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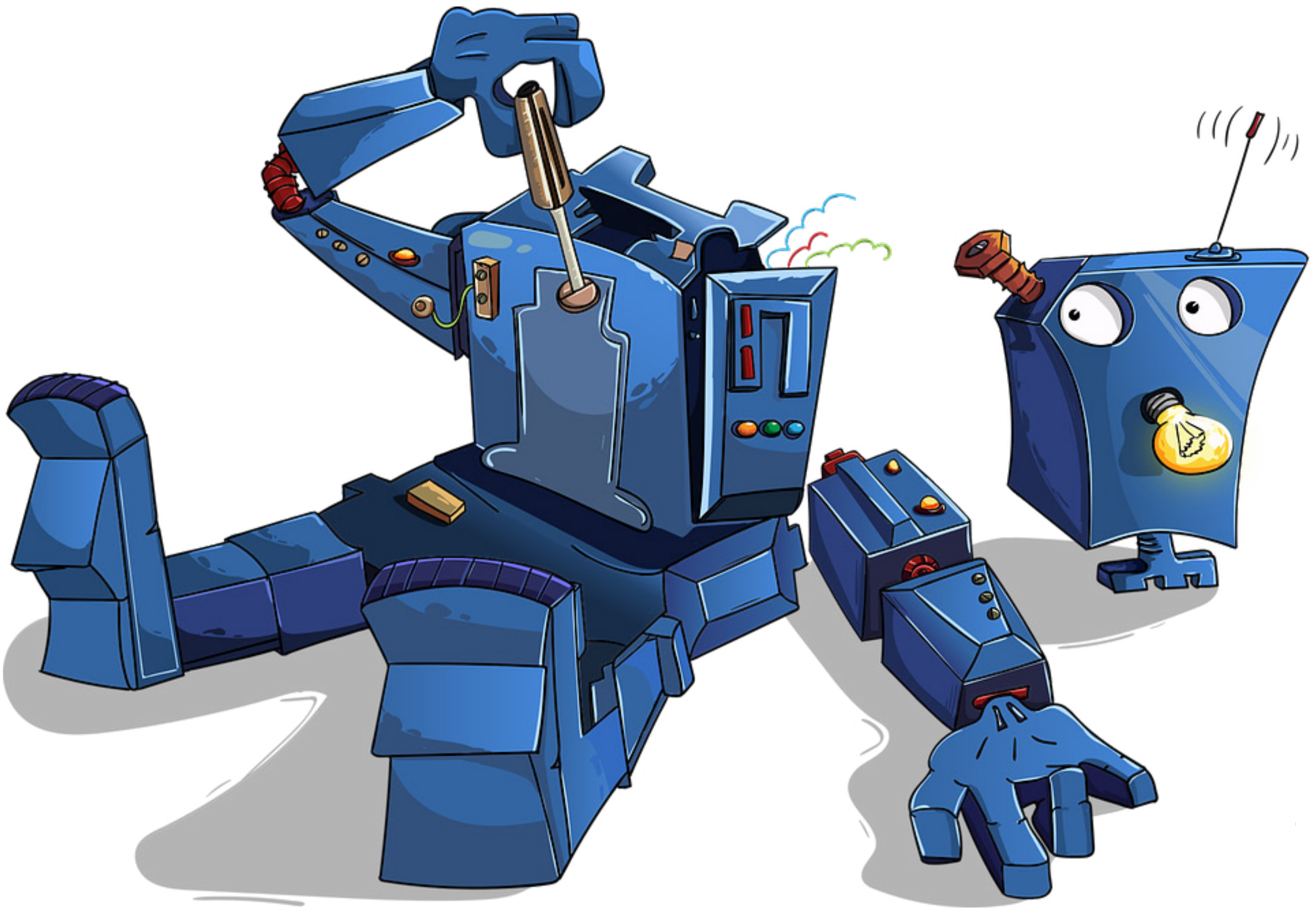
Handbook of Teaching Materials

"Developing Teaching Materials for Preschool Teaching Undergraduates on Computational Thinking and Introduction to Coding"



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EARLYCODE

"Developing Teaching Materials for Preschool Teaching Undergraduates on Computational Thinking and Introduction to Coding"

Erasmus+ 2018-1-TR01-KA203-058832

IO2 - Handbook of Teaching Materials

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Dear Reader,

This handbook has been written by the partners of the Erasmus+ European Project "**EARLYCODE – Developing Teaching Materials for Preschool Teaching Undergraduates on Computational Thinking and Introduction to Coding"** (Project Number 2018-1-TR01-KA203-058832) which has the main aim of fostering and developing computational and algorithmic thinking in Early Years Education.

