Mathematics, Science and Computational Thinking - MASCOT

1 Excellence

1.1 State of the art, knowledge needs and project objectives

State of the art. Computational thinking (CT) has been described as a universal 21st century skill: a generic competence that plays an important role in fostering analytical and critical thinking, creativity, problem-solving and scientific literacy practices in children (Voogt, Fisser, Good, Mishra, & Yadav, 2015). CT is not new in education, and can be traced back to Seymour Papert's (1980) analysis of the relationship between programming and thinking skills. He argued that students' constructions through programming could facilitate thinking and learning across multiple disciplines such as mathematics, science, and literature (Papert, 1980; Zhang & Nouri, 2019). In recent years, CT has acquired a more prominent place in education theory and policy. It has been operationalised as a set of thinking and problem-solving skills that make use of conceptual tools such as logic, algorithms, decomposition and abstraction, and methods such as tinkering, creating, debugging, persevering and collaborating (Barefoot Computing, 2016; NDET, 2019).

It has been argued that there are several benefits to embedding CT in mathematics and science (often referred to as core STEM subjects). Modern science and mathematics rely heavily on computations; the reciprocal relationship between learning CT and learning science and mathematics facilitates the use of real-world examples; and the integration of CT brings STEM education more in line with current professional standards (Weintrop et al., 2016). However, influenced by Wing's (2006) idea that everyone should think like a computer scientist, CT in education has had a technology-centred focus, relying heavily on programming and computer science (Buitrago Flórez et al., 2017; Shute, Sun, & Asbell-Clarke, 2017). This approach has been criticised for being too narrow and at odds with the broader view of CT as fostering analytical and critical thinking (Kafai, Proctor, & Lui, 2019; Mannila et al., 2014).

CT has now been implemented in school curricula in many countries (Heintz, Mannila, & Farnqvist, 2016), including the Nordic countries. Finland, Denmark and Norway are at different stages of implementing and integrating CT and are doing so through differing strategies (Bocconi, Chioccariello, & Earp, 2018). Finland has adopted CT through a combination of cross-curricular and subject-specific measures (FNBE, 2014). Denmark has implemented a broad approach through the subject Technology Comprehension, which is being piloted in primary and lower secondary schools and includes CT and digital citizenship as two central areas of competence (Ministry of Children and Education, 2018). Digital citizenship involves having abilities to negotiate the realities of the technological world and being empowered to ask questions about and with technology (Brennan & Resnick, 2012). From autumn 2020, Norway will implement a revised curriculum which includes CT, particularly in relation to science, mathematics, arts and crafts and music (NDET, 2019). These three Nordic countries have all implemented a broad interpretation of CT that emphasises logical thinking and problem-solving skills (Bocconi et al., 2018) rather than the ability to create particular technological products (Brennan & Resnick, 2012; Weintrop et al., 2016).

Knowledge needs. Despite the implementation of CT across the curriculum in many countries, there remains a lack of shared definitions, rationales for, and interpretations of CT for school and teacher education (TE), resulting in incoherent practices (Bocconi et al., 2018; Román-González et al., 2019; Voogt et al., 2015; Zhang & Nouri, 2019). Most critically, there is a mismatch between approaches to CT, learning goals and assessment – a mismatch that limits students' possibilities to display their full range of CT competences.

Numerous studies of CT in primary and secondary education have identified the need to design didactic approaches that support learning CT skills (Nouri, Zhang, Mannila & Norén 2020; Zhang & Nouri 2019). Musaeus & Musaeus (2019) argue that there is the need to inform teachers on how to foster students' development of CT in different subjects. In primary and secondary school, CT is being taught in a plethora of ways and contexts as there is not yet an established consensus of which CT skills to teach, how to embed CT in the different school subjects, as well as how to assess CT in this context. As such, TE can learn from the initiatives in schools and a collaboration between school initiatives, TE and educational research will benefit all arenas.

Assessment is an essential component in education, and research has shown that implementing a broad interpretation of CT requires multiple means of assessment which provide complementary information

(Brennan & Resnick, 2012; Román-González, Moreno-León, & Robles, 2019). Brennan and Resnick (2012) argue that different assessment tools have different scopes with respect to the various dimensions of CT. Generic computational skills demand different assessment tools from subject-specific skills (Brennan & Resnick, 2012; Swanson, Anton, Bain, Horn, & Wilensky, 2019). However, many existing studies have focused only on assessment of students' products (Chen et al., 2017).

TE has a responsibility to educate teachers who are qualified to teach current curricula. With regards to CT, however, recent research from countries that have already introduced it in curricula indicates that student teachers with no previous exposure to CT have a superficial understanding of its core concepts even after its introduction in curricula (Mouza, Yang, Pan, Ozden, & Pollock, 2017; Yadav, Gretter, Good, & McLean, 2017). Yadav et al (2017) further argue that while it is crucial for student teachers to understand CT in the context of the subject area they will be teaching, there is currently a limited understanding of how to engage student teachers in CT skills and activities. These studies suggest that many of the student teachers will not be capable of designing lessons that integrate CT in a meaningful way, which indicates a future challenge for schools. There is therefore a critical need to address CT in TE in order to ensure that student teachers will be capable of designing lessons that integrate CT in a meaningful way and that TE and school curricula will be aligned.

