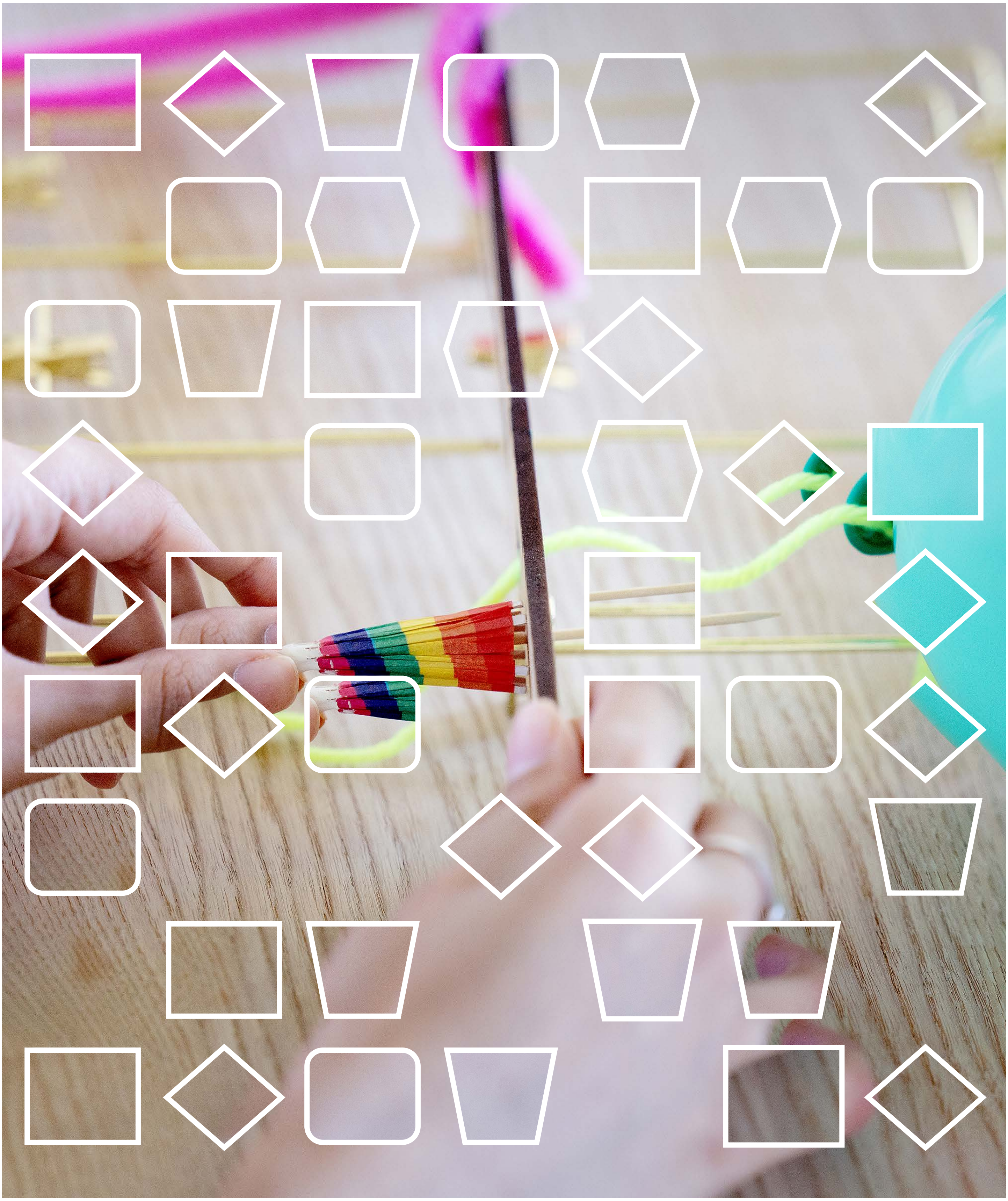
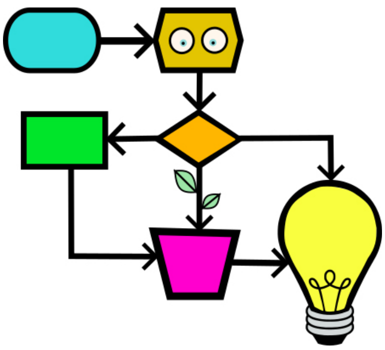


Roadmap for using Computational Thinking in schools



Summary

Computational Thinking

Computational Thinking (CT) is generally defined as "The thought processes involved in formulating problems and their solutions so that the solutions are represented in a form that can be effectively carried out by an information-processing agent." (Wing 2006; 2011). It is a fundamental skill that every person should develop in order to effectively perform within a modern and technologically-driven society. This is why we present this roadmap for primary school teachers and educators, so that they can take the initial steps towards integrating CT within their classrooms.

How?

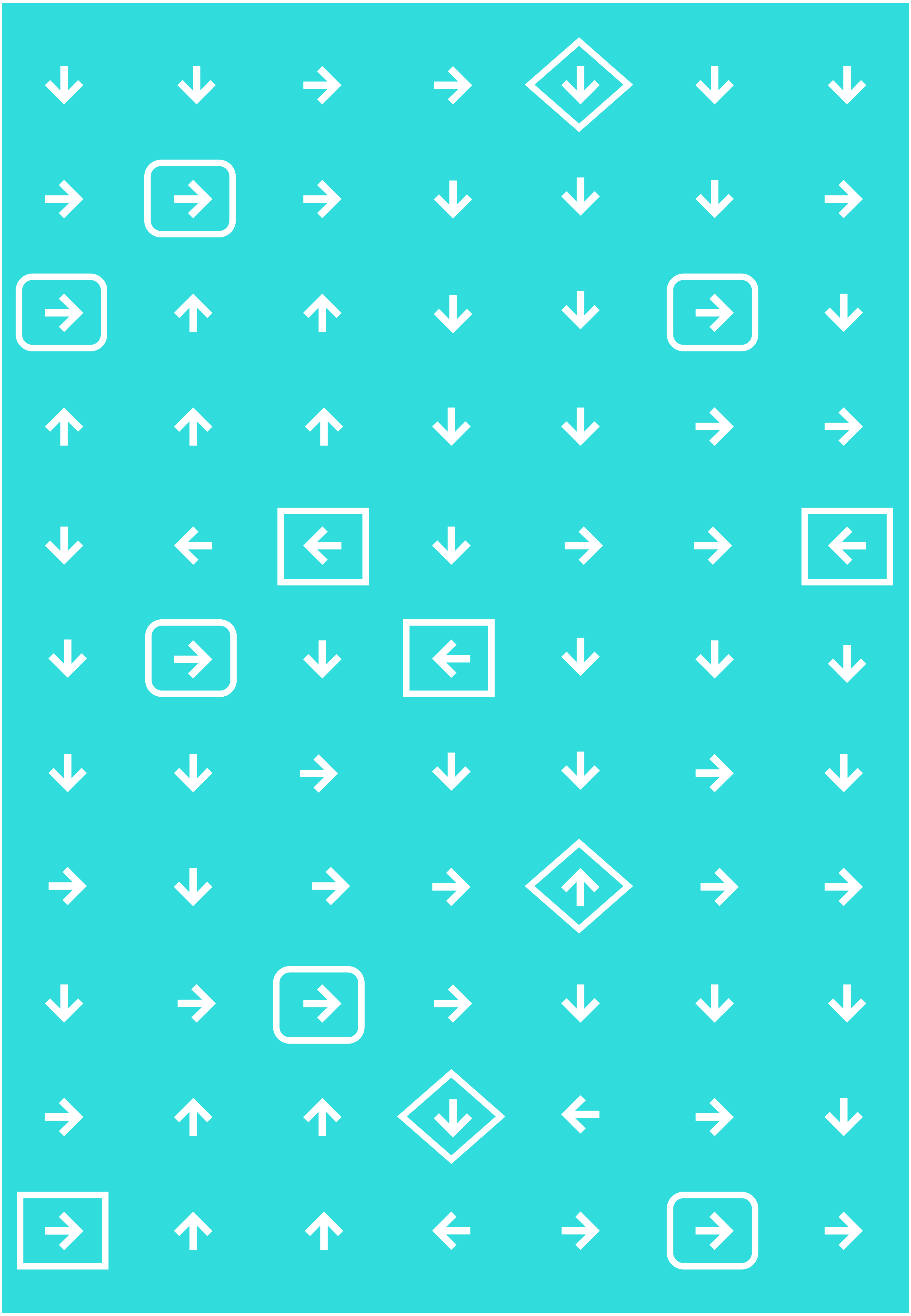
First, we introduce the rationale for developing CT skills within primary education (section 1); next, we explain the four foundations of CT (section 2) and present the first steps one must undertake to introduce CT in a transformative way within primary education (section 3). Section 4 provides guidance on how to design your own activity, including the guiding principles and competencies that can be developed while working on concepts related to CT as well as the first questions to reflect on. In the last section, we provide information for head teachers or school coordinators to help them integrate CT at the school level.