This handbook is explicitly designed for teachers who want to develop their knowledge in teaching Computational Thinking and Coding in Early Childhood Education and to obtain further tools and strategies to improve their teaching skills.

Talking about Coding in Early Years Education can seem daunting, but there are a lot of tools available that are designed to help you. The main tools that you can use are robots without a screen (i.e. Bee-Bots, Cubetto, mTiny, etc...) and/or unplugged robotics tools (which means without the use of electricity, i.e. motion games, cards, physical games, etc...). Some screen-based devices also exist that you can use (i.e. Scratch Jr, Bee-Bots App, code.org, etc...). However, in this handbook we give you an overview of these techniques focusing on screen-free and unplugged devices, which are much more intuitive than the screen-based tools. As we know, children in preschools need to physically interact with tools to understand concepts and to improve their manipulation skills without being alienated by a screen.

We have provided you with a selection of activity plans that you can use immediately in your preschool classroom. These are kept as simple as possible and do not focus on a specific device, allowing you to choose the device you prefer. We know that beginning a process like this can be challenging, so there are sample activity plans for you to follow as well as blank activity plans for your own use.

We hope that this manual will inspire you to teach Computational Thinking and Coding in Early Years Education.

We welcome your comments so please email earlycoderseu@gmail.com
For further information about the project please visit our website www.earlycoders.org.

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Glossary

3D model
Digital or mathematical representation of a 3-dimensional object.

3D printer
Tools that are capable of building, using different techniques, a 3-dimensional object, starting from its digital representation (3D model).

Algorithm
A finite sequence of steps that can solve a class of problems or perform a computation.

Code
In the field of IT a code is a computer program. It is a list of instructions written by a programmer, that can be interpreted by a computer, that can then use it to perform a task.

Coding
The act of creating a code, or a computer program.

Cognitive development
Cognitive development is a field of study in neuroscience and psychology focusing on a child's development in terms of information processing, conceptual resources, perceptual skills, language learning, and other aspects of the developed adult brain and cognitive psychology.

Computational
Something related to the process of mathematical calculation and/or computers usage.

Computational Thinking
A set of problem-solving methods that involve expressing problems and their solutions in ways that a computer could execute

Condition
A Statement that can only be true or false.

Conditional statements
Instructions that can be used to change the path of execution of a code, basing the choice on the evaluation of a conditional statement.

Decomposition
Process of splitting a problem into multiple smaller problems.

Educational robot
Robotic tools designed to be used as a teaching tool.

Educational robotics

Educational approach that uses robots, and related devices and strategies, as teaching devices.

Iteration
The act of repeating some instructions into the execution of a code. The iteration is submitted to the evaluation of a conditional statement that determines how to repeat the instructions.

Loop
Refer to "Iterations"

Programming
Act of creating a computer program

Proprioception
Also referred to as kinanesthesia, is the sense of self-movement and body position.

Robot
A robot is a programmable machine capable of carrying out a series of actions automatically. It can do this because it is programmed to perform actions – using the actuators that act in the physical world – that react to the information, acquired by the sensors, about the surrounding environment.

Screen-based device
An educational device that can be only used with a computer, or tablet, or smartphone, so with another device which uses a screen.

Screenless device
An educational device that can be used without computers, tablets, or smartphones.

Sprite
In the field of educational robotics, a sprite is an image that can be used as a character and programmed to perform an action, and so can be animated.

Unplugged coding
The process of creating a code or a program without the use of digital or electronic devices. The code is represented using analogue devices, and manually interpretated by humans.

Unplugged robotic
An educational approach that uses unplugged coding, and manually performs movements for humans or puppets, acting as if they are robot programmed by the unplugged code.

Introduction

Introductory Overview

Computational Thinking and Coding are cognitive activities which involve problem solving at a higher level. They are expressive mediums which engage emotional and social domains. Coding is very much a field of expression just like any other language. In the Early Years, learning coding without screens and interacting with physical objects in a playful environment will have a positive impact on children's desire for learning and exploration.

Scope and application

The "Handbook of Teaching Materials" has been created to help teachers to develop computational thinking skills in children from three to six years old. The activity plans offer ideas on teaching coding and providing contexts to develop children's perception of space, orientation and understanding of tasks. Moreover, you will find empty activity plans for your own use. Be flexible and open minded when creating your own plans for developing children's critical problem solving and logical thinking.

Resources

The handbook contains activities that are ready to use or to adapt according to your needs, resources for implementation and empty plans so that you can create your own lessons. The handbook will guide and support you to practice developing coding and computational thinking. The lessons are presented in a logical order, starting with physical-motor activities/games (understanding instructions) and continuing with lessons for grouping instruction into sequences, adding conditions, loops and ending with coding and using screen-based devices.

