

Flemish Learning Objective: Pupils to Analyse the Impact of Digital Systems on Society through Computational Thinking

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Abstract

Flanders' mandatory learning objectives demand that pupils acquire the ability to analyse the societal impact of digital systems through the principles of computational thinking. To address the challenges teachers encounter in implementing this requirement, we have developed the Computational Thinking and Impact Framework.

CCS Concepts

• **Social and professional topics** → **K-12 education**.

Keywords

computational thinking, teacher training, impact of technology, K-12 education, curriculum

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1 Introduction

In an increasing number of countries, computer science has become a mandatory subject in schools and more and more the societal impact of digitalisation is being incorporated into the curriculum [3]. This also applies to Flanders, where new learning objectives have been introduced.¹ For middle school (K-7-8, since 2019): “The pupils purposefully design a digital and non-digital algorithm according to the principles of computational thinking and debug it”, referring to the core concepts ‘decomposition, abstraction, pattern recognition, and algorithmic thinking’. For high school (K-9-10, since 2023): “The pupils analyse the impact of digital systems on society from the principles of computational thinking”. The two objectives are mandatory for all pupils, regardless of their field of study, in general education and in VET (vocational education and training). In middle school, the focus lies in developing computational thinking (CT) skills. This includes that pupils can identify the building blocks of a digital system and comprehend how they interact to form a coherent

¹<https://onderwijsdoelen.be>



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system. In some cases, even recognising digital applications proves to be a demanding task [7]. In high school, the pupils must use CT “to lift the hood” [5] of a digital system or application. They apply CT to understand how a digital system functions and what its impact on their own lives or society could be.

Many teachers are not trained in CT and find it hard to teach [1]. The aforementioned learning objective for high school is even more complicated than mere applying CT. Furthermore, in Flanders, school principles have the autonomy to decide which teachers should teach these objectives and in which subjects, which often means that they differ from computer science classes. Therefore, to support teachers in overcoming this challenge, we propose The Computational Thinking and Impact Framework (CTI) in Figure 1.

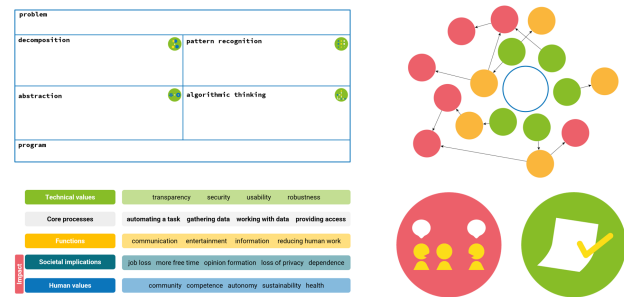


Figure 1: The CTI Framework consists of a computational thinking principles schema, a mind map, a societal impact table [6], and class discussion and assessment.

2 The CTI Framework

The CTI Framework consists of four elements designed to address the high school learning objective in a structured manner. In consultation with teacher trainers, pedagogical advisors, teachers, and computer scientists, and taking into account both the definition provided by the Flemish Government and the international consensus on what CT entails, we first defined CT and the core concepts decomposition, abstraction, pattern recognition, and algorithmic thinking.² We then elaborated examples showing how these concepts appear in a specific digital application (see the schema on the upper left in Figure 1). Dong et al. [2] found that their similar model stimulates teachers to make connections between CT and lesson content. This part of the framework can already be used in middle school to support a learning pathway towards high school, where pupils take it a step further. First, they use the CT schema to identify

²https://dwengo.org/en/computational_thinking/

the fundamental components of a digital system to understand its working. Subsequently, to analyse its impact, they use the mind map (upper right) and the ‘impact’ table (bottom left).