Curricula in Spain, Curaçao and the Netherlands

Finally, we have compiled the main references in the national curricula related to TC, so that schools can assess the extent to which their countries incorporate CT within primary education.

Resources

This roadmap is complemented with two other resources that we consider incredibly useful for teachers: first, a list of third-party activities and resources compiled by the consortium; and secondly, a set of activities that we developed over the course of the project that address different concepts and competencies associated with CT.



Content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1.

Why is computational thinking an important skill to learn?

Computational Thinking is considered a key skill in education, in addition to being included in the European Commission's digital agenda as an essential digital competence for the twenty-first century. Digital Competency is defined as the set of knowledge, attitudes and skills required when using ICTs to perform different tasks (manage information, communicate, solve problems, create or share content), in an effective, efficient, appropriate, flexible, or critical manner. One of the emerging educational trends that either integrates or operates in parallel with digital competence is Computational Thinking (CT) and robotics. CT, along with some of its attendant concepts (coding, programming, algorithms), promotes itself as a new form of digital literacy that is fundamental to effectively functioning in the twenty-first century.

This roadmap aims to introduce teachers to CT, describe the associated concepts and provide support for its integration within primary education.

The roadmap is complemented by both an extensive list of various activities and numerous links to resources from different countries and organisations. Alongside this, we also provide a detailed set of activities developed by the consortium, which serve as a step-by-step guide to introducing CT and gradually building up the difficulty.

2.

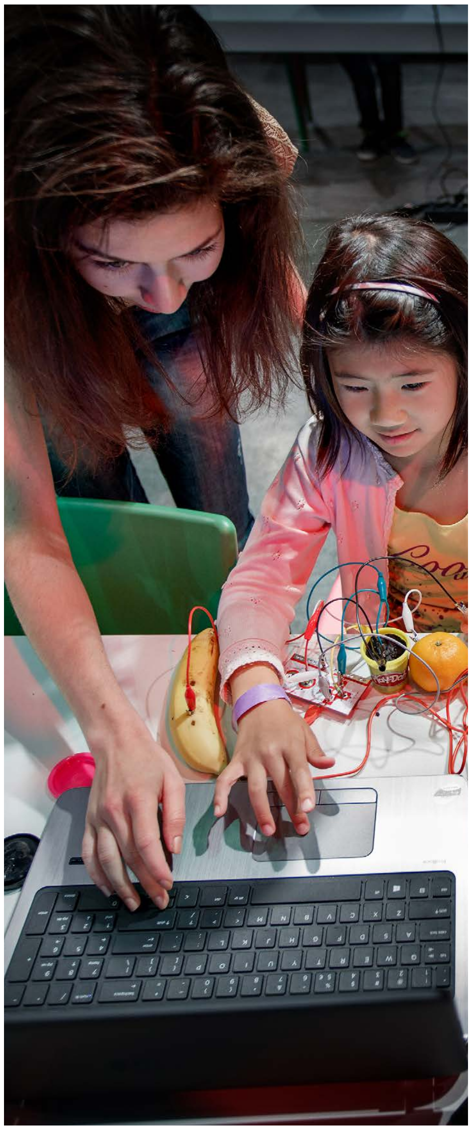
What is computational thinking?

Computational Thinking (CT) is a set of skills that help to solve problems by proposing step-by-step solutions that can be carried out by either a person or a computer. **It is important to note that CT is not thinking like a computer, but rather the opposite: it is about being able to tell a computer what to do to solve a problem.**

These are the foundations of CT[1]:

- **Decomposition**: dividing a complex problem or system into smaller components that are easier to understand. We can divide a complex and/or big task or data (e.g., modelling a student) into simpler and smaller tasks or data components (e.g., personal data and data related to their courses). This allows us to work in parallel, define the tasks in greater detail, and check the partial results of these small tasks, etc.
- **Pattern recognition**: finding similarities between problems or systems that allow for the use of previous solutions. Identifying patterns in information allows us to process it more efficiently (i.e., the data from students' courses have the name of the course, the number of hours, the name of the teacher and the grade in common).
- **Abstraction**: separating the fundamental from non-essential elements, in order to help ignore irrelevant details with respect to solving the problem or understanding the system. Following the example of the aforementioned students' courses, we focus on the common characteristics of all students, that is, those features that define the student category, rather than focusing on individual characteristics.
- **Algorithms**: developing a step-by-step solution to the problem that can involve sequences, loops and alternatives. A typical example of an algorithm is a cooking recipe, which comprises a set of steps that must be followed systematically in order to obtain the desired final result.

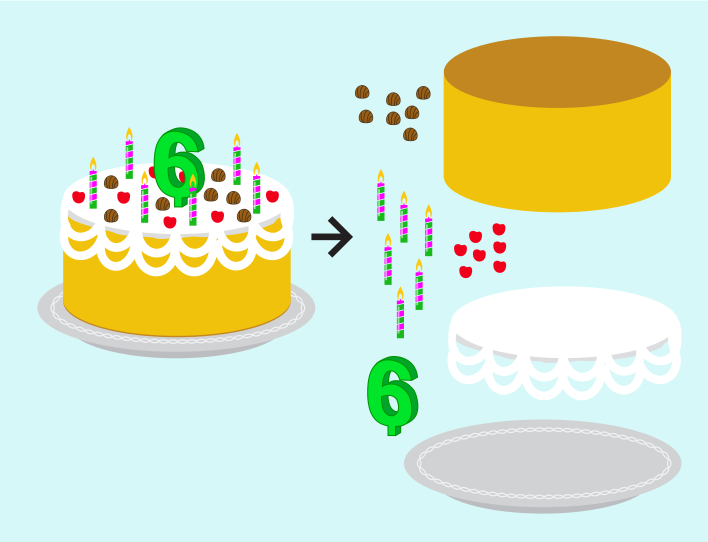
1 In Chapter 3 (page 6), you can find four activities that introduce each of the four foundations of CT as well as explaining their relationship to CT.