Educational Approaches

Learning theories give us representative models for fostering and developing computational and algorithmic thinking in the early years and provide us with:

- a vocabulary and a conceptual map to translate learning examples.
- a conceptual and practical framework to be used for investigation and searching solutions.

The three learning theories (behaviourist, cognitive constructivist, and social constructivist) help us understand how learning occurs and how we can use teaching strategies to provide educational settings for children to foster positive social interaction and support intrinsic motivation. The teaching strategies must focus on building knowledge and enhancing skills and abilities, by using flexible pedagogical approaches, and allowing for individual learning, while developing self-evaluation capabilities and a reflective spirit.

This handbook is built around
1. Algorithm based methods, that lead to familiarization and compliance with working rules, and

2. Problem based learning, learning through discovery, cooperation, simulation, role playing, and developing divergent thinking and creativity.

The preschool period is marked by important cultural acquisitions, intense intellectual uptake, deepening understanding and multiplying the ways of approaching situations, milestones, and events.
During this preschool stage, brain development surpasses the primary animism, the belief that nature and objects are alive with human-like characteristics (e.g., when your child says that the ground made them fall). It also surpasses the simplistic syncretism, eg , preschoolers often rely on transductive reasoning, whereby they believe the similarities between two objects or the sequence of events provides evidence of cause and effect. For example, if a child sees their teacher at school in the morning and again when they leave, they may believe their teacher must live there. It also surpasses the interrogative investigation - into the "now" and "here". Symbolic capacities contribute to the development of cognitive functions which are now stronger, provide direction, and are more efficient.

The preschool period between 3 to 6 – 7 years old is metaphorically defined as the age of external reality discovery. The child is not only adapting their behaviour to different systems of requirements under conditions of guardianship, protection, and affection, but at the same time, creating a great awareness of the diversity of the world and life around them, a denser and more complex understanding of decision making, curiosity, and internal feelings regarding numerous and unusual situations.

During the first years of life, children are learning about their bodies and the surrounding world, become able to stand up, move, learn the meaning of sounds, and then develop language as a means of communication. Children learn to relate to nature, the environment, and other people. When we observe children, we observe their behaviour, which reflects their brain activity. The connection between the brain and behaviour is very strong. If the brain is processing information in a disorganised manner, then multiple aspects of the children's behaviour are disorganised.

To better understand the contents of this handbook, and how to use it, we need to reflect on child development stages in preschool. There are three main developmental milestones that are mentioned by various sources and theorists.

From three to four years old: this period is characterized by how the child lives through the excitement of exploring and experiencing the environment. This is a transition period, a shift from focusing on meeting immediate body/physical needs to activities in which their needs are more complex and more psychologically oriented.
From four to five/six years old (middle preschool): the child adapts to the kindergarten environment, playing games based on actions, simple and complex activities. Knowledge about the environment is enriched. He / she shows a maximum receptivity towards the environment, and this leads to perception development which is now an oriented process, with tasks and their own ways of accomplishing them. Emotional responses are more controlled and adapt to parents' and educators' requirements. Another particularity is the rapid pace of socialization, a part of future personality.
From five to six/seven years old: this period is characterized by systematic activities even though playing remains the core activity. Preparation for school starts. Perception turned into observation is practiced and becomes proficient. Language is more structured and solid, being built according to the rules of grammar. However, games and playing are the dominant activities for these preschool stages, starting to make connections with educational tasks.

Activities: Learning strategies

The description of the relationships /interaction strategies between children and children and adults is an argument for choosing physical-motor activities/games. **Activities Number 1 to 6** propose that children move in the physical space to prepare the game, to coordinate the movements, to understand the instructions and to follow the teacher. All these proposals from the activities can be found in the specialized literature.

Over time, children's interaction strategies become more refined, moving from non-verbal to verbal strategies. It has been found that those children who are more easily able to start a game or respond to the suggestions of others, are sought out by the other children to play with them. Positive interactions with other peers lead to friendships, the development of cooperation and conflict resolution skills. However, not all children can easily establish friendships. Shy or introverted children, although they want to play with others, have difficulty approaching their peers to play together. In contrast, extremely enthusiastic or extrovert children, with problems controlling their own behaviour, do not have the patience to be invited or are not allowed to join others. Both categories of children are frequently excluded from group activities. At the age of 3 to 4, children initiate interactions based on non-verbal rather than verbal behaviours: they observe the facial reactions of the other children, smile at them, and spend time in the proximity of the others, as is the case of parallel play. Starting at the age of 4 to 5, non-verbal behaviours are increasingly accompanied by verbal exchanges that demonstrate reciprocity in the interaction. The children manage to interact in growing groups and to cooperate during games. At the age of 5 to 6, because of their experience in cooperative games, children improve the ability to get involved in a game "on the go", that is to integrate into a game already in progress. In this sense, children learn strategies such as imitating the actions of others to "get in" the game. Group play also promotes the development of conversational skills. That is why, in addition to non-verbal strategies, they learn to use verbal strategies, which involve asking and waiting for the permission of others to join the game.

