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# Comparing the implementation of programming and computational thinking in Denmark, Sweden and England

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## Background

The mathematical competencies that students need in the 21st century contain a sizeable digital element and include programming and computational thinking (PCT). Many countries are attempting to implement PCT in compulsory education (Bocconi et al., 2016), calling for a range of national and local decisions about the relation between mathematics and technology teaching. These decisions regard content, the group of teachers responsible, and the school subjects adopting PCT.

Different countries are investing massively in pursuing different paths relating PCT and digital mathematics. Still, there is currently no solid knowledge foundation on which decisions about these matters can rely. In some cases, PCT is considered part of mathematics. Others view it as part of an integrated science topic, a transdisciplinary element in all topics, or a subject in its own right.

The Danish government is experimenting with a two-tier strategy where PCT is both a subject or specialization and an approach integrated into subjects. In Sweden, programming has been a compulsory part of the mathematics curriculum from grades 1-9 to since August 2018. Here, PCT is strongly associated with algebraic thinking and the concept of algorithm. In the UK, programming has been part of the curriculum since 2013 as an individual topic, with an explicit dedication to algorithmic and computational thinking. Being a first-mover, the UK has solid experiences with the various challenges of implementing programming into compulsory school, including mathematics.

## Approach

The so-called second wave of focus on PCT in compulsory education can be traced back to Wing (2006), who described computational thinking (CT) as decomposition, data representation and pattern recognition, abstractions, and algorithms. Building on Wing's definition, educational research has attempted to clarify and activate CT as a set of teachable competencies. This endeavour is often done by highlighting the relations to mathematical competencies such as abstraction, problem-solving, modelling and algorithm building.

To study the relation between mathematics and programming, we apply the Danish competencies framework (Niss & Højgaard, 2011) augmented with the notion of "Mathematical Digital Competencies (MDC)" (Geraniou & Jankvist, 2019). MDC involve "being aware of which digital

tools to apply within different mathematical situations and contexts, and being aware of the different tools' capabilities and limitations" as well as "being able to use digital technology reflectively in problem-solving and when learning mathematics" (p. 43). It also entails "being able to engage in a techno-mathematical discourse" (p. 42), which we envision becomes crucial concerning PCT.

Besides giving theoretical meaning to PCT and MDC, we acknowledge the need to study implementation aspects, such as the lack of PCT-trained teachers and curricular compatibility. We relate to the work in implementation research in mathematics education (Koichu et al. 2021; Jankvist et al. 2021) to frame the inclusion of PCT as an educational innovation set to be put into practice.

## Method and Plan

The project combines a comparative study of how PCT is integrated with mathematics teaching at the compulsory level in three countries with design experiments and the development of exemplars. To develop synergies between mathematics teaching and PCT in the Danish school system, we are in the process of comparing approaches and collecting resources from the three countries (mid-2020 to mid-2022). This work is described in Elicer and Tamborg (forthcoming). Based on these findings, we are planning design-based interventions to verify and refine our understanding of potential synergies between PCT and mathematics (early 2021 to early 2023). The refined teaching sequences and model of synergies will be developed as educational resources in the last part of the project (2023 and 2024).

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