Computational thinking

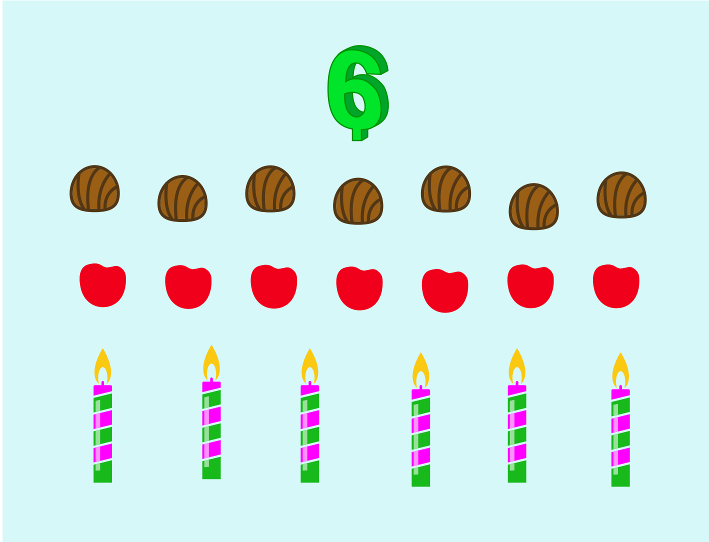
Decomposition

Take ideas and problems apart



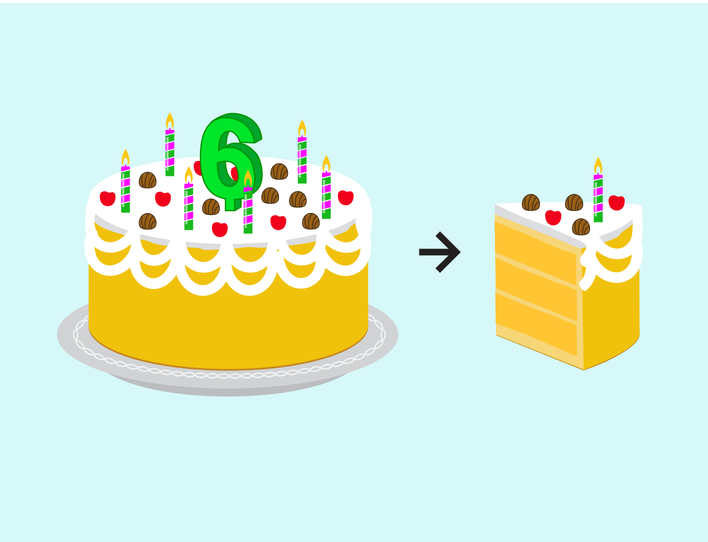
Pattern recognition

Look for similarities or trends



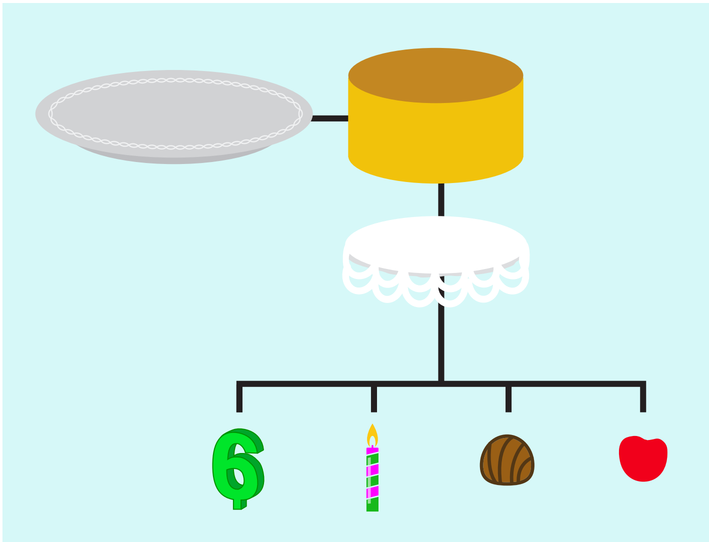
Abstraction

Removing unnecessary information



Algorithms

Create step by step instructions



3.

How can you use Computational Thinking?

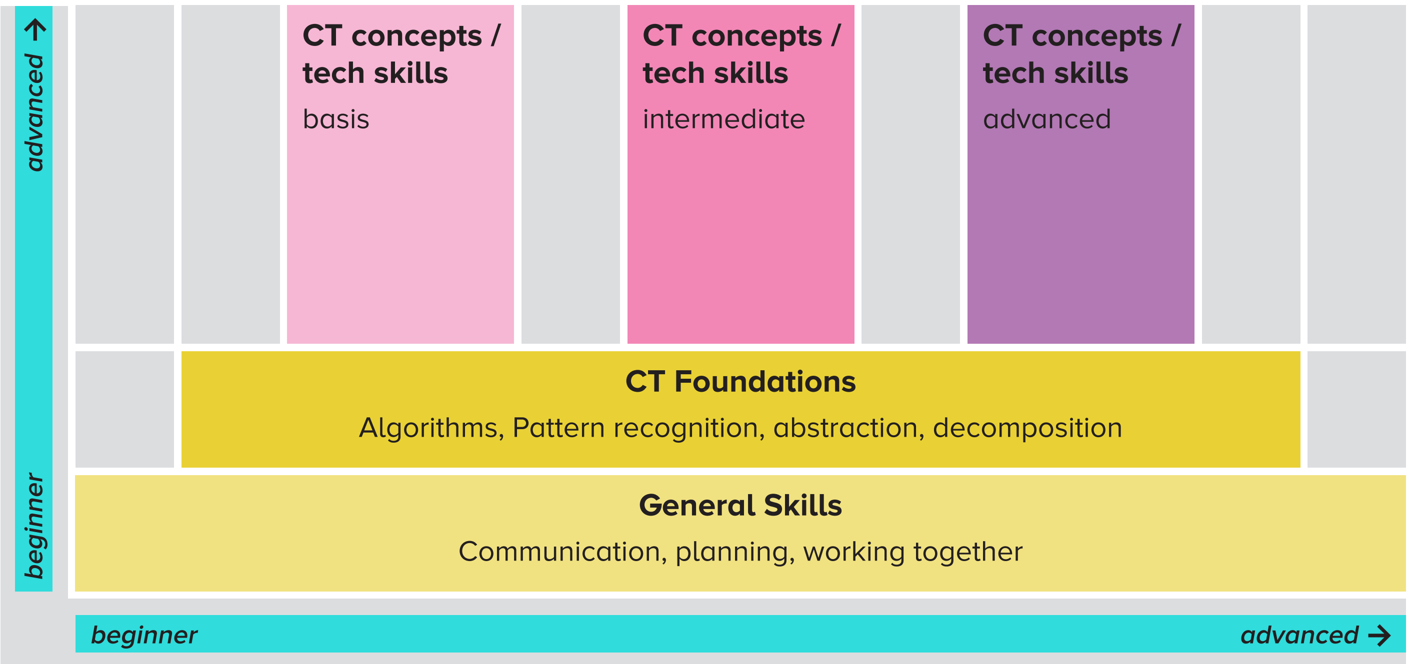
1. Using CT in school

The four foundations of CT can be subdivided into smaller concepts consisting of lower-level technology-related concepts; for example, in order to understand and work with algorithms, one needs to understand variables, sequences, loops and conditionals. Both these concepts themselves and understanding how to use them can be grouped into different levels according to their level of difficulty.

However, knowing these concepts is not enough; rather, solving the challenges or problems associated with developing CT also requires other more general skills, such as, for example, collaboration, creativity, critical thinking, or communication.

Developing CT is a progressive and cumulative process, one which is gradually built with technological concepts, transversal competencies, and the aforesaid four foundations. At the same time, it is a learning process that is best characterised as a learning-by-doing approach.