In sum, current approaches fail to address the essential interplay between CT as a generic skill and CT as a subject-specific skill in mathematics and science. There is a clear need for research on new tools and approaches for teaching as well as assessing the full range of CT competences.

Project objectives. MASCOT's primary objective is to **develop significant research-based knowledge about the teaching, learning and assessment processes of computational thinking in TE and schools**. This includes developing systematic knowledge about research and policy on computational thinking, as well as knowledge about educational practices and assessment as implemented through different approaches in Nordic teacher educations and schools. The project's secondary objective is to **use the knowledge gained to develop new educational practices and means of assessment that take into account both subject-specific and generic CT skills**. It is a goal to make sure that knowledge gained from research in schools and TE programmes mutually inform each other in order to improve professional educational practices and assessment in both arenas. In this way, MASCOT aims to address and rectify the current mismatch between curricular goals and teaching and assessment practices.

To achieve these objectives, MASCOT proposes a research project that directly intervenes in TE programmes as well as schools in three Nordic countries (Norway, Finland and Denmark), emphasizing collaboration between the project partners to gain insight from each other. Two unique strengths set the project's design apart from previous research and help to ensure that MASCOT achieves its aims. One is a broad and interdisciplinary project consortium from three Nordic countries that all employ different approaches to, and are at different stages of, implementing CT in school curricula. The other is a research plan with work packages (WPs) and research questions specifically designed and developed in collaboration with practitioners to link together a learning and assessment focus in primary and secondary education as well as in TE. Through such a collaboration, the project is well positioned to deliver on its ambitious objectives. In doing so, MASCOT will make a significant contribution to the international research front on the topic of CT in education. At the same time, it will provide schools, TE institutions and policymakers with crucial knowledge for research-based implementation of CT in Nordic and especially Norwegian schools.

1.2 Research questions, theoretical approach and methodology

MASCOT is organised as a research – practice partnership (RPP), which Coburn & Penuel (2016, p. 48) have defined as "long-term collaborations between practitioners and researchers that are organized for investigating problems of practice and for developing solutions for improving school practice and even school districts" . RPP bridges the gap between educational research and practice, and therefore foster teachers' professional learning (Coburn & Penuel, 2016). The project objectives and research questions addressed in this project have been developed in collaboration with the teachers/practitioners involved in the project.

Research questions. The project's objectives are addressed in five research questions (RQs), which will be answered through five corresponding and interdependent WPs, illustrated in Figure 1 (page 4).

RQ1: How is CT understood as a competence for teachers, student-teachers and students?

RQ2: a) What is the relationship between digital citizenship, generic and subject specific CT skills in TE b) What characterises curricula, teaching and assessment practices of CT in TE in the Nordic countries?

RQ3: a) How do teachers approach the integration of CT in science and mathematics classrooms? b) In what ways do students engage with CT in science and mathematics?
RQ4: What indicators of generic and subject specific CT skills can inform assessment practices?
RQ5: What insights for teaching and learning can we develop through designing, implementing and assessing CT in schools and TE in the Nordic context?

Theoretical approach. In examining the above research questions, MASCOT draws on a sociocultural perspective of learning. From such a perspective, learning exists at the intersection between tools and interaction. Tools from this perspective are culturally, institutionally and historically situated, which means that we need to study the context to understand them fully. Vygotsky (2012) differentiated between two types of tools – material (paper) and psychological tools (language, mnemonics, maps). The purpose of psychological tools is to shape the mind and change actions. However, the boundaries between material and psychological tools are not clear-cut. An example of this is a computer. The materiality of a computer (e.g. plastic) is a physical object that can be touched and can exist across time and space regardless of whether it is used. But it is also a psychological tool, made up of signs and symbols, that requires mental interpretation. Consequently, it is more fruitful to consider tools as 'cultural tools' (Wertsch 1998). Referring to tools as cultural tools in analysing their use in the classroom helps in understanding the contextual and cultural factors of the activity that the tools mediate. For example, computers have changed our actions in several ways, including the ways we work, read and process information. Meaning and purpose are given to tools by the socio-cultural context to which they belong (Wertsch 1998, p. 29). CT is such a cultural tool, and its importance in society has increased with its recent introduction in curricula in the Nordic countries as a key generic skill.

The introduction of new tools in the classroom changes teaching and learning practices (Säljö, 2006), creating new opportunities as well as challenges to existing understandings of learning. As a new curricular competence, the introduction of CT creates challenges for the teacher in the forms of translating curricular goals into practice and developing means of assessment. Tools and mediated action must be studied in context, as an action "cannot be separated from the milieu in which it is carried out" (Wertsch, 1991, p. 18). Therefore, MASCOT will study the role of CT in the context of the development of related activities and interactions in the classroom, building on previous research to understand the ways in which CT may transform actions. By taking a sociocultural approach, MASCOT will research CT in teaching and learning in a way that enables a thorough and multifaceted quest for answers to the five research questions above and thus achieve the project's objectives. This approach accepts that concepts do not emerge in a vacuum but are culturally constructed. Such a perspective will enable the understanding of how CT is socially constructed in digitally oriented classroom contexts, capturing the different dimensions ascribed to computational thinking such as creativity, problem solving and scientific literacy practices.

