Enhancing the Role of Computational Thinking in Primary and Secondary Education in Switzerland (Poster Abstract)

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ABSTRACT

Computational Thinking (CT) is a fundamental and important skill set in our world and should therefore be taught and practiced in school. In this poster abstract, we present our ongoing initiative on establishing CT as a fundamental and interdisciplinary contribution of Computer Science as a necessary component of general education and describe our aim to enhance the knowledge about it in Switzerland's teacher communities. We give an outline of our planned activities and present first results from a field test in a Swiss high school with an original example of CT-tailored teaching material for the subject of logic.

CCS CONCEPTS

• **Social and professional topics → Computing education programs**; **Computational thinking**;

KEYWORDS

computational thinking, teacher education, primary and secondary education

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1 INTRODUCTION

As stated in the seminal article by Wing [8], CT is a fundamental and important skill set in our digital world and will be used by everyone by the middle of the 21st Century. As put in [6], CT "is regarded as one of the main contributions of informatics to general education". According to [4], CT can be seen "as a mental discipline for thinking about designing computations of all kinds, a skill at the advanced levels honed and improved through extensive practice and experience." Therefore, CT should be taught and practiced in computer science and other school subjects.

Teachers at Swiss primary and secondary schools need to be assisted in their continued professional development in order to put more emphasis on CT in Swiss schools. Or as stated in [4]: "we hope that all teachers of computing bring their students a good sense of the richness and beauty of the many dimensions of computation."

Switzerland has a general shortage of professionals in STEM jobs and lacks teachers for STEM subjects in Swiss general education [5]. We aim to contribute to the CT skills of Swiss pupils and medium-term to the mitigation of the shortage of professionals in STEM jobs. To quote [5]: "A sustainable increase in the proportion of STEM courses in the number of tertiary courses can only succeed if the interest in mathematics and technology that exists among Swiss pupils towards the end of lower secondary education can be increased."

Therefore, we started an initiative that aims at enhancing the role of computational thinking in general education in Switzerland and give a short overview in the following sections.

2 OUR APPROACH

We seek to foster the role of CT in primary and secondary education in Switzerland. We build on previous work like e.g. [6] where around 30 self-contained teaching units have been designed in six different school subjects. As [4] sees CT "as mostly domain dependent — for example, how you think about computation in biology is different from physics, chemistry, or humanities", we are convinced it makes sense to target different school subjects. We plan to design and provide a collection of suitable exemplary self-contained teaching units for (Swiss) teachers and promote this material through workshops in continuing education for teachers.

We follow the approach of design-based-research [2, 7] and interdisciplinarily develop and test teaching material suitable to introduce the idea of CT in different school topics. For this we are collaborating with experts and teachers from various fields, both from Swiss secondary and tertiary schools. For qualitative evaluation and iterative improvement, we test our approaches and its accompanied teaching materials at schools directly with the target audience. Our approach consists of three main parts, as described in the following three subsections.

2.1 Developing original teaching material

Our plan is to provide original teaching material for different school topics and levels, suitable for introducing or fostering ideas from CT. This original teaching material will be developed, tested in classes and provided online. In comparison to the previous work by [6] (where around 30 self-contained teaching units have been designed in six different school subjects), which had a main emphasis on primary education, we focus on secondary education and thus plan to partially reuse and adapt material already designed and made available by others.

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To give an impression of the direction we are heading to, we shortly outline an original idea for a concrete teaching unit with CT-focus. The topic covered is logic, more specific propositional calculus, which relates to the learning goal "pupils are able to use logical operators" in the Swiss Lehrplan 21 [3]. This teaching sequence is based on the online learning environment LogicTraffic [1] which is since 2021 available online[1]. LogicTraffic allows for a contextualized introduction to propositional calculus through the real-world example of traffic control at road junctions with traffic lights, see figure 1. LogicTraffic consists of three main representations: situation (a road junction with traffic lights), a truth table (representing all combinations of traffic light settings) and formula editor (for direct entry of formulas). A formula is considered 'safe' for a given situation if it does not allow green traffic lights for any two intersecting lanes.