When developing CT, we are providing students with the skills



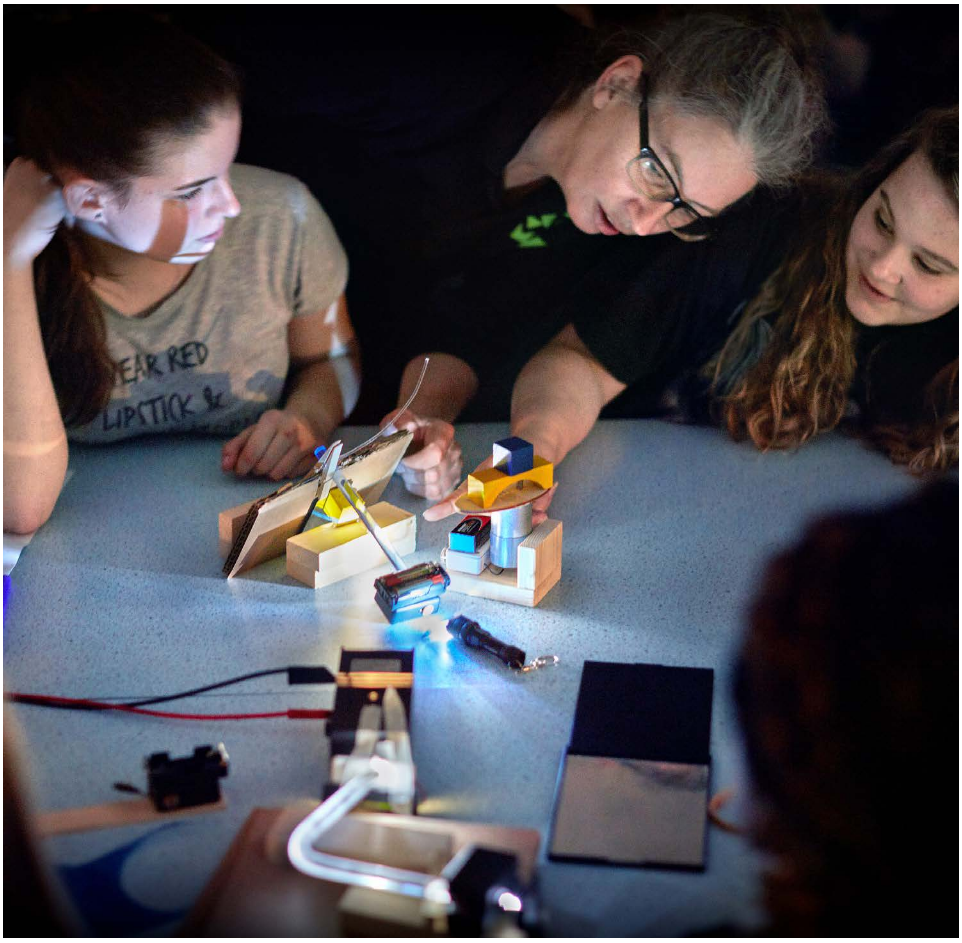
and competencies needed to face challenges and problems in a specific way, that is, the way that computers do. Therefore, it is important to provide them with challenges and projects in a wide range of contexts that enable them to put these skills into practice. In this sense, when developing CT, the most important thing is not how to use a specific tool per se (such as Scratch or robot), but rather learning how these tools can be used to solve problems. **In other words, technologies are not the goal, but rather the means to achieve certain goals. The objective is to properly integrate the concepts, methods and tools related to CT in other areas of knowledge.**

Within the learning of CT, programming is a language of expression, and robotics is an instrument of representation. Ultimately, both are necessary for problem solving. Through **interdisciplinary projects**, we can work on both the objectives and contents of the educational curriculum using both programming and robotics. This is the best way through which to contextualise the learning of CT within meaningful learning experiences.

In order to get to this point as either a teacher or a school you can also work on different lessons. This roadmap intends to support teachers throughout the whole process, by helping them to begin to use CT activities in their daily lessons up to engaging in interdisciplinary projects of a flexible duration that integrate several subjects and concepts.

2. Inclusiveness of CT

One of the goals of this project is to make CT more accessible. We want to achieve this through both the roadmap and our activities by ensuring we appeal to a broad target audience and that the materials are accessible.



▪ Appealing to a broad target audience

The topics for the lessons are diverse in terms of both their theme and format (from choreography to a maze race) in order to appeal to a large group of students. The activities are a mixture of more closed and open activities, so as to ensure that students have the level of freedom they need to make the activity their own. It also allows students to choose which part of the assignment they want to pay the most attention to, which, in turn, promotes both a sense of ownership and, importantly, fun and, ultimately, learning. It offers teachers the opportunity to properly tailor their lessons to the target audience.

▪ Accessibility of the materials

It is important to open up CT to all schools, irrespective of the budget that individual schools have to buy materials. You do not need expensive materials to begin to implement CT within classrooms, and you can also work with CT offline for very low cost and with easily available materials. It is for this reason that we developed all of the activities related to general skills and the foundation of CT in such a way that they do not require either a computer or other expensive materials. Rather, these activities can be carried out with materials that are generally already available within schools. For the tech concepts activities, we created both a plugged and unplugged version. Hence, schools and organisations that do not have access to computers or internet facilities can also follow the entire programme of activities.

The activities that use online software are all open source and free to access online. For the lessons in which we do use hardware, we made sure the hardware can be replaced with similar alternatives. In the event that a school or organisation happens to have another similar set of hardware in house.

3. Integration of CT within the classroom

CT is not regularly implemented in schools around the globe. Therefore, this roadmap offers a brief guide along with key tools to help readers get acquainted with CT. It offers practical advice on how to begin to introduce CT within your school or organisation, both via the use of stand-alone activities and in a more substantial manner.

The integration of CT within the classroom should be done progressively and after careful reflection on the behalf of teachers regarding the objectives, skills and content to be developed. There are many ways to approach these preliminary steps. The roadmap presented below is designed to help you choose activities that best fit your situation.

We recommend progressively introducing CT within education, beginning with the implementation of one or several activities within the classroom each academic year, which are then subsequently evaluated and modified according to the experience and results obtained.
For schools and organisations that wish to start with implementing CT via stand-alone activities, we have compiled an extensive list of best practices from around the world. We have also added a lot of search terms (cost, language, topic, duration, etc.) in order to ensure that it is as easy as possible to find the activity that best suits your purposes. This makes the list a convenient starting point from which to start searching for CT-related teaching materials.

For those schools and organisations that wish to implement CT more substantially, we have created a diagram with lessons that you can use to learn and practise the necessary skills.

4. ROADMAP - For students aged 6-12 years old

This roadmap offers a step-by-step introduction to CT, which gradually builds up the difficulty level:

1. The basis of CT lies in being comfortable with **general skills**. We have provided a few examples that you can work with in your daily lessons.
2. On top of the general skills, it is important that you become acquainted with the **foundations of CT**.
3. Once you have mastered both the general skills and foundations of CT, it is time to work on the **programming skills**. We have provided six creative activities to work on these programming skills, which provide a more creative approach to using CT within your lessons and activities.

We designed these activities to encompass all levels of primary education, to take the learner on a learning path that increases in difficulty as you go, and to cover a wide range of CT concepts and skills. Moreover, teachers can include and adapt any activity from the extensive list of third-party activities that are included with this roadmap.