Inspired by the Future Wheel methodology [4], the framework stimulates learners to reflect on the implications of certain building blocks and examine the cascading effects that may arise from those initial consequences. The pupils construct a mind map to synthesise the interconnections among the components in the first schema and to analyse the implications of their functionalities. Then, they use this analysis to work towards a conclusion regarding the selected potential impact. To support this process, we provided the pupils with the ‘impact’ table as a guiding model. The original table was developed by Rücker [6], with whom we agree “to define impact in relation to human values”. We adopted his model with only minor adjustments. In consultation with pedagogical advisors, we removed the arrows and assigned ‘impact’ to the last two rows of the table. Pupils are allowed to remove elements from the second column they consider irrelevant and are encouraged to add new ones when appropriate. They should also be able to explain the final version of the table they deliver. The last part of the framework (bottom right) focuses on pupils to formulate a conclusion, which may take the form of a written report, an exit ticket, or an oral presentation. This stage could also include a class discussion of the pupils’ conclusions. All parts of the framework offer opportunities to assess pupils’ learning progress, for example through a portfolio. Finally, we encourage teachers to explicitly establish transfer to other similar digital applications. They could challenge their pupils to explore other digital applications that are comparable to the one discussed, to promote the transfer of knowledge to new contexts.

Figure 2 shows how the framework applies to the application of automatic water taps in public environments such as restaurants and libraries. Pupils could address the positive impact on health, but also sustainability or economics when focusing on reduced water consumption.

3 Conclusions and future work

The CTI Framework is being rolled out in Flanders through professional development initiatives that prepare teachers to start working with it. To support implementation and integration into classroom practice, we provide worked examples on our website. The high school activities start with a whole-class brainstorming session regarding a digital system, challenging the pupils to identify a possible impact on their own lives or society. The CT schema helps them to figure out its working and via the mind map tool and ‘impact’ table they analyse its impact. To end the task, they formulate a conclusion and often also participate in a class discussion.

Once rolled out, we plan to gather information on how teachers implement the high school learning objective “The pupils analyse the impact of digital systems on society from the principles of computational thinking”. We want to measure whether there is a difference in effectiveness regarding pupils’ learning outcomes between teachers who use our framework and those who do not.

Acknowledgments

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problem How does a tap that you can operate without touching it work?	
decomposition - What should the device do? When activated: water flows from the tap. After a while, the device should become inactive. - Is the tap set to a specific flow rate or duration? - Identify components: motion sensor or distance sensor; microcontroller. - What is the input? (Distance between hand and sensor) - What is the output? (Tap is open, dispenser is open, motor is running in towel dispenser.)	pattern recognition - All devices that are activated without being touched work with a sensor that detects something: distance to an object, movement, the breaking of an infrared beam, etc. They are therefore controlled by similar computer programmes. - Examples include automatic soap or towel dispensers and automatic sliding doors.
abstraction - The sensor determines the distance to an object. It does not take into account whether it is a human hand or not. - The tap opens when the hand is close enough to the sensor. Close enough is an abstraction of the distance you must choose when programming the microcontroller. - When programming, you can abstract this distance by using a variable.	algorithmic thinking - IF something is close to the sensor THEN the tap runs ELSE the tap does not run - More abstract: IF something is close to the sensor THEN the device is activated ELSE the device is not active
This activity can be done without a computer. If you choose to programme, you can do so using blocks.	

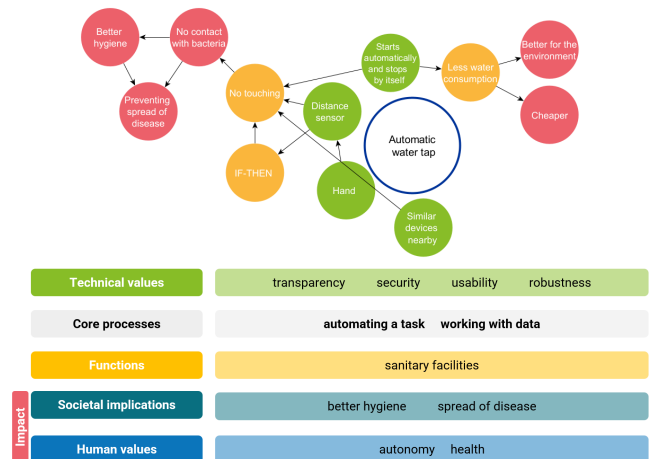


Figure 2: The CTI Framework to analyse the impact of automatic water taps in public environments.

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