Methodology. The overall research approach in MASCOT is design based research (DBR) (Juuti & Lavonen, 2006; McKenney & Reeves, 2018). In DBR emerging insights evolve over time through multiple iterations of investigation, testing and refinement (McKenney & Reeves, 2018). In our project we will collaborate with teachers from different partner schools and refine interventions based on mutual discussions. Therefore, DBR is well suited to investigating the complex realities of teaching, learning and assessing computational thinking both as a generic and subject-specific skill. When conducting projects within the field of practice, DBR has clear advantages because it focuses on collaboration between researchers and practitioners. This will help the project to extend on previous research on CT to improve professional educational practices in TE and schools. In MASCOT, the research will be shaped by literature (WP1), participant expertise and field testing, and performed as a close collaboration with the field of practice (WP2-5 - see Figure 1). MASCOT combines complementary methodological approaches, including document analysis (see WP1 below), thematic and interaction analysis. While a thematic analysis provides an opportunity to view patterns across the whole corpus of data, interaction analysis is useful for analysing the social interactions between the participants and their use of artefacts during their learning processes. This three-tiered approach allows for in-depth analysis of both in-situ interaction and a broader perspective on evolving processes (Moen, Mørch, & Paavola, 2012). The methodological and analytical approaches are explained in more detail in the description of the WPs below.

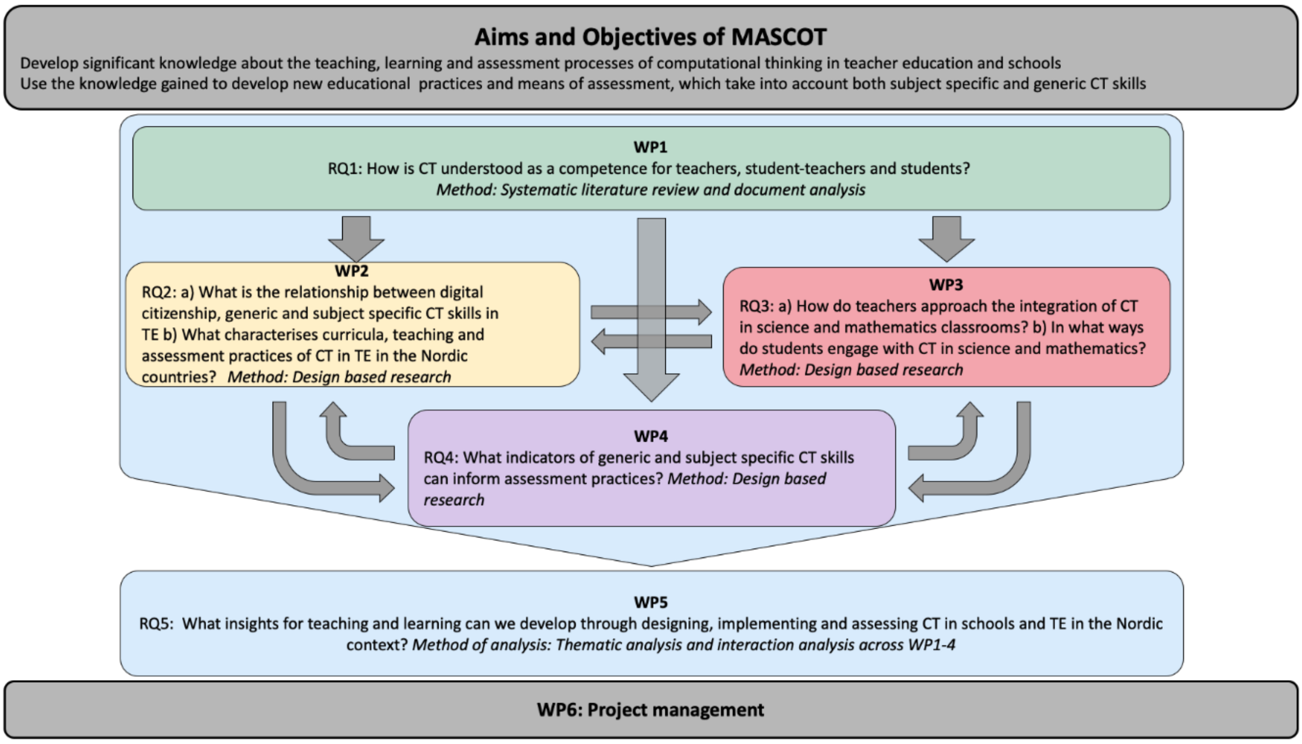

Figure 1: Project structure, aims, objectives, and the interdependent relation between the work packages.

Work packages

Work package 1: Systematic review of computational thinking in education

Leader: Mifsud; Co-leader: Holt; Participants: Ebbesen, Dokken Sollid, Lavonen, Rehder. Months 1–18.

RQ1: How is CT understood as a competence for teachers, student-teachers and students?