Level of the student	*Subject*	*Title*	*Description*	*Offline/online*
All levels	**General skills**	General skills	Short Activities to practice some of the general skills needed for CT: Creativity, collaboration, brainstorming, etc	Offline
	CT Foundations	Introduction to Algorithm	What is an algorithm and how can you use it? What is its meaning and relevance within CT. Concepts: Algorithm, programming	
	CT Foundations	Introduction to Pattern.	What is it and how can you use pattern recognition within CT? Concepts: Sorting, Classes and objects, functions	
	CT Foundations	Introduction to Abstraction	What is it and why is it important within CT? Concepts: programming, algorithm-thinking, Interface design, structured data types	
	CT Foundations	Introduction to Decomposition	What is it and why is it needed within CT? Concepts: algorithm, logical-thinking, data structures	
Beginner	**Programming**	Offline programming	Create a dance and learn the basics of programming	Offline
	Programming	Online Programming	Learn the basics of programming in online environments: three different activities (Kodetu, Scratch, sandwich)	Combination
Inter-mediate	**Tinkering with CT**	Roadrunner en Coyote	Make your own roadrunner and find your way through the maze without being caught by the coyote.	Offline
	Tinkering with CT	Say it with cardboard	Say it with cardboard. Use the micro:bit (or other technology) to promote a message.	Combination
Expert	**Use CT in a project**	Make X/Make a light show	Make X, a format to integrate CT within your lessons and activities. Including two examples of the Make X lesson. Make a mini lightshow (offline) and make a (mini) lightshow with micro:bit.	Offline and online version
	Integrating multiple CT concepts and skills	CT Escape room!	An escape room with CT-related challenges to solve and build an algorithm-driven theatre play	Combination

4.

Designing your own activities

Guiding Principles

We will begin by describing some key principles for integrating CT within the classroom. The activities provided along with this roadmap serve as an example of how these competencies can be developed while working on concepts related to CT.

Interdisciplinarity
It is recommended that students develop and put into practice the competencies associated with CT across different areas of the curriculum. CT comprises a specific way of thinking, of facing problems, of analysing information, and so on; in this respect, it is a form of thinking that can be applied to many areas of knowledge. To this end, teachers should provide a varied and interdisciplinary array of activities.

Inclusiveness
The challenges, activities and projects presented to students that include CT should be varied and connected to the different interests of students. In robotics, for example, we should not fall back upon the classic examples of motorised vehicles. Rather, we

can also engage with the tastes and interests of students by drawing upon art, music and theatre. CT is present across many areas of our lives and, hence, can be explored from all of these angles, which, in turn, should spark the curiosity of all students.

In addition to engaging with the full range of students' interests, we must also take into consideration the diversity of the student population. Students have different learning routines and styles; therefore, we must define alternatives in our activity that allow everyone to both achieve the minimum objectives and develop their knowledge and competencies related to knowledge, skills and prior learning.

Empowerment

Students live in a digital age in which they are continuously encountering information. They are not only consumers of information and content, but in many cases are (and should be) also the creators of this information. In this sense, we want to empower students to be responsible consumers and creators. They should be aware of the impact of their actions when developing technology (social, economic, ethical, etc.), and feel competent and autonomous to create their own content and develop their own projects.

Moreover, it is important to encourage student-student interaction, where each student can contribute and support their classmates, and value the skills and knowledge of every student. Here, the teacher focuses on supporting the learning process, accompanying and facilitating knowledge.

Inspiring and motivating

The challenges and projects we present to students should be inspiring, spark their curiosity and generate a desire to explore and advance their knowledge. It is important for the students to set out from their own interests, and refer to real challenges that are relevant to them. This will help students to engage with new areas of knowledge and encounter new problems. The challenges addressed in the classroom represent opportunities for our students to discover new vocations and come even closer to scientific and technological areas.

Collaborative

CT activities are ordinarily developed in collaborative environments in which students are grouped around a common goal. When encouraging group work, it is important to define different roles amongst students and rotate them so that every student gets to experience and work in different roles. Teamwork facilitates an interdisciplinary approach, where each student brings their own experience and develops the facets that most interest and motivate them. This collaborative work is close to the real work carried out as part of professional teams.

Learning Ecosystem

When integrating CT within the classroom, it is important to think about how to do it. We must reflect on the Learning Ecosystem of our classroom and the need to create it from scratch, transform the one we already have or adapt it in some respects. When we refer to the Learning Ecosystem, we must think about the contents we work on, the methodologies we use and the resources we need. These are the three pillars from which to build an adequate Learning Ecosystem for both the teaching and learning of CT. With respect to implementing CT within the classroom, we recommend to both think of teaching and learning as a process through which knowledge is incrementally built up across each stage, and to stress the importance of learning-by-doing.

When developing CT we are providing students with the skills and competencies needed to face challenges and problems in a specific manner: the way that computers do. Therefore, it is important to provide them with challenges and projects in a wide range of contexts that allow them to put these skills into practice. In this sense, when developing CT, the most important thing is not how to use a specific tool per se (such as Scratch or robot), but rather learning how these tools can be used to solve problems. Technologies are not the goal in this respect, but rather the means through which to achieve these goals. The objective is to properly integrate the concepts, methods and tools related to CT within other areas of knowledge.

Within the learning of CT, programming is a language of expression, and robotics is an instrument of representation. Both are necessary for problem solving. Through interdisciplinary projects, we can work on the objectives and contents of the educational curriculum by using both programming and robotics. This represents the best way through which to contextualise the learning of CT within meaningful learning experiences.

Starting point for creating lessons

After answering these questions below, you will have a clearer sense of the activity that you want to do with your students. The questions can be helpful for designing the best strategy for each case. We also provide you with an Evaluation Rubric example (see Annex V).

- Which teacher(s) will be involved?
- Which concept(s) could I start with? Here, choose one or more concepts that would integrate naturally with the curriculum.
- Does it involve one or more subjects?
- How much time will I dedicate to this activity? How many hours and/or how many days or weeks.
- What resources do I need, and can I get those I do not currently have? It is important to consider here that in many instances there is a low-cost option to integrate CT within your classroom. There is often an assumption that expensive equipment or devices are needed to do this, but this is often not the case.
- Is there an activity I can build on to work on the concept(s)? What adaptations would be required? We recommend starting with existing activities and tools.
- What other transversal competencies am I interested in developing? How can I address them in the activity?
- How would I evaluate the activity? How would I define the objectives, indicators, process, evidence, etc.?

5.

Didactic integration of CT at the school level

The integration of CT within the classroom can be approached in multiple ways. Ideally, the integration of CT should be designed at the school level, so that the learning objectives are defined at the different educational stages and there is a learning progression. While individual initiatives are good, ultimately a deep and meaningful understanding of CT requires time and integration with other disciplines.

The integration of CT at the school level requires a deep reflection on the characteristics of the school (teachers, community, size, environment, equipment, etc.), the needs of the school, and the objectives that are being pursued, which, in turn, leads to a realistic and adapted adoption of CT within the school.

Below, we present a series of key issues that are important to keep in mind when designing a school plan as well as the questions that schools should reflect on prior to seeking to integrate CT at the school level.

THE SCOPE:

Specific subject or integration within existing subjects? At what educational level? How many groups per level? How many students per classroom?

One important decision concerns whether to opt for a transversal integration within existing subjects in the curriculum or to create a specific CT subject.
Both of these options are valid. Often the best way to start is to create a specific subject for students to acquire the basic skills and knowledge of CT, before then moving towards a more transversal integration by establishing specific objectives for the different subjects.

Ideally, the integration of CT should be oriented towards this more transversal perspective. The ultimate goal is for students to acquire CT skills in an interdisciplinary manner and to be able to put these skills into practice in the different disciplines that make up the curriculum.

It is also important to decide at which educational levels and in which courses we want to include CT. We recommend implementing an approach spanning from kindergarten to secondary education. To this end, learning objectives must be defined for each of the stages, ensuring progression and connection in the learning journey.

This reflection helps us to define the approximate number of students that should be involved, which is vitally important when it comes to specifying the resources that are needed.

THE TEACHERS:

How many teachers do we want to involve? Should coordinators or other heads also be involved? Do the teaching staff have any prior training? Do they need it?