Activities 7 to 14 on patterns, sequences, conditional statements, and loops are based on the children's abilities such as cognitive skills. In the high preschool period, creative activity is obvious, with differentiation tendencies. Drawing, singing, collages, construction, and mosaics are very interesting to children.

The whole development of the brain enters a new stage; it goes through a stage of inventiveness that prepares for more complex operational thinking. Important progress is being made in conservation. A series of experiments, using glasses of the same size which were filled with beads or coloured liquid, was carried out with children of varying ages. One of the glasses is kept as a reference on the screen, while the contents of the other glass are transferred into other glasses of different shapes and sizes. This experiment was difficult for the children to understand. The 3-year-olds and even the 4-5-year-olds tended to regard the number of beads or amount of coloured liquid as unequal, if the beads or liquid were moved to a different shaped glass – higher or deeper - which changes the "perceived level". This showed that the concept of conservation (to recognize that objects that change in form do not change in amount) is not yet fully developed.

In the dynamics of cognitive development, the correction, but also the error on these stages is due to the perception and representations which are still incomplete. However, these logical evaluation schemes are being formed. At the age of 3-4, the child evaluates the objects in the distance as being taller or shorter, wider, or narrower. After the age of 5 the size of people is also evaluated better from a distance.

This causal relationship highlights several particularities in the case of experiences regarding floating objects - the pre-schooler of 4-5 years associates the size with the weight. At 5/6 years the child, although spontaneous, can operate with the ratio between size and weight, correctly anticipating this in many situations. Through the intuition of relationships, articulated and more reversible intuitions are created through which the mental operation is prepared in response to concrete operations, creating another relationship between appearance and essence. However, up to 6 years of age, thinking acquires a general (non-specific) operability, with a certain speed, that highlights the establishment of some basic operations on this plane, such as logical shapes/figures.

At the age of 4, the high frequency of the “why?” questions is an indication of the great hunger for reality and for observing correlations in the preschool child’s thinking. This curiosity deepens according to child’s investigations into the world around him/her.
These characteristics of “cognitive dissonance” that the child faces are very important for brain development.

In general, cognitive development allows children to analyse the experiences they have accumulated, using previously acquired strategies and through trial and error.

Activities: Learning Settings

As a preschool teacher using this handbook, you will want to know where to start and how to organize your work. In this section you will find some practical advice that will help your activities. Remember to be flexible. Feel free to adapt the content to meet the needs of your specific class of children. The way you use these sample activity plans should be because of an inquiry or based on your previous experience: Therefore, you should consider the following criteria:

- children’s age group.
- children’s current abilities.
- mixing both criteria.

As mentioned in the previous section, the activity plans must be used taking the age group and developmental stages of the children into account. If you have 3- to 5-year-old children, you can start with physical-motor activities/games lessons – there are a selection of six different activity plans that you can choose from. Through the proposed activities and specific objectives, these activity plans are the basis of developing spatial orientation, space perception, becoming aware of positions, directions, movement speed and body coordination. Language and cognitive development, following simple instruction and rules are also considered.

In this stage, children can identify and understand sequences, which is the basis for coding and promotes logical and divergent thinking.

In Activity no. 7, starting with sequences, you should consider children's previous learning. It is the teacher's role to plan simple and clear actions, to work with physical objects and offer children practical representations and investigations using available resources.

If you are working with children over 5, you can focus more on the lessons from the second part of the handbook (**Activities 7-11**), because children are shifting from concrete-intuitive thinking to abstract thinking. However, you can still use the physical-motor activities/games as introductory lessons and assess the current developmental stages of the children through these.

Each "Activity" presents situations in line with the curriculum and the set objectives, respecting the didactic principles (age particularities): learning from simple to complex, from particular to general taking into account children's learning stages.

For example: the simple formulation of questions, of comparison, of games, of applications that can be solved in multiple ways, assures a verification and an evaluation of the correct solutions, of combining the resolutions based on algorithmic or heuristic methods.

Activities: Recommendations

Number of children. For each activity we must consider the number of children. Depending on the total number in your class, it is recommended to separate into groups of 10 to 12 children. A second adult/teacher may be needed.

Children's age: You are given guidance on the age-range for each activity. You can also adapt activities (from the second part of the handbook) to shorten the number of instructions and actions.

