BRIDGING COMPUTATIONAL THINKING AND ARTIFICIAL INTELLIGENCE IN SWEDISH CLASSROOMS: THE POTENTIAL OF EMERGENT TECHNOLOGIES IN K-12

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ABSTRACT
Artificial intelligence (AI) and other emergent technologies are increasingly used in different areas of our modern society thus the importance of developing digital competences among young students is a clear necessity. Efforts towards the development of digital competences in K-12 education have been made with the introduction of programming and computational thinking (CT) in different countries around the world. However, AI-related education in K-12 is still trying to find its place (Touretzky & Gardner-Mccune, 2019). In the particular case of Sweden, efforts towards developing digital competences among K-12 students have been made with the introduction in 2018 of programming education in the subject matters of mathematics and technology (Skolverket, 2018). However, both CT and AI literacy have only been implicitly included in the current study programs (Skolverket [the Swedish National Agency for Education],2022). Developing AI literacy in young students is therefore among the urgent challenges that Swedish K-12 education must face in the coming years.

In order to better understand the challenges of introducing AI concepts to students that have no previous formal education in this field, we conducted a small exploratory study with a class of 8th graders (17 students aged 14-15) that was carried out during the autumn semester 2023/2024 in a municipal school in southern Sweden. This group of students had previous experience doing basic programming, as they had received education in this topic as part of their study programm, however they had received no previous formal education in AI technology. The study consisted of six workshop sessions for a total of 16 classroom hours. The activities carried out with the students were mainly focused on introducing basic concepts of AI and machine learning (ML), with only a few activities focusing on traditional rule-based programming. These workshops were loosely based on the MIT AI Ethics Curriculum (Payne, 2019) and the AI literacy competency framework from Long and Magerko (2020), for those activities focused on AI, and the framework for assessing development of CT (Brennan & Resnick, 2012), for those activities focused on CT and rule-based programming. Regarding the pedagocical

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methods, for the design of the activities for this workshop series we used *challenge-based learning* and *inquiry-based learning*, both with a constructionist approach, thus these workshops had a special emphasis on hands-on activities.

The selection of tools we used was based on the specific topics that we wanted to cover for introducing the students to general concepts of AI technology while at the same time reviewing some basic concepts of programming. Some of these tools are well-known, such as Machine Learning for Kids, Scratch and Teachable Machine, which are widely used as they are web-based tools that can run on any laptop computer. However, we also used some other less known tools such as Misty Robotics, a so-called social robot which uses AI-based technology such as natural language processing, computer vision, and other functions based on ML techniques. The selection of educational tools for these workshops was made not just to cover the specific topics of CT and AI, but also to offer a fun experience that would increase students' engagement in the activities.

The main methods we used for data collection during the workshops were: (1) screen recordings, (2) sound recordings, (3) participant-generated content, and (4) observations and field notes. The method for the data analysis was qualitative content analysis. We used the AI literacy and competencies from Long and Magerko (2020) to assess the activities regarding AI and ML, and the framework for CT assessment from Brennan and Resnick (2012) to evaluate the activities regarding rule-based programming. Our results suggest that there are several challenges when introducing young students to basic concepts of AI and ML and even regarding traditional programming we identified some relevant issues. For example, in one of the activities where students were given different challenges of programming small robots, out of five challenges, only the first one (the simplest which required the use of loops) was completed by all the students. The other four challenges which required using programming concepts such as conditionals, logic/arithmetic operators and variables, were completed by less than 50% of the students. As for the activities related to AI and ML, after the students tried different tools working with concepts such as image and sound recognition, training ML models and trying different methods such as unsupervised and supervised ML, over 90% of them managed to provide a definition of AI that is at least partly related to the main AI competencies listed in the framework for AI literacy (Long & Magerko, 2020). Nevertheless, when engaging in activities where the students had to create a working solution based on AI and ML, the rate of success was as low as 20%. Among the possible reasons for this relatively low performance of students when devising a working solution using rule-based programming and AI methods could be their limited skills in traditional programming. In addition, althugh students seemed to have managed to acquire an understanding of basic AI concepts and principles, this knowledge might still be superficial and thus the students struggled when trying to transfer the knowledge they acquired on AI to other contexts different from those they had to deal with during the workshops. An integrated and complementary teaching of CT and AI is therefore necessary for developing AI literacy, increasing digital competences and fostering problem-solving skills.

In future studies we intend to continue exploring how to bring together CT and AI in K-12 education using social robots and other types of physical computing. The idea is to explore the possibilities offered by the many sensors and input methods that modern robotics have to study to what extent AI methods such as ML can help students create innovative solutions that, in combination with traditional rule-based programming, could improve their skills to solve problems and create innovative digital solutions.

Keywords: Computational Thinking, Programming, Artificial Intelligence, Machine Learning, AI literacy, K-12 education

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