WP1 aims to investigate key elements and scope of definitions, understandings and presentations of computational thinking in school and TE in internationally published literature and Nordic policy documents, through conducting an extensive systematic literature review and a document analysis of policy documents. This review is the first step in the research design, where the field of practice is partly shaped by the literature. The aims of the systematic review are to identify available knowledge for professional practice, experts within the field, unpublished sources and effective research techniques (Fink, 2019), thus establishing an overall understanding of the field (macro-level). The systematic review will follow Fink's well-established 7-step process to ensure that the results of the review can be independently reproduced (select research question, identify search terms, screen, pilot review, review, synthesize results, conduct descriptive or analytic review). In addition, policy documents will be analysed using document analysis (Bowen, 2009) to identify, compare and analyse the policies, with a particular focus on how computational thinking is mentioned in relation to education and TE, relating this to the review. The design of the interventions in WPs 2, 3 and 4 will draw on the insights gained from the review.

Work package 2: Computational thinking in teacher education

Leader: Schrøder; Co-leader: Aalbergsjø; Participants: Swensen, Ebbesen, Møller, Middelboe Rehder, Pajchel, Rognes, Andersen, Sundtjønn, PhD student 1. Months 4-36.

RQ2: a) What is the relationship between digital citizenship, generic and subject specific CT skills in TE b) What characterises curricula, teaching and assessment practices of CT in TE in the Nordic countries?

WP2 aims to investigate and understand the opportunities and challenges of introducing CT in TE and to understand the relationship between computational thinking as a generic skill, computational thinking as subject-specific skills, and digital citizenship. Currently, CT education in Denmark is part of a broader cross-curricular subject (Technology Comprehension) which includes both CT and digital citizenship, while in Norway CT is implemented in specific subjects. However, digital citizenship is a core concept in the Norwegian curriculum as well, oriented around the need for students to understand the digitalization of society (NDET 2019). WP2 will seek to conceptualise and clarify the relationship between digital citizenship and more specific CT skills in both countries.

Drawing on DBR, WP2 develops and examines new ways of teaching and building curricula in Danish and Norwegian TE within the area of CT and digital citizenship, as part of generic and subject-specific skills. The research design will consist of two intervention cycles with four phases each, drawing on the work by Amiel and Reeves (2008): 1) Analysis of practical problems by researchers and practitioners in collaboration, 2) Development of solutions informed by existing design principles and technological innovations, 3) Iterative testing and refinement of solutions in practice, and 4) Reflection to produce "design principles" and enhance solution implementation. The student perspective will inform the evaluation in steps 3 and 4 through student interviews. The first cycle (C1) will be performed by København profesjonshøjskole/University College Copenhagen (KP) (C1- KP). Benefiting from the evaluations and findings from the first cycle, the revised second cycle (C2) will be performed at KP (C2- KP), OsloMet (OM) (C2- OM) and Inland Norway University of Applied Sciences (INN) (C2- INN). The analytical framework for WP2 is built around findings from WP1 augmented by the three key dimensions of CT developed by Resnick: 'computational concepts', 'computational practices' and 'computational perspectives' (Brennan & Resnick, 2012). This framework is used to investigate the wide variety of concepts, practices and perspectives incorporated in the development of new curricula in TE. Data will be collected through video and participant observations, interviews of 40 student teachers and teachers, and student-created artefacts (also linked to WP4 and WP5). Data will be analysed using thematic analysis giving an overview of the whole corpus of data (Braun & Clarke, 2006) and interaction analysis scrutinizing the trajectories of teaching and assessment practices (Jordan & Henderson, 1995).

Work package 3: Exploring teachers' and students' computational thinking practices in science and mathematics

Leader: Juuti; Co-leader: Rognes; Participants: Pajchel, Lavonen, Markkanen, Myllyviita, Loukomies, Holt, Aalbergsjø, Nordby, Mifsud, Teglverket school, Fagerlund school, Vigernes school. Months 5-38.

RQ3: a) How do teachers approach the integration of CT in science and mathematics classrooms? b) In what ways do students engage with CT in science and mathematics?

Through creative use of digital technologies, WP3 aims to design, implement and study digitally oriented computational thinking lessons in science and mathematics for classes in primary and secondary school. Drawing on WP1, WP3 will directly intervene in the classroom together with practitioners in two partner schools in Finland and three in Norway. The intervention involves several iterative collaborations between the field of practice (school) and participant expertise (teachers and researchers) through annual workshops and school visits. In designing the interventions, researchers scaffold teachers' classroom practice, thereby ensuring user involvement. WP3 aims at empowering teachers and students to model, analyse and design solutions to real-world problems integrating science and design practices (Inkinen et al., 2020; Sinervo et al., 2020). In order to capture the richness of the learning processes, data will be collected through video and participant observations, students' self-generated "video-blogs" (Loukomies, Juuti, Lavonen, & Salmela-Aro, 2019), interviews of 30 students and 4 teachers, student-created artefacts and learning outcome data (also linked to WP4 and WP5). Data will be analysed using thematic and interaction analysis. These data combined will provide a unique basis for understanding how computational thinking is taught and learnt as a subject-specific and generic skill in subject-specific classes. Findings from WP3 will be analysed and integrated as research-based content for student teachers (related to WP2) and school practice.

