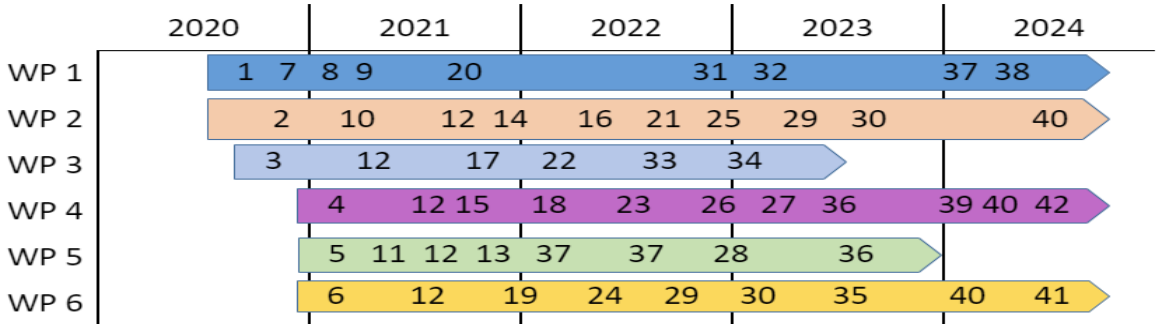

Figure 1: Gantt-chart. Numbers correspond with the progress plan in the application form

Table 1: Project overview per WP. WP-leaders are underlined in the list of participants

WPs	Deliverables	Research questions	Methods and data	Participants
WP1: Project management and commun-ication	Deliverables: An international conference with invited speakers targeting international collaborators as well as teacher education institute-ons in Norway. Contributions at conferences for science teachers and teacher educators. Contributions to blogs and other social media			OsloMet & HVL: Henriksen, Jeg-stad, WP-leaders and Adv.board
WP2: Mapping and developing the conditions for RBSTE	Best-practice recommendatio ns for structure and content of RBSTE programs; research articles	2.1 In what ways can a research component of science teacher education be identified in course plans, reading lists, lesson plans and assignments in teacher ed. programmes? 2.2 What is the role of school placement within research-based science teacher education – through the eyes of mentors? 2.3 Inquiry-based science as an example sub-field of RBSTE: How is inquiry-based learning (IBL) implemented in in science teacher education; what does research tell us about best practice and challenges, and which areas need more research? 2.4. How do teacher educators and student teachers conceptualise and relate to RBSTE with particular focus on IBL? 2.5. What opportunities and challenges and best-practice examples can be identified for implementing RBSTE?	• Literature review, document analysis • Individual and focus groups interviews at both institutions	OsloMet & Nord: Henriksen, Aspfors, Aalbergsjø, Strat, Eklund, Jegstad, Kind
WP3: Explicit RBSTE: The research assignments	Guidelines for working with RBSTE through R&D assign-ments and master's thesis; research articles	3.1 How do student teachers experience working with research assignments (both R&D assignment and master's theses)? 3.2 How do newly qualified teachers experience the relevance of their research assignments for the teaching profession? 3.3 How do teacher educators conceptualize their role in student teachers' process of writing master's thesis?	• Student teachers' essays before and after R&D assignments, master's thesis, and after one year as qualified teachers. • Interviews with teacher educators (master thesis supervisors), N=10)	OsloMet & HVL: Eklund, Jegstad, Henriksen, Mestad, Pajchel