General considerations

- With each activity, gradually increase the information offered and tasks to be accomplished.
- Always ask for confirmation of understanding and give clear enough examples.
- Create a safe learning environment, in which children feel comfortable.
- **Do not forget!** Each child is unique in how he / she develops and acquires skills and competences.

Children go through similar stages of development, but at different paces. We do not expect all children to meet the same standards at the same time or at the same level of performance.

Overview on Computational Thinking

"Computational Thinking" (CT) is a concept that has gained popularity over recent years; particularly after being defined in 2006 by Wing. At the same time, CT literature is at an early stage of its maturity, and it is often difficult to explain what CT is, or how to teach and acquire this skill. Not so long ago, computing was regarded as a skill possessed by specialists such as computer engineers, scientists, mathematicians, and people from similar disciplines. However, nowadays, regardless of age, everybody is expected to possess basic computing skills in line with the latest technological developments. Therefore, students who are considered as digital citizens are required to possess computational thinking skills as defined by International Society for Technology in Education (ISTE) in 2007.

While it is commonly considered that computational thinking was first mentioned in Wing's (2006) article, it was previously used by Papert in 1996. Its ambiguity emerges because of its reference as "procedural thinking" and not being clearly defined in the article by Papert in 1996. However, Jeannette Wing explained and described CT as a skill for everyone rather than only computer scientists in 2006. The basic definition of CT was defined by Wing (2006) as a way of "solving problems, designing systems and understanding human behaviour by drawing on the concepts of computer science". This definition allows the integration of CT into educational curricula and how to observe students' CT ability both general and abstract (Zhenrong, Wenming, and Rongsheng, 2009). Google and Microsoft favoured the idea very much and supported disseminating CT across different curricula. At the same time, the International Society for Technology in Education (ISTE) and Computer Science Teacher Association (CSTA) described CT as;

A problem-solving process that includes (but is not limited to) the following characteristics:

- Formulating problems in a way that enables us to use a computer and other tools to help solve them.
- Logically organizing and analysing data.
- Representing data through abstractions such as models and simulations.
- Automating solutions through algorithmic thinking (a series of ordered steps);
- Identifying, analysing, and implementing possible solutions with the goal of achieving the m st efficient and effective combination of steps and resources.
- Generalizing and transferring this problem-solving process to a wide variety of problems (CSTA and ISTE, 2011).

In addition to the definitions indicated above, Mannila and her colleagues (2014) stated that CT covers a variety of computer science concepts and thinking processes. These concepts and thinking processes assess the formulation of problems and their solutions in diverse disciplines. In the same way, Riley and Hunt (2014) referred to the cognitive strategies of thinking as "the best way to characterize CT as the way that computer scientists think, the manner in which they reason" (p.4). Furthermore, Sysło and Kwiatkowska (2013) also emphasized that CT is a group of thinking skills and these skills do not necessarily result in computer programming. Computational thinking must "focus on the principles of computing rather than on computer programming skills (p. 50)". In 2011, CSTA and ISTE described CT as: abstraction, problem decomposition, algorithms and procedures, simulation and parallelization, data collection, data representation, data analysis, automation.

Components of Computational Thinking

The key components of computational thinking show some divergence of opinions between the researchers. The components used by several researchers have been indicated below.

Components of Computational Thinking	Source
Abstraction, Algorithms, Automation, Problem Decomposition, Parallelization, Simulation	Barr & Stephenson (2011)
Abstraction, Automation, Analysis	Lee et al. (2011)
Abstraction, Algorithmic Thinking, Decomposition, Evaluation, Generalization	Selby & Woollard (2013)
Abstraction, Algorithms, Decomposition, Debugging, Generalization	Angeli et al. (2016)
Abstraction, Algorithms, Automation, Problem Decomposition, Generalization	Wing (2006, 2008, 2011)

Even though the components of computational thinking may differ among the researchers, the essential concepts are similar. CT abilities are a group of skills that are required to convert complicated, disordered, real-world problems into a structure that a mindless computer can resolve them without much assistance from a human (BCS, 2014, p.3).

The four components of computational thinking such as problem **decomposition**, **pattern recognition**, **abstraction**, **algorithmic thinking** is explained in detail below.

Problem Decomposition is a method for breaking down a complicated problem or system into smaller, more manageable parts. It is also known as "Divide and Conquer". Problem decomposition enables children to evaluate the problem at hand and identify all the steps that are required to complete the task. Problem decomposition is a crucial life skill for the future when children and adults need to fulfil major tasks. Children will learn how to participate and take charge in group projects and acquire skills on time management.