Work package 4: Assessment of computational thinking in science and mathematics

Leader: Pajchel; Co-leader: Lavonen; Participants: Juuti, Markannen, Myllivattni, Aalbergsjø, Rognes, Loukomies, PhD student 2 (OFFPhD), Teglverket school, Fagerlund school, Vigernes school. Months 6-38.

RQ4: What indicators of generic and subject specific CT skills can inform assessment practices?

WP4 aims to identify features of CT that can be used in connection with assessment, and to develop assessment methods that support and evaluate students' learning processes and outcomes. The core curricula of the countries represented in the project contain both learning goals and assessment criteria. The new Norwegian curriculum also highlights the importance of fostering students' awareness of assessment both as a tool for giving direction to the students' knowledge creation and for displaying their competences (NDET 2019). However, before teachers can do this they need to develop an understanding of what to assess and what assessment methods need to be applied to support the students' learning processes and outcomes in CT. Such criteria are currently not operationalised in the curriculum. Assessment is therefore a central part of the planned intervention cycles, and data collection and analysis will be integrated in the DBR approach of WP2 and WP3, where collected information will feed into the iterative testing, refinement and reflection. Building on existing analytical frameworks related to both generic and subject-specific CT skills (Brennan & Resnick, 2012; Weintrop et al., 2016), WP4 aims to design a rich spectrum of assessment criteria and methods, and thus also address assessment challenges which arise from tensions between generic and subject-specific skills. The methods of assessment developed in WP4 will cover a range of evaluative approaches that are relevant in educational contexts, including summative, formative and diagnostic approaches.

Work package 5: Identifying interdisciplinary synergies of computational thinking

Leader: Andersen; Co-leaders: Rognes, Aalbergsjø, Juuti, Holt; Participants: Møller, Mifsud, PhD student 3, Teglverket school, Fagerlund school, Vigernes school. Months 22–42.

RQ5: **What insights for teaching and learning can we develop through designing, implementing and assessing CT in schools and TE in the Nordic context?**

WP5 aims to integrate, compare and analyse research findings across WP2-3-4, and use these findings to add to current theoretical insights of CT (WP1). WP5 straddles the whole project, providing the link between teaching, learning and assessing CT, both as a generic and a subject-specific skill, both in TE and school practice in the Nordic countries. The work done in WP5 is crucial to achieving synergy between the TE and schools, including especially a mutually informed understanding of generic and subject-specific aspects of CT in these two spheres. WP5 is where research from the other WPs will be integrated and consolidated, in order to push the research front forward, especially with theoretical advances. The resulting research-based knowledge will be of significant value to emerging practices regarding CT in TE and schools, as well as providing valuable input to policymakers. The Advisory Board will play a crucial role throughout the whole project period but will in particular have an invaluable role in WP5, discussing the research findings and identifying interdisciplinary synergies of computational thinking (see section 3 - Implementation).

Work package 6: Project management

Leader: Mifsud; Co-leaders: Andersen, Pajchel. Months 1-42.

The final WP will ensure the running of the project according to plan, the coordination between WPs and researchers at different institutions as well as the Advisory Board (AB) and National Stakeholder Committee (NSC). WP6 is described in more detail in section 3.2.

Risks. MASCOT has taken measures to minimize risk in both project management and research activities. All WPs have a WP leader and co-leader in place in case of sickness or other unforeseen events. A data management plan will be developed, and a steering committee with members from participating institutions and schools and covering all WPs will be established. The partner schools involved are university schools or teaching placement schools. These schools have a history of collaborating with their respective TE institutions (letters of intent attached). Some of the technological means of MASCOT's data collection, such as reflexive blogging, are ambitious; however, students of all ages are highly skilled in using tools related to digital communication. Methods of data collection will also be adjusted to the primary school participants. The application to be used for video blogging is relatively new, and together with NSD Data Protection Services, we will determine if a data protection impact assessment (DPIA) is required. Data will be stored at the University of Oslo's Service for Secure Data (TSD).

Ethical perspectives. MASCOT will collect qualitative data from both TE institutions and classrooms with students aged 7-15. This requires research permission from the national boards of ethics in the different countries. In addition to obtaining parents' consent, the students will receive information adapted to their age, and their consent to participate will be sought. We will emphasize that their decision on whether to participate will not affect their relations with the school. Design experiments are planned along the local curricula and co-designed with teachers. This means it will be adjusted to the local schools and not interfere or disrupt with their teaching. Data collection will interfere minimally with students' learning. Students will only be asked to self-report matters that are pedagogically relevant and useful from a learning perspective.

Gender issues. Gender is clearly a relevant aspect of CT. Concerns have been raised about girls' lower and different interest in computational thinking activities, and girls have traditionally opted out of CT classes.

The integration of CT in mandatory subjects instead of in optional computational science subjects, rules out self-selection of CT (Weintrop et al., 2016). Through creating learning designs that also appeal to girls, MASCOT may therefore contribute towards reducing the effects of stereotyping CT. The research team is gender-balanced, with male and female participants, a female project leader and a combination of male and female WP-leaders and co-leaders.

Interdisciplinary approach. MASCOT is an interdisciplinary collaborative project, drawing on the fields of STEM education, educational science and computer science. In order to advance our fundamental understanding of CT in education MASCOT integrates knowledge, perspectives and concepts from these different disciplines.