WP4: Implicit RBSTE: Inquiry-based learning (IBL)	Learning resources and teacher guidelines for implementing research-based IBL and P&M in science (teacher) education. Research articles	4.1 How can research literature on IBL be included and used to develop novel learning activities in science teacher education? 4.2 Which characteristics of IBL teaching material and learning activities promote deep learning of science concepts and work forms? 4.3 How do student teachers experience teaching and learning activities related to IBL, and what challenges and opportunities do they identify? 4.4 What characterizes the student teachers' ability to reflect critically on own practice as expressed in discussions or in assignments? 4.5 How do the student teachers perceive the relevance of these activities for their pre-service practice and future classroom practice?	• Design-based research to develop learning materials • Interviews with student teachers, teachers and teacher educators • Sound/ video recordings of student discussions during learning activities • Participant observations of learning activities	HVL, OsloMet & Lillestrøm: <u>Mestad</u>, Schoulze, Pilskog, Strat, Henriksen, Jegstad, Aksland, Kind, PhD 1
WP5: Implicit RBSTE: Programming and modelling (P&M)	Learning resources and teacher guidelines for implementing research-based IBL and P&M in science (teacher) education. Research articles	5.1 How can research literature on P&M in school science be included and used to develop novel learning activities in science teacher education? 5.2 How do student teachers experience teaching and learning activities concerning P&M, and what challenges and opportunities do they identify? a) within mathematical models and science simulations b) within creative problem solving in context with "Skaperskole» 5.3 How do student teachers perceive the relevance of these activities for their pre-service practice and future classroom practice? 5.4. Which teaching approaches and learning activities can contribute to bridging the gap between block-based programming for the primary school stages and text-based programming for secondary stages? 5.5. How can experiences from in-service training for teachers in P&M be utilised in pre-service science teacher education? 5.6. How can P&M activities for school science and for science teacher education be designed in collaboration between teacher educators and in-service teachers	• Design-based research to develop learning materials • Interviews with student teachers, teachers and teacher educators • Sound/ video recordings of student discussions during learning activities • Participant observations of learning activities	OsloMet & Lillestrøm; UiO: <u>Pajchel</u>, Sollid, Aalbergsjø, Brevik, Henriksen, PhD 2
WP6: Supporting research-based science education in schools through collaborative learning networks (obj. 4&5)	Report on the success criteria for developing research-rich collaborative learning networks among science teachers. Research article(s)	6.1 How can teacher educators, in-service teachers and school owners work collaboratively in developing research-based practices in teacher education and school science? 6.2 How do in-service teachers experience teaching and learning activities concerning IBL, and what challenges and opportunities do they perceive? 6.3 How do in-service teachers experience teaching and learning activities concerning IP&M, and what challenges and opportunities do they perceive? 6.4 How do the teachers perceive the relevance of these activities for classroom practice? 6.5 In what ways can collaborative learning networks in schools support pre- and in-service teachers' development of research literacy?	• Interviews with teachers and STEM coordinators • Sound recordings of teacher discussions while engaging in learning activities. • Reflection notes written by teachers before and after teaching activities	OsloMet, HVL, Lillestrøm, VilVite: <u>Jegstad</u>, Sollid, Pajchel, Brevik, Mestad, PhD 3

References

Anderson, T., & Shattuck, J. (2012). Design-based research: A decade of progress in education research? *Educational Researcher, 41*(1), 16-25.

Aspfors, J., & Eklund, G. (2017). Explicit and implicit perspectives on research-based teacher education: newly qualified teachers' experiences in Finland. *Journal of Education for Teaching, 43*(4), 400-413.

Bell, M., Cordingley, P., Isham, C., & Davis, R. (2010). Report of professional practitioner use of research review: Practitioner engagement in and/or with research. *CUREE, GTCE, LSIS & NTRP. Available at: http://www.curee.co.uk/node/2303.*

BERA. (2014). *Research and the teaching profession. Building the capacity for a self-improving education system*. Retrieved from https://www.bera.ac.uk/wp-content/uploads/2013/12/BERA-RSA-Research-Teaching-Profession-FULL-REPORT-for-web.pdf?noredirect=1

Braun, V., & Clarke, V. (2006). Using thematic analysis in psychology. *Qualitative research in psychology, 3*(2), 77-101.

Brinkmann, S., & Kvale, S. (2018). *Doing interviews* (2 ed.). Los Angeles: Sage.

Burn, K., & Mutton, T. (2015). A review of 'research-informed clinical practice'in Initial Teacher Education. *Oxford Review of Education, 41*(2), 217-233.

Capps, D. K., Crawford, B. A., & Constas, M. A. (2012). A review of empirical literature on inquiry professional development: Alignment with best practices and a critique of the findings. *Journal of Science Teacher Education, 23*(3), 291-318.

Crawford, B. A. (2014). From inquiry to scientific practices in the science classroom. In N. G. Lederman & S. K. Abell (Eds.), *Handbook of research on science education* (Vol. 2, pp. 515-544): Routledge.

Derry et al. (2010). Conducting video research in the learning sciences: Guidance on selection, analysis, technology, and ethics. *The Journal of the Learning Sciences, 19*(1), 3-53.

Eklund, G. (2018). Does research-based teacher education matter? Student teachers' experiences of Research-Based Teacher Education in Finland. *Nordisk Tidskrift för Allmän Didaktik, 4*(1), 3-17.

Friesen, N., Henriksson, C., & Saevi, T. (2012). *Hermeneutic phenomenology in education: Method and practice*: Sense Publishers.

Furtak, E. M., Seidel, T., Iverson, H., & Briggs, D. C. (2012). Experimental and quasi-experimental studies of inquiry-based science teaching: A meta-analysis. *Review of educational research, 82*(3), 300-329.