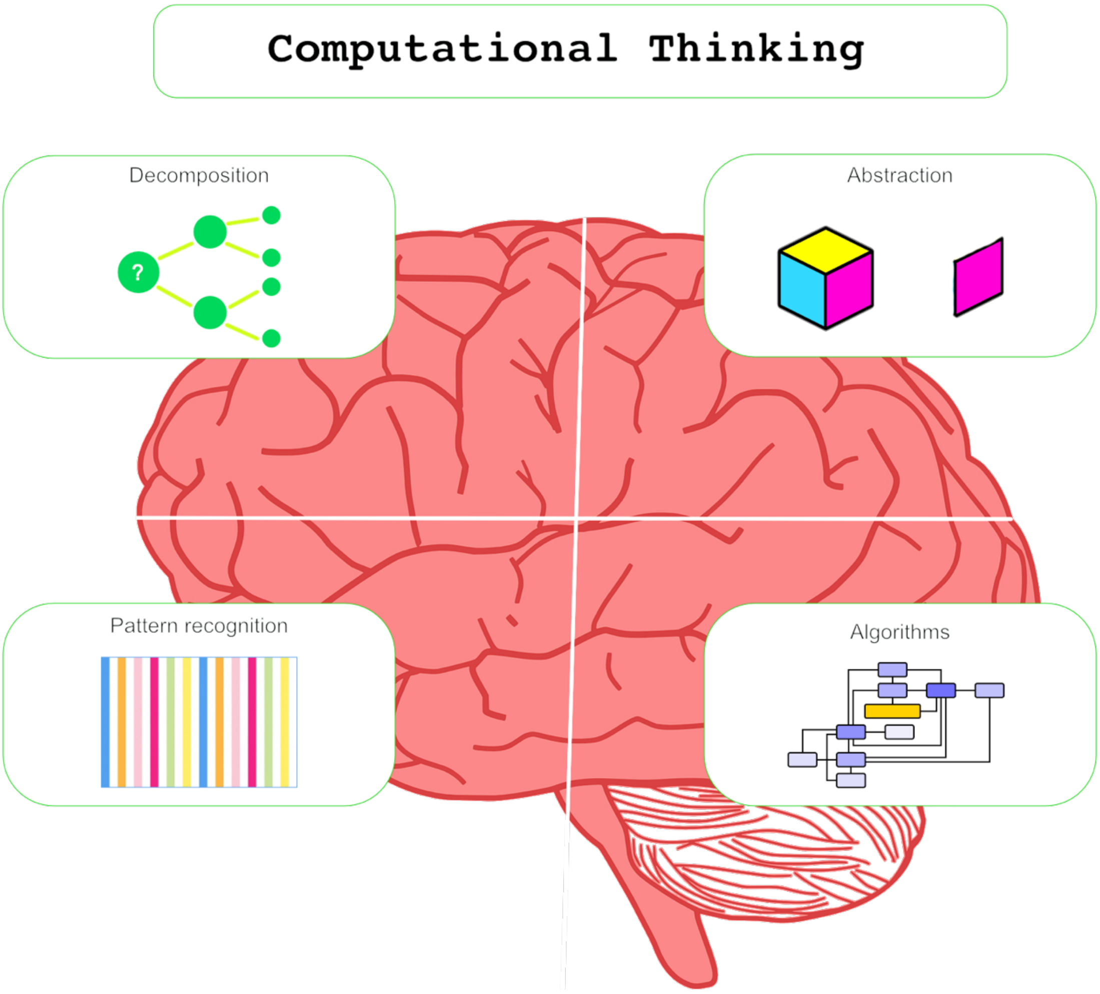
Pattern Recognition as the second component of computational thinking, is a way to look for similarities or patterns within problems. It allows children to analyse similar objects or experiences and identify commonalities. By determining what the objects or experiences have in common, children can develop an understanding of patterns. Therefore, they will be able to make predictions.

Pattern recognition starts with the simple ABAB pattern which is taught in the early years of education and increases to more complicated layers of thinking. Daily routine examples can be used to teach the concept of patterns such as eating which includes the repetition of biting, chewing, and swallowing.

Abstraction is a method used to focus only on the essential information and to dismiss unnecessary details. In this way, it leads children to more understandable and straightforward solutions. Determining the essential information in a problem and ignoring the unrelated information is one of the toughest phases of computational thinking.

Building activities such as LEGO sets are a good example of abstraction. Children are provided with numerous extra and irrelevant pieces and objects of the design. They will need to determine which pieces are required for the design and which pieces are unnecessary.

Algorithmic Thinking is a method used to develop an ordered steps solution to the problem, or the rules to be followed to provide solutions to the problem. To teach this concept to children assign a task to them and ask them to write down the steps they took to complete the task.



Four main elements of Computational Thinking

Sample Activities

The sample activities and information about how to use them are in this section. They are ready to be used or you may want to make changes to suit your needs. Feel free to create your own activities using these examples.