Stakeholder/user knowledge. MASCOT has established both a national stakeholder committee (NSC) and an international Advisory Board (AB). The NSC will be engaged in planning the incorporation of the new insights in future policy and ensuring the dissemination of results. The AB will advise on the general direction of the project as well as on ethical and methodological issues, as well as contribute to dissemination and impact activities.

1.3 Novelty and ambition

MASCOT will fill several gaps in existing research on CT in education. The introduction of CT both as a generic skill and as a subject-specific skill in the Nordic countries has implications for how and what to teach, learn and assess. The interplay between the different approaches to CT is complex. MASCOT aims significantly to expand current research in this field through intervening and studying the different approaches in Nordic teacher educations and schools. This research agenda makes MASCOT an original and ambitious project, even more so for the following reasons: The project has a comprehensive research program which connects school and TE; it has an interdisciplinary approach to researching the interconnections of CT as a generic and subject-specific skill; its innovative interventions engage a broad composition of researchers, practitioners and students who will provide complementary perspectives on learning and assessment of CT; and its unique Nordic consortium of researchers bring in different perspectives on CT and international comparative approaches. In this manner, the project aims to produce new theoretical insights into CT combined with empirical knowledge from the classroom and TE. It thereby has the potential to make a significant contribution to the development of theory in the field of education and in particular with respect to assessment. Moreover, as a research – practice partnership project it also has the ambition to inform CT practices in TE and in actual classroom settings.

2 Impact

MASCOT will have significant societal as well as academic impact, in both an immediate and a long-term perspective. The major outcome of MASCOT is increased knowledge about teaching, learning and assessment processes regarding computational thinking (CT) in a Nordic context. Through MASCOT OsloMet, with (representing) ~~its~~ expert consortium of Nordic partners and close collaboration with (between) TE and schools, aims at empowering student teachers and teachers with the tools and renewed state-of-the-art knowledge necessary to teach and assess CT as a generic and subject-specific skill, and consequently prepare students for the future. The project bridges knowledge and research from schools and TE, enhancing professional practice as well as research-based TE.

2.1 Potential for academic impact of the research project

MASCOT has the potential to make a significant academic impact. The project employs an innovative methodological approach, that combines different types of data (documents, observation, self-reflective videoblogging, interviews) and a variety of Nordic approaches that give a unique opportunity to scrutinize CT as a phenomenon from different angles. Furthermore, MASCOT will move the research on CT beyond the state of the art through a firm theoretical foundation and close collaboration between practitioners (teachers and student teachers) and researchers. The new insights will contribute to an improved understanding of the complex notion of CT in education. It will also result in crucial knowledge about assessment in CT, an area where the lack of research has been a particular concern. For its academic output, MASCOT targets high-quality international journals and conferences, which will ensure that the research conforms with high standards. MASCOT will strive to publish in Open Access journals when possible. WP1-5 will have the following deliverables:

WP1: A *framework* overview of concepts of CT (D1.1), a *conference presentation* (D1.2) at an education conference such as EC-TEL and an *academic publication* in a peer reviewed journal (D1.3) such as Computers and Education or Technology, Media and Education.

WP2: Two *conference contributions* (D2.1 and D2.2), a Nordic conference (e.g. Nordic Educational Research Association (NERA) and one European conference (e.g. ICERI or ESERA), and two *research articles* (D2.3 and D2.4) in Nordic or national journals (e.g. Nordic Journal of Digital Literacy and Tidsskriftet Læring og Medier (LOM)).

WP3: Four *presentations* at a national or international conference or network meeting in Finland and Norway (D3.1) and two *articles* (D3.2 and D3.3) in for example Educational Science, Science Education or Mathematics education journals such as Nordic Studies in Science Education (NORDINA).

WP4: *Framework criteria* for assessing subject-specific and generic computational thinking competences (D4.1), presented at one *international conference* (D4.2) and two *articles* (D4.3 and D4.4) in international journals, for example BJET, Computers and Education.

WP5: The final conference will be arranged as a *symposium* at a conference such as ATEE or ECER, (D5.1) and a *special issue* in a relevant journal (4-6 articles), such as the Nordic Journal of Digital Literacy or Technology, Knowledge and Learning (D5.2) drawing on findings from across the whole project.

2.2 Potential for societal impact of the research project

MASCOT aims to produce the knowledge and tools that schools, and teachers, need in order to enable students to develop and display CT competences. The project is in other words conceived and designed as a response to a set of research needs arising from new curricula – curricula which in turn are a response to developments in society that have brought a shift in competence needs for future citizens. The fundamental long-term societal impact of the project, therefore, is that it will contribute to fulfilling central new curricular goals that will prepare students for life and work in the 21st century.

MASCOT is strongly in line with the Nordic strategies for digitalisation of higher education and schools. This relevance is further secured through the project's close collaborations with TE, schools and stakeholders, ensuring that the research maintains a solid grounding in and relevance for all the involved spheres. As one prime objectives of MASCOT is to bridge the gap between the academic and practice field, MASCOT will facilitate an application for a PhD fellowship from the public sector through the Research Council of Norway's OFFPHD-programme. The prospected OFFPHD candidate will be part of OsloMet, Faculty of Teacher Education and International Studies' PhD programme.