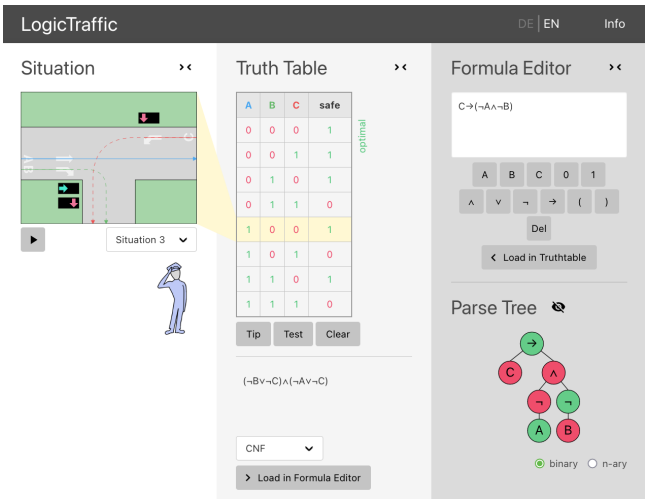

Figure 1: Screenshot of LogicTraffic showing two different safe formulas for the given road junction (one generated below the truth table, the other entered in the formula editor).

From a CT point of view, one of the most interesting question is how to come up with such safe formulas for given road junctions, i.e., without manually filling a truth table and have it automatically created that way. In our first field test in a high school in Zurich, we first gave the pupils a general introduction to logic and LogicTraffic, our teaching material used is available online[2]. We then presented the pupils two different procedures to construct safe formulas, one leading to formulas in conjunctive normal form (CNF), e.g.: $(\neg B \vee \neg C) \wedge (\neg A \vee \neg C)$ for the given situation in figure 1. The other procedure constructs formulas with an implication, e.g.: $C \rightarrow (\neg A \wedge \neg B)$ for the same example. In a sample poll, 10 out of 14 pupils found procedure two (with implication) easier and more intuitive to use, this led to fruitful discussions about different procedures solving the same problem. Further field tests and investigations are planned to become a clearer understanding of pupils preferred procedure to come up directly with safe formulas.

[1]https://www.logictraffic.ch/
[2]https://bit.ly/logic-22 (please note that all material is available in German only)

2.2 Searchable teaching material collection

Our second main contribution will be a collection of teaching material for different school subjects. This collection will be searchable by criteria such as subject and level, and will consist of our original material as well as references to material provides by others, e.g. [6]. This collection with sustainable visibility will support teachers with ready-made teaching material thus allowing them to integrate aspects of CT into their teaching activities with (hopefully) moderate effort.

2.3 Teacher training

With our personal and professional networks, we are able to reach a large number of (future) teachers in (Central) Switzerland. Besides pushing CT in the education of future STEM-teachers and giving workshops for current teachers, the trained students and teachers work as multiplicators for Swiss STEM-education promoting interdisciplinary, applicable, and contemporary examples of CT in different school subjects.

3 OUTLOOK AND FUTURE WORK

We believe that CT is an important skill set in the digital world. Having working and well-tested teaching material for different school subjects readily available for teachers is one promising ingredient to foster the role of CT in general education in Switzerland. With our low-barrier offers, we hope we can reach a critical mass of (future) teachers of different subjects and with various backgrounds and thus have a sustainable impact on the STEM education in Switzerland.

Much work and research still need to be done and there are many open questions, including the following ones:

- What makes teaching material (or a topic) suitable to convey the idea of CT?
- How can we identify existing teaching material as suitable for CT?
- How do we best evaluate if our approaches (materials, tools, workshops, …) are suitable for the desired purpose?
- How do we convince none-CS teachers of the importance of CT?

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