The lessons are divided into six main sections:

1. Physical-motor activities/games
2. Concept of sequences and Pattern recognition
3. Coding and sequences – Algorithm and Application of Computational Thinking (CT)
4. Conditional structure and concept of "if, "if/or else" in coding – Algorithm and Application of CT
5. Concept of wait and loops in coding – Algorithm and Application of CT
6. Screen-based devices – Algorithm and Application of CT

The first section focuses on activities/games not directly related to coding, and which do not use programmable devices. The aim of this section is to provide a list of activities/games designed to improve the perception of space, time and movements in young children. These skills are fundamental to developing coding and computational abilities in early childhood.

The second section focuses on the concept of sequencing of actions which is the basis of the coding process. These activities demonstrate the concept of coding using timelines, through the use of drawings.

The third section introduces the concept of coding, starting from simple movements and basic actions done in sequences, moving then to the concept of conditions and iterations in sections four and five.
In these sections unplugged robotics or educational robots are used.

The sixth and last section, introduces screen-based devices. The introduction of these technologies must be done gradually, so we suggest repeating the complete activities – from sections 2 to 5 – but now using a different, and more complex yet powerful, system: a screen based one.

The plans are designed to teach Coding and Computational Thinking to young children- skills useful throughout our lives. We hope that teachers will find these plans a useful tool to benefit their teaching practice.

Note about assessment and evaluation

"Assessment is a procedure used to determine the degree to which an individual child possesses a certain attribute" (Gullo, 2005).

In this manual we offer some ideas on how you can evaluate and assess the work of your children. Gathering this kind of information is useful, both to value the worth of the educational programme and to have a deeper understanding of the learning and development taking place for your children.

This area is also shared in the Washington National Council Report, Early Childhood Assessment: Why, What, and How, where evaluation and assessment are defined "gathering information in order to make informed instructional decisions" (Snow & Van Hemel, 2008).

Several assessment criteria exist. Gullo wrote about the evaluation in play-based-learning, that will be adopted throughout this handbook. He wrote that a teacher could observe children. Doing so, he/she can obtain information about the children's skills. In this handbook we suggest evaluating your children by directly observing them. You can make observations of children and annotate key indicators for each child.

Although the project does not foresee a stringent impact assessment, it is nevertheless useful for the teacher to observe the children's behaviour in the project activities and to document this behaviour.

The first general evaluation grid concerns the children's interests:

1. how much the children enjoy and are involved in the activities
2. whether they ask for the activities
3. whether they remember the activities and talk about them at school and at home

The second and an important parameter is the engagement and the engagement time span.

The third is memory and recollection: Do the children ask for the activities again and talk about them at home or with their classmates?

These observations can be complemented by others concerning children's participation in activities, expressions of spontaneous creativity, the ability to work in groups and overall development in computational thinking.

You can also use a checklist, to directly check each essential element in the learning approach and keep the information for easy access.

Furthermore, to help you understand the key learning elements in each activity plan, the key expected outcomes are outlined. You can use these to design your personal checklist and to focus on the main learning aspects of the activities.

Physical - motor activities / games

Activity Number 1 – Physical-motor Activity 1			
Title	Duck Duck Goose	Duration	20 mins
Topic	Explore sequences and follow instructions		
Objectives	To be able to follow instructions, improve attention skills, make decisions		
Key CT Elements	Abstraction, algorithms		
Age range	> 36 months		
Learning settings	Indoors or outdoors	Activity type	Physical-motoractivities/games
Resources/Materials	Puppet		

Learning Process

• All the children sit on the floor in a circle.
• Movement in directions and going around the outside of a circle is introduced.
• The adult demonstrates how the game is played using a puppet - going around the circle tapping each child on the shoulder saying 'duck'. Eventually the puppet taps one child on the shoulder saying 'GOOSE'. The Goose has to get up and chase the puppet around the circle. The puppet has to try to reach the GOOSE's place in the circle and sit down before being caught.
• Children observe how the game is played.
• Then one child is chosen to be on the outside walking around the circle tapping each child on the shoulder saying duck.
• Eventually they pick one child to be the "goose" by tapping the child on the shoulder and saying 'GOOSE'
• They run around the circle to try to take that child's place before the "goose" catches them
• If they reach the end without getting tagged, the "goose" returns to their own seat and the original player continues around the circle.