The teaching staff are a key element for guaranteeing the effective integration of CT within the school. Teachers should have the necessary knowledge and skills in the field and, if they do not, they should be provided with specific training. This means that in our integration plan we have to analyse the investment that is required to train teachers (hours, budget, place, date, etc.), prior to thinking about investing in technology.

We recommend designing a progressive training programme. First, a group of selected motivated teachers can be trained (CT ambassadors), and in a second phase, a larger group of teachers can be trained, with the ambassadors operating as supporters. These are key players in the integration of CT at the school level, insofar as their knowledge and motivation can serve as the basis for designing the objectives for the different courses and coordinating the programming of the activities.

In addition to specific training, the teachers responsible for designing the programming of activities in the different courses will also need to have hours allocated for this in their work models.

THE RESOURCES:

Do we have a computer room or does each student have a personal device? What types and how many technological devices do we have (computer, tablet, mobile phone, etc.)? What are their characteristics? Do we have a stable wireless connection (Wi-Fi)? Do we need technology?

Before making any economic investment in devices, we have to analyse the equipment we have in the school and the concrete need for integrating CT. It is important to know the compatibility of the school's equipment with the technologies we are interested in. For example, can programs be installed on classroom computers, or do we have to work online? Is the Internet connection stable enough for online work? Do our computers need a Bluetooth connection to work with any of the

resources? Based on these answers, we will then orientate the investment in equipment and resources.
First, consider unplugged CT and boardgames as a very good option for many of the activities in the classroom.

SPACE:

What space is available in the school? How is the furniture (tables, chairs, etc.) currently arranged? Can the furniture be moved? Can different types of groupings be proposed?

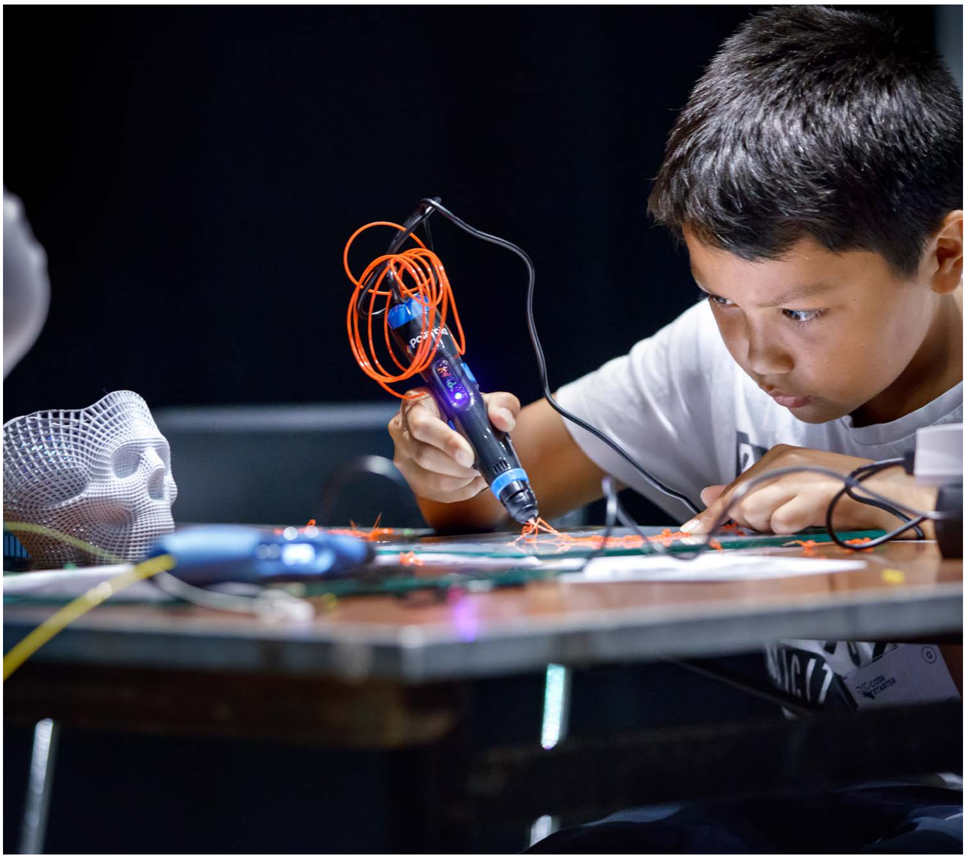
Since the activities related to CT are very diverse and require different types of groupings, it is important that the classrooms we use allow us to move tables so that students can sometimes work individually with their computers and other times in small groups, and that they can charge the battery of their computer equipment, etc.

TECHNOLOGY:

How is the equipment distributed amongst the different groups? What are the rules for using the equipment?

When we integrate robotics, for example, we have to think about how many students we have in the classroom, how many kits we need for each class, and if students will be working in pairs, or in groups of four, etc. We also have to think about whether the same kit or equipment can be shared between different classes. Some technology requires assembling and cannot be disassembled between classes, which makes it difficult to share. However, one possible solution in these cases would be to time the use of a given piece of equipment in different periods.

It is also important to define the rules for the use and maintenance of the equipment, so that the condition of the equipment is regularly checked.



To this end, we could make students responsible for the maintenance and care of the equipment, with this responsibility being rotated amongst the students in order to ensure fairness.

INTEGRATION PLAN:

What time period do we set for designing the integration of CT within the school? What should we prioritise in each phase of the integration plan?

A realistic school-level integration of CT cannot be achieved in the short term. Rather, a plan must be set with different objectives for each year or phase. Within the integration plan, we could design different objectives for the different educational stages and learning objectives, teacher training and investment in resources. We could also start in the early stages of integration by addressing skills related to algorithms and programming languages, while in the more advanced stages we could define the objectives related to robotics and prototype design.

Annex I - GLOSSARY OF TERMS

- **Algorithm**: a process or set of rules to be followed in calculations or other problem-solving operations, especially by a computer.
- **Algorithmic Thinking**: creating a set of ordered steps and then doing them in a particular order to solve a problem or accomplish a task in a way that could be repeated by others (using an algorithm).
- **Binary code**: a coding system using the binary digits 0 and 1 to represent a letter, digit, or other character in a computer or other electronic device.
- **Class**: in object-oriented programming, a class is an extensible program-code template for creating objects.
- **Condition**: conditions are statements (questions) programs that result in a value: true or false. It is a type of step in an algorithm where a decision must be made.
- **Constant**: a name for a piece of memory where the value cannot be changed while a program runs.
- **Data type**: is a classification that specifies which type of value a variable has; it is an attribute associated with a piece of data that tells a computer system how to interpret its value.
- **Debugging**: the process of identifying and removing errors from computer hardware or software.
- **Interactive**: refers to software which accepts and responds to input from people.
- **Electronics**: the branch of physics and technology concerned with the design of circuits using transistors and microchips; circuits or devices using transistors, microchips and other components.
- **Event**: is an action or occurrence that can be identified by a program and has significance for system hardware or software. Events can be user-generated, such as keystrokes and mouse clicks, or system-generated, such as, for example, program loading, and running out of memory and errors.
- **Function**: a block of organised, reusable code that is used to perform a single, related action. Functions provide better modularity for your application and a high degree of code reusing.
- **List**: is an abstract data type that represents a finite number of ordered values.
- **Loop**: a sequence of instructions that are continually repeated until a certain condition is reached.
- **Object**: in object-oriented programming, an object is an instance of a particular class with the class's methods and data variables.
- **Pattern recognition**: is the automated recognition of patterns and regularities in data.
- **Procedure**: is a small section of a program that performs a specific task.
- **Computer Programming**: the process of writing code to facilitate specific actions in a computer, application, or software program, and instruct them on how to perform.
- **Robotics**: Robotics is a branch of engineering that involves the conception, design, manufacture and operation of robots. The goal of robotics is to design machines that can help and assist humans.
- **Sorting**: ordering data in an increasing or decreasing manner according to some linear relationship amongst the data items.
- **Sensor**: a device that detects and responds to some type of input from the physical environment. This input can be light, heat, motion, moisture, pressure, or any number of other environmental phenomena.
- **Variable**: a value that can change, depending on the conditions or instructions executed in a program.