The interdisciplinary and international nature of the research project targets a broad audience, increasing the potential for impact beyond the research community. Through close collaboration with the AB and NSC, MASCOT has established strategic connections with relevant stakeholders and researchers in both departmental and academic sectors in order directly to link research with practice and policy. Stakeholders have been carefully chosen for the potential for dissemination and influence on policy making, such as central employees at the Directorate of Education and National Science Centre as well as teachers from the project group.

2.3 Measures for communication and exploitation

MASCOT's dissemination plan involves all partners, the Advisory Board, and the National Stakeholder Committee, thereby targeting national and international audiences. MASCOT plans three types of dissemination activities: *scientific publications*, *communication with the research community,* and *communication with practitioners and stakeholders*. The project includes several dissemination activities and co-publications across the research group.

Scientific publication: The project aims to publish ten to twelve scientific articles in leading Nordic or international peer-reviewed journals (see section 2.1 for details).

Communication with the research community: The project aims to target research conferences in Europe and the Nordic countries (see section 2.1 for details).

Communication with practitioners and stakeholders: MASCOT will reach out to national stakeholders and practitioner meeting places, such as professional teachers and teacher educator networks in Norway (National Network for Science) and Denmark's Learning Festival, and national networks concerned with

Technology Comprehension in schools (Nationalt netværk om teknologiforståelse for grundskole/National network about Technology Comprehension in Primary and Secondary School) and similar fora in Finland. MASCOT will also target popular scientific magazines such as Bedre skole, Tangenten and Naturfag. MASCOT aims at reaching a broad specter of people with the research by also making the results from the research activities available in different social media channels such as Facebook, Twitter and Snapchat in order to reach a larger audience, for example teachers in schools who usually do not follow the more formal research channels. A project website will be created to disseminate results and increase impact.

3 Implementation

3.1 Project manager and project group

MASCOT will be managed by the Department of Primary and Secondary Education (GFU) at the Faculty of Teacher Education and International Studies (LUI), **Oslo Metropolitan University**, the leading TE institution in Norway. The research will be done in close collaboration with other leading Nordic TE institutions: **University College Copenhagen** (KP), **University of Helsinki** (UoH) and **Inland Norway University of Applied Sciences** (INN).

The project manager is Professor **Louise Mifsud** (CV attached), an experienced educational scientist who has led several international projects and has 20 years of experience contributing in the field of technology enhanced learning. The project team is further composed of **an interdisciplinary group of experts** from STEM education, computer science and education (technology enhanced learning), as well as DBR-specialists. The team is organised around and across the WPs to ensure that the knowledge gained in each WP is transferred to the others. Thus, each WP team has been assigned at least one expert from each area, and members from each of the other WPs participate in WP5. Participants from each university lead or co-lead at least one WP to ensure commitment and to enhance a common understanding of the theoretical foundation elaborated as part of WP1.

The project team covers the following combinations of expertise and consists of the following researchers (CVs attached): STEM and CT (**Katarina Pajchel, Siv G. Aalbergsjø, Andre Rognes, Per Øyvind Dokken Sollid, Jari Lavonen, Anne Holt, Trude Sundtjønn, Kristin Ebbesen, Siri Nordby**); DBR and STEM (**Kalle Juuti, Anni Loukomies,** Jari Lavonen); technology enhanced learning (**Vibeke Schrøder, Mads M. Rehder, Emilie Møller,** Louise Mifsud); and CT in education (**Renate Andersen, Håkon Swensen,** Katarina Pajchel, Siv G. Aalbergsjø, Per Øyvind Dokken Sollid). The project also includes two young teacher-researchers from Finnish partner schools who are currently in the process of finalising their PhD dissertations on digital tools and science education (**Ari Myllyviita** and **Aleksi Markkanen**), and six teachers from Norwegian partner schools, enhancing the sector-university collaboration.

Together, the team members bring a wide range of experience to the project, and many of the members are also part of other research initiatives, which will open for considerable synergy effects and a wider international network. The team will be further complemented by **3 PhD students** based at OsloMet. Two will be employed with open calls if the project gets funded; one will be supported by the project and the other by OsloMet/LUI and the third recruited through OFFPHD. Finally, the project team will include **master student research assistants**, who will be involved through their master projects as well as in various administrative aspects.

MASCOT will also have an **Advisory Board (AB)**, composed of the following international figures in the field who are able and willing to provide independent advice and expertise to the project: **Dr. Tor Ole Odden**, University of Oslo, expert in science and computational thinking; **Prof. Anders Mørch**, University of Oslo, expert in technology enhanced learning; **Prof. Susan McKenney**, University of Twente, expert in DBR; **Prof. Elaine Munthe**, University of Stavanger, expert on TE, and **Dr. Michael E. Caspersen**, University of Aarhus, expert on computational thinking. The AB members are selected for their expertise relevant to the themes addressed in MASCOT and with the aim of **reaching a wide range of academic and non-academic communities and maximising the project's impact in those spheres.** Beyond the project group and AB, the project team will draw on a solid network at each of the TE departments, where there are strong and well-established research groups especially within the fields of school subjects, educational science and digital competence.