Henriksen, E. K., Dillon, J., & Ryder, J. (2015). *Understanding student participation and choice in science and technology education*. Dordrecht: Springer.

Jakhelln, R. (2015). Universitetsskoler og profesjonell praksis. In U. Rindal, A. Lund, & R. Jakhelln (Eds.), *Veier til fremragende lærerutdanning* (pp. 69-74).

Jegstad, K. M., Gjøtterud, S. M., & Sinnes, A. T. (2018). Science teacher education for sustainable development – A case study of a residential field course in a Norwegian pre-service teacher education program. *18*(2), 99-114.

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

Ministry of Education and Research. (2016). Fag - Fordypning - Forståelse. En fornyelse av Kunnskapsløftet. Meld. St. 28 (2015-2016). Retrieved from https://www.regjeringen.no/no/dokumenter/meld.-st.-28-20152016/id2483955/

Ministry of Education and Research. (2017). *Teacher Education 2025. National Strategy for Quality and Cooperation in Teacher Education*. Retrieved from https://www.regjeringen.no/contentassets/d0c1da83bce94e2da21d5f631bbae817/kd_teacher-education-2025_uu.pdf

Ministry of Education and Research. (2019). NOU 2019: 3 Nye sjanser – bedre læring — Kjønnsforskjeller i skoleprestasjoner og utdanningsløp. Retrieved from https://www.regjeringen.no/no/dokumenter/nou-2019-3/id2627718/

Munthe, E., & Rogne, M. (2015). Research based teacher education. *Teaching and Teacher education, 46*, 17-24.

National Research Council. (2012). *Education for Life and Work. Transferable Knowledge and Skills for the 21st Century.* (J. W. Pellegrino & M. L. Hilton Eds.). Washington, DC: The National Academies Press.

OECD. (2018). OECD Learning Framework 2030. Retrieved from http://www.oecd.org/education/2030/E2030%20Position%20Paper%20(05.04.2018).pdf

Osborne, J. (2014). Teaching scientific practices: Meeting the challenge of change. *Journal of Science Teacher Education, 25*(2), 177-196.

Pajchel, K., Ramton, A. M. S., & Sollid, P. Ø. D. (2020). Modeller og modellering i naturfag. In A. Holt, L. O. Voll, & A. B. Øyehaug (Eds.), *Dybdelæring i naturfag*. Oslo: Universitetsforlaget.

Rocard, M., Csermely, P., Jorde, D., Lenzen, D., Walberg-Henriksson, H., & Hemmo, V. (2007). Science Education Now: a Renewed Pedagogy for the Future of Europe. European Commission, Directorate-General for Research, Science. *Economy and society*.

Shute, V. J., Sun, C., & Asbell-Clarke, J. (2017). Demystifying computational thinking. *Educational Research Review, 22*, 142-158.

Skagen, K., Løndal, K., Kleve, B., & Smestad, B. (2018). Masteroppgaver og profesjonsrelevans i pedagogikk, matematikk og kroppsøving. *FoU i praksis, 12*, 7-27.

Stadler, M., & Jorde, D. (2012). Improving science education through European models of sustainable teacher professional development. In D. Jorde & J. Dillon (Eds.), *Science Education Research and Practice in Europe* (pp. 375-393): Springer.

Tatto, M. T., & Furlong, J. (2015). Research and teacher education: papers from the BERA-RSA Inquiry. *Oxford Review of Education, 41*(2), 145-153.

The Norwegian Directorate for Education and Training. (2019). Fagfornyelsen - høring om nye læreplaner. Retrieved from https://www.udir.no/laring-og-trivsel/lareplanverket/fagfornyelsen/horing-nye-lareplaner/

Weintrop, D., Beheshti, E., Horn, M., Orton, K., Jona, K., Trouille, L., & Wilensky, U. (2016). Defining computational thinking for mathematics and science classrooms. *Journal of Science Education and Technology, 25*(1), 127-147.

Winch, C., Oancea, A., & Orchard, J. (2015). The contribution of educational research to teachers' professional learning: Philosophical understandings. *Oxford Review of Education, 41*(2), 202-216.

Yin, R. K. (2009). *Case study research: Design and methods*. Los Angeles: Sage.

Ødegaard, M., Haug, B., Mork, S. M., & Sørvik, G. O. (2014). Challenges and support when teaching science through an integrated inquiry and literacy approach. *International Journal of Science Education, 36*(18), 2997-3020.