Annex II - connecting to the curriculum in Spain

Development of computational thinking within the Spanish curriculum

The Spanish education system currently includes the development of Computational Thinking (CT) from the early childhood stage and defines objectives across all the following stages of education. More specifically, in the primary education curriculum the Spanish education system promotes the development of CT through the areas of science and mathematics.

The LOMLOE law (January 2021) proposes a competency-based and transversal learning model in which ICT plays a crucially important role. In the case of primary education, the section on digital competences includes the creation of digital content and aspects related to programming and CT; specifically, at the end of this stage, one of the things students should be able to do is "develop simple computer applications and creative and sustainable technological solutions to solve specific problems or respond to proposed challenges in a creative way", which is why block programming and educational robotics should be included within the classroom.

Specific competences and basic knowledge related to CT have been included both in the area of knowledge of the natural, social, and cultural environment (Science) and in the area of mathematics. Therefore, in the classes within these two areas, throughout the three cycles of primary school, pupils will learn to solve problems through interdisciplinary projects, using design thinking and CT, in order to cooperatively generate a creative and innovative product that responds to specific needs. They will also learn to use CT by organising data, breaking it down into its constitutive parts, recognising patterns, generalising, and interpreting, modifying and creating algorithms in a guided way to model and automate everyday situations.

KNOWLEDGE OF THE NATURAL, SOCIAL AND CULTURAL ENVIRONMENT (SCIENCE)		
FIRST CYCLE *6-8*	*SECOND CYCLE* *9-10*	*THIRD CYCLE* *11-12*
Specific Competence: Solve problems through interdisciplinary projects, using design thinking and CT, in order to cooperatively generate a creative and innovative product that responds to specific needs.		
Phases of design projects: Identification of needs, design, prototyping and testing, evaluation, and communication.	**Phases of design projects:** Identification of needs, design, prototyping and testing, evaluation, and communication.	**Phases of computational thinking** (decomposition of a task into simpler components, pattern recognition and creation of simple steps for problem solving...).
Introduction to programming: Analogue and digital resources adapted to the pupils' reading level (digital platforms for introduction to programming, educational robotics, etc.).	**Introduction to programming:** Digital resources: digital platforms for beginners to programming.	**Programming by blocks,** sensors, motors, simulators, 3D printers... to complete the project.

MATHEMATICS		
FIRST CYCLE *6-8*	***SECOND CYCLE*** *9-10*	***THIRD CYCLE*** *11-12*
Specific competence: **Describe** simple routines and activities of everyday life that are carried out in a step- by-step manner, using basic principles of CT in a guided way.	Specific competence: **Automate** simple everyday situations that are either carried out step-by-step or follow a routine using basic principles of CT in a guided way.	Specific competence: **Model** everyday situations using basic principles of CT in a step-by-step manner.
Patterns: Strategies for identification, oral description.	**Patterns:** Identification, verbal description, representation, and prediction.	**Patterns:** Strategies for identification, representation, and prediction. Creation of recurring patterns.
	Introduction to programming: digital platforms.	
Computational thinking: Strategies for the **interpretation** of simple algorithms (routines, instructions with ordered steps...).	**Computational thinking:** Strategies for the **interpretation and modification** of simple algorithms (game rules, sequential instructions, loops, repetitive patterns, block programming, educational robotics...).	**Computational thinking:** Strategies for the **interpretation, modification, and creation** of simple algorithms (sequences of ordered steps, diagrams, simulations, repetitive patterns, loops, nested and conditional instructions, computational representations, block programming, educational robotics...).

Annex III - connecting to the curriculum in the Netherlands

Computational thinking within the Dutch education system

Dutch education system

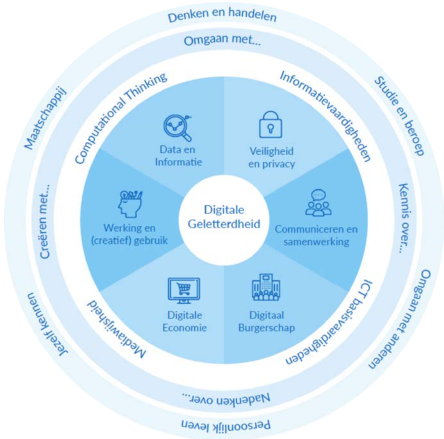
The curriculum of schools in the Netherlands has been determined by a set of key objectives since 1993 (albeit with some minor changes over the years). The contents of these key objectives are not precisely defined, which gives schools considerable freedom over the content of their curriculum. Some schools need more guidance, and therefore the SLO (the national expertise centre for the curriculum) provides examples of the key objectives.

A new curriculum

Computational Thinking (CT) is neither mentioned nor referred to specifically in the key objectives. This is going to change, however, as between 2019 and 2021 Curriculum.nu made a proposal for a new curriculum. In this proposal, digital literacy is identified as one of the key learning areas of the new curriculum. From 2021 to 2024, the proposal will be researched in order to come up with a draft of the new core objectives in the summer of 2023. After this, these draft targets will be tested in practice.

CT and the Key objectives

Although it will take some time before digital literacy officially becomes part of the curriculum, there is already substantial information about what this will look like in practice, as many



organisations and schools are already consciously working on it. CT will be one of the four main domains of digital literacy, along with the following domains:

- ICT-skills
- (Social) Media Literacy
- Information Literacy
- Computational Thinking

SLO has also created a learning pathway for digital literacy as well as one specifically for CT.

Current use of CT within schools

Despite not yet being an official part of the curriculum, there is a general awareness (in education, business, and government) in the Netherlands regarding the importance of CT. The vision on using CT (mainly programming) within education received a significant boost in 2015 when the CodePact initiative was started by the Dutch government. As a result of this initiative, many projects, materials, websites and organisations are available on the topic of CT. Despite this extensive support and widespread recognition of the urgency for digital literacy and CT, the survey Digital Literacy Monitor in Primary Education shows that the focus on digital literacy in teaching programmes is still largely ad hoc. For example, less than a quarter (24%) of primary school teachers work with defined learning objectives for digital literacy, while the majority (58%) do not use a learning pathway or learning objectives at all when it comes to making their pupils digitally literate.

It is our hope that this project can support teachers and schools by providing a roadmap and extensive list that makes the information that is already available easier to find and more accessible.

Useful links:

SLO: Leerlijn Computational thinking
https://www.slo.nl/@5695/computational/

SLO: Digitale geletterdheid.
https://www.slo.nl/sectoren/po/digitale-geletterdheid-po/digitale-geletterdheid-po/

Kennisnet: Workshop Computational Thinking:
https://maken.wikiwijs.nl/70012/Workshop_Computational_thinking

Kennisnet: Leerlijn programmeren in het onderwijs:
https://maken.wikiwijs.nl/74282/Programmeren_in_het_PO#!page-1843082

https://ecp.nl/wp-content/uploads/2021/11/DUO-OO-20211177-Infographic-digitale-geletterdheid-PO-10.pdf

Annex IV - connecting to the curriculum in Curaçao

Current situation concerning the integration of Computational thinking within schools in Curaçao (April 2022)

Much like other countries, Curaçao also has its fair share of challenges to overcome with respect to Computational Thinking (CT). The main issue to overcome is the correct and synchronised interpretation and application of science and technology within the schooling system as a whole. A general method needs to be presented from the governmental organisation if the potential of CT is to be achieved. Other obstacles to be overcome pertain to the lack of devices, outdated software and an internet connection that is either unstable or fails to reach classrooms. While teachers' hearts are in the right place, they are in urgent need of guidance, resources and parental support (where possible) to achieve the general goal of implementing CT.