3.2 Project organisation and management

Project organisation and management is organised as a separate work package (WP6), led by Louise Mifsud. Renate Andersen and Katarina Pajchel will be co-leaders, both in order to ensure the robustness of the management and to provide project continuity in case of unforeseen events. The objective of WP6 is to ensure the quality of implementation of MASCOT. WP6 is organized in four main tasks. **Task 6.1**. is to work on all formal procedures and administration, overseeing and monitoring all project activities, application to ethical board and ethical considerations. **Task 6.2** and **Task 6.3** are to organise the Advisory Board (AB) and National Stakeholder Committee (NSC). **Task 6.4** is to organise and establish a mandate for a steering committee (SC). The project leader and WP leaders will make up the SC. This committee will meet on a regular basis to discuss progress and project strategy. **Task 6.5** is to create a website and social media and organise both online and face-to-face meetings and research activities. An online platform will be used for communication, to share working documents, and other relevant material. Regular meetings are important for risk management and discussing critical points and alternative ways to implement the research plan. Project members will meet regularly, either for WP-workshops or online. WP leaders are otherwise responsible for organising the activities within each WP. MASCOT plans two 2-day workshops (in 2021 and 2023) with the international scientific advisory board. Figure 2 below gives a summary of the main activities, tasks and deliverables of the project.

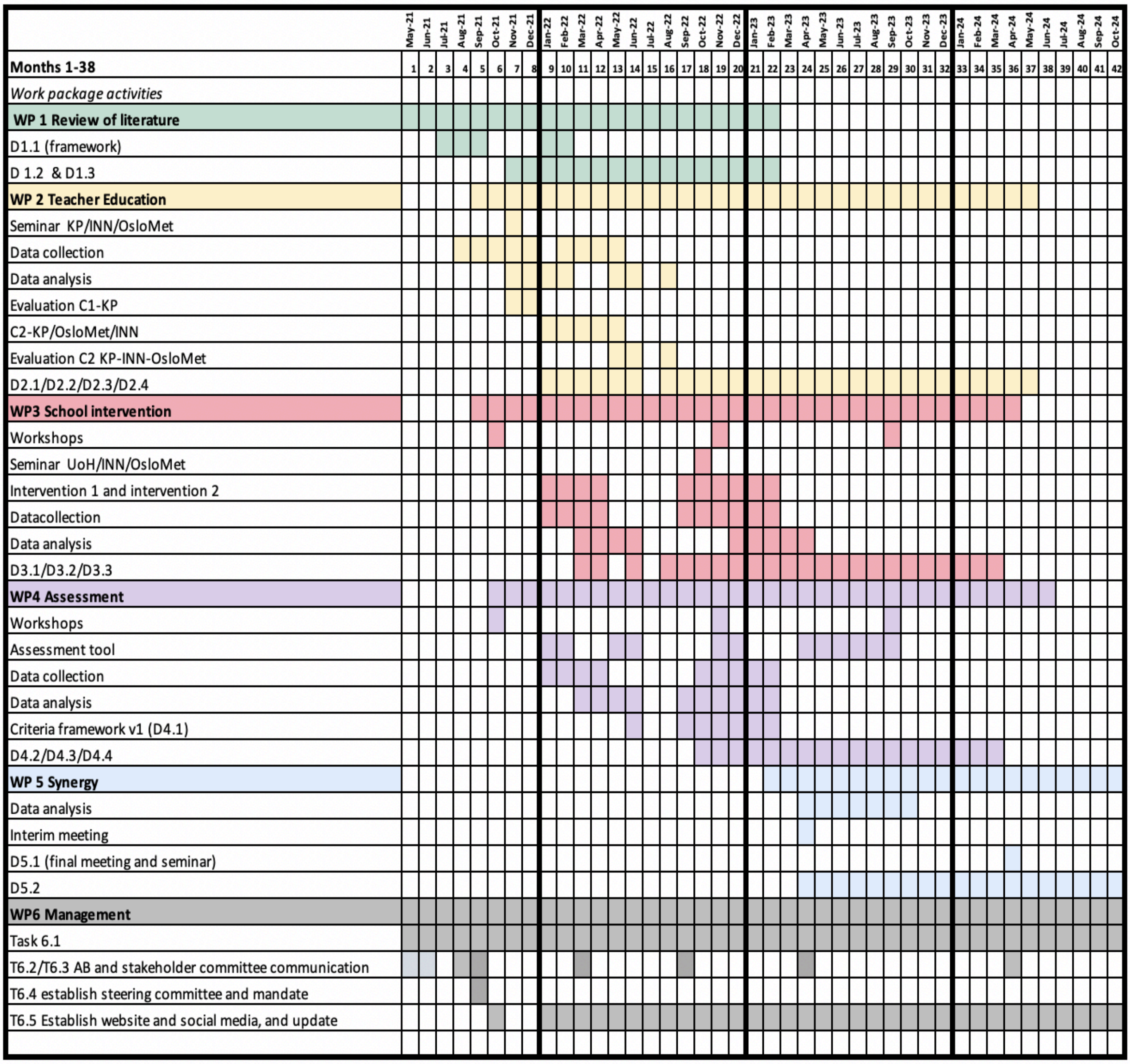

Figure 2: Gantt chart

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