With regard to CT specifically, the current legislation is incredibly vague and refers mostly to the use of computers and the need to digitise the educational system. Both the interpretation and implementation of CT is left to the school boards, of which Curaçao has nine. Each school teaches subjects based on their curriculum and learning objectives and of course the implementation is strongly dependent on the available finances.

Solutions for implementation
CT must be integrated within the school curriculum. When implementing CT within schools, it has to be done with no restrictions. One way to start the process is to explore daily routines, customs, traditions, culture, behaviour and games. Students should experiment by building and creating things with their hands that they are interested in, while science and technology should be encouraged by tinkering.

Alongside the development of these activities, it is important to train teachers to become at ease with CT.

In a small country such as Curaçao, promotion of what is developed and ready to use is of critical importance. Curaçao already celebrates a science technology and art day, which could also be used to promote the implementation of CT.

Furthermore, it is important to make use of creations that can be useful for the community, draw attention to programmes of science and technology that can be sustainable and implore the government to subsidise the teaching of Science, technology and art within schools in Curaçao.

OUTCOME OF THE INTERVIEWS

To gain insight into both the level of comprehension and use of CT within primary schools in Curaçao, we conducted interviews in combination with questionnaires, in addition to examining the Education Legislation of the island and the school curriculum. A small percentage of schools within so-called "less fortunate" areas were selected to take part in the interviews. The rationale for this selection was that they were the target group who would later experience the activities that would be developed during the CT Primed project.

Interviews:
Eight teachers from 3 different schools and two head teachers were interviewed and completed a questionnaire.

Target group
For this project, Tinkersjòp targeted students aged 6 to 12 years old, who came from a socio-economically deprived background.

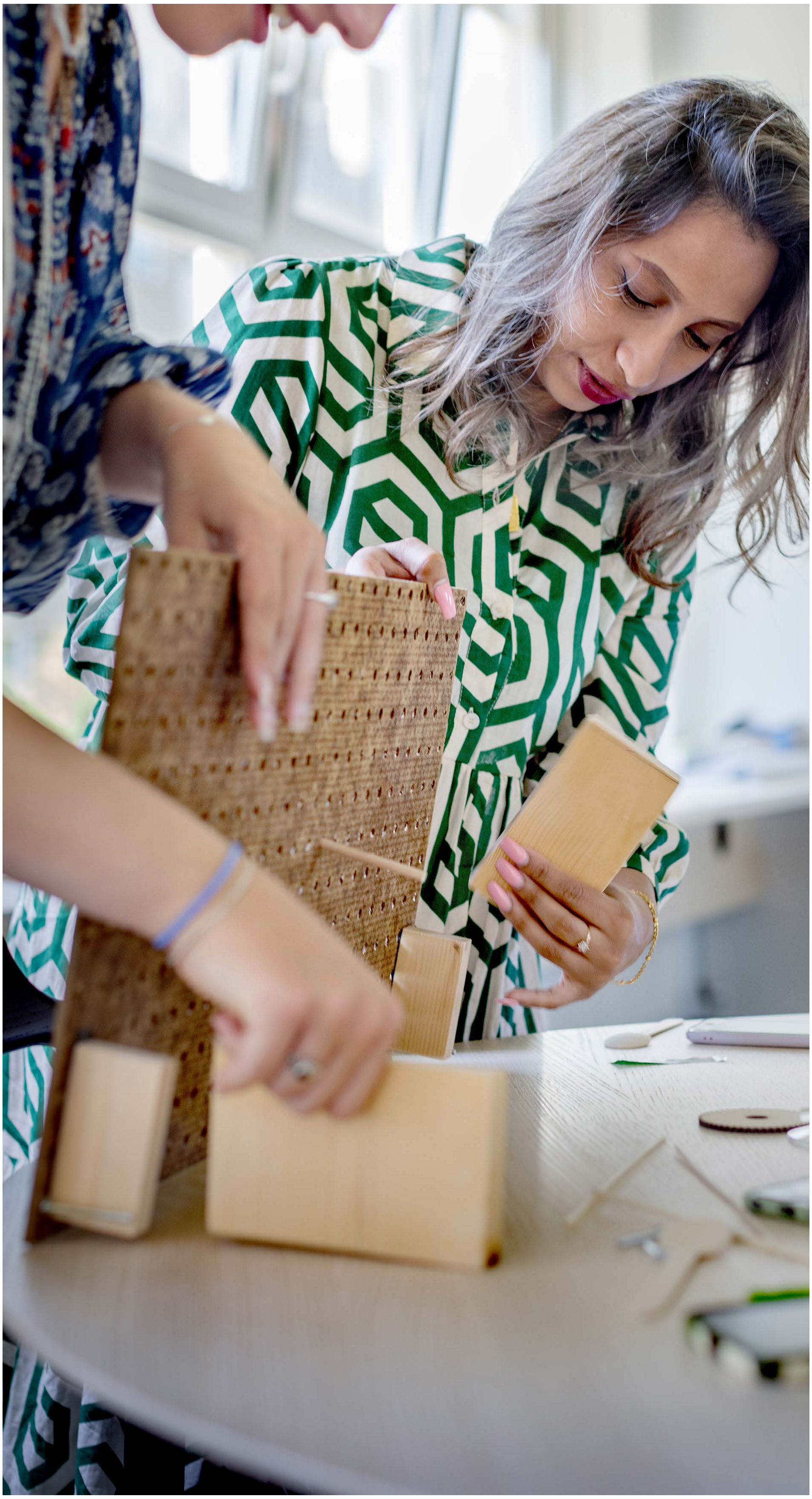
Given that their primary guidance comes from primary school teachers, these teachers were also included in our target group.

The most recurring responses from the interviewees were:
Much like other countries, Curaçao also has its fair share of challenges to overcome with respect to Computational Thinking (CT). The main issue to overcome is the correct and synchronised interpretation and application of science and technology within the schooling system as a whole. A general method needs to be presented from the governmental

organisation if the potential of CT is to be achieved. Other obstacles to be overcome pertain to the lack of devices, outdated software and an internet connection that is either unstable or fails to reach classrooms. While teachers' hearts are in the right place, they are in urgent need of guidance, resources and parental support (where possible) to achieve the general goal of implementing CT.

Tinkersjòp did not want to solely draw attention to problems, but rather also wished to contribute to solutions, ideas and measures to reach both our target group and Curaçao society more broadly. To this end, they provide the following recommendations.

- CT has to be integrated within the school curriculum
- The implementation of CT within schools has to be done with no restrictions (drempelloos)
- Explore daily routines, customs, traditions, culture, behaviour and games in Curaçao
- Experiment by having students build and create things with their hands that they are interested in
- Encourage science and technology by tinkering
- The next step is to connect the tangible with the digital world by encoding
- Train teachers/trainers in Curaçao simultaneously along with the creation process
- Showcase to the country what has been achieved through promotional events and contests
- Tinkersjòp should go into the neighbourhoods to reach children
- Make use of creations that can be useful for the wider community
- Develop science and technology programmes that are sustainable
- Reach out to the government to establish a Science, technology and art school in Curaçao
- Create a science, technology and art day that is celebrated all across Curaçao (an official date has yet to be determined for this)



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