Evaluation	Use a rubric and observe the children
Expected Outcomes	o Children can understand the rules o Children can follow a sequence o Children can make decisions

Notes

• Follow the sequence – duck, duck goose. This can be made more difficult by adding number of times the sequence has to be done
• As children play this game, they think about how to pick a goose
- such as someone who isn't paying attention which will help them get back to base without being tagged.
• Children need to plan ahead when they are the 'goose'

ISTE/Curriculum Syllabus Reference and Further comments

Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application

Activity Number 2 - Physical-motor Activity 2			
Title	Dodgems Cars	Duration	20 mins
Topic	Spatial Awareness / Directions / Following instructions		
Objectives	Be aware of own space, begin to follow directions and understand instructions		
Key CT Elements	Abstraction, algorithms		
Age range	> 36 months		
Learning settings	Indoors/Outdoors	Activity type	Physical-motoractivities/games
Resources/Materials	Markers or Chalk to assist finding a space. Hoops or steering wheels		

Learning Process

1. Each child finds themselves a space – use marker or chalk.
2. Each child has a piece of equipment to hold like a steering wheel / or a hoop that the children can stand inside and hold it around their waist to give the idea that they are in a car. They can also hold the hoop or steering wheel in front of them.
3. Children **start** on their own marker and then learn to move around the play space slowly not bumping into each other, using the equipment as a steering wheel
4. Once they are familiar with this you can introduce instructions, given to children in form of lights or coloured tags
   o RED – the children stop
   o ORANGE the children jog/march on the spot
   o GREEN the children move again around the playspace

Evaluation	Use a rubric and observe children
Expected Outcomes	o Children can move in different directions o Children can move at different speeds o Children can avoid obstacles o Children can work independently in own space o Children can follow a leader

Notes

Introduce instructions one at a time to ensure understanding
Remind children to look out for obstacles
Use different coloured cards to help understanding of instructions
You can introduce travelling at different speeds for safety and encourage the children to call out "beep beep" when they are near another "dodgem" to develop their spatial awareness

Make play space larger to make activity easier or smaller to make the activity harder
Introduce additional instructions to make activity harder – "roundabout" children turn round on the spot. "Busy road" to encourage children to drive more slowly
Include arrows/lines to direct pathways

ISTE/Curriculum Syllabus Reference and Further comments

Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application

Activity Number 3 – Physical-motor Activity 3			
Title	Journey to the Tree-house	Duration	20 mins
Topic	Ways of travelling, Positional language, Following Instructions		
Objectives	Use large and small movements/Understand positional language/overcome obstacles/ begin to understand instructions		
Key CT Elements	Abstraction, algorithms		
Age range	> 36 months		
Learning settings	Outdoors/indoors if space	Activity type	Physical-motoractivities/games
Resources	Markers to create stepping stones/skipping ropes to mark out the tree house station		
Learning Process			
1. Arrange the markers in lines of 3 or 4 to create steppingstones around the play area. 2. Lay out the skipping rope to create the tree house 3. Children observe the space, and then move around the space in pairs using giant strides or on tiptoes 4. When they come to a set of steppingstones, they travel across them choosing to jump, leap, spring or step across. 5. They can evaluate if they will cross in turn or work together to help each other across 6. When they come to the treehouse station the children make a climbing, push pull action up the imaginary ladder. 7. The children who reach the treehouse shout out 'I can see you' and the other children must freeze like statues, holding their balance. 8. Then the treehouse children climb down and they all continue to move around the area and repeat.			
Evaluation	Use a rubric and observe children		
Expected Outcomes	o Children can move in different directions o Children can move at different speeds o Children can avoid obstacles o Children can move using large and small movements		
Notes			
Make play space larger to make activity easier or smaller to make the activity harder Place steppingstones closer or further apart Make ladder rungs on ground/floor wider/narrower Practice one move before progressing to another Link the moves to create a sequence Move in different directions Travel at different speeds Create different shaped statues Introduce instructions to freeze when on steppingstones/treehouse and when not.			
ISTE/Curriculum Syllabus Reference and Further comments			
Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application			

Activity Number 4 – Physical-motor Activity 4			
Title	Mirror Mirror	Duration	20 mins
Topic	Observational Skills, Imitation, Coordination skills, Bilateral/Unilateral/Contra-lateral Movements		
Objectives	To improve observational, imitation and coordination skills, To be able to move their body using mirroring movements To move their bodies in a variety of ways		
Key CT Elements	Abstraction, algorithms		
Age range	> 36 months		
Learning settings	Outdoors/indoors if space	Activity type	Physical-motor activities/games
Resources/Materials	Music, small equipment like balls, bean bags, scarves		

Learning Process

o This activity could be introduced using a real mirror and looking all together how the mirror works, seeing and observing how images are reflected by the mirror.
o Then children sit in their own space facing the teacher. They copy the simple actions he/she makes, acting like a mirror
o Encourage actions that use:
Both arms and hands doing the actions at the same time e.g.

1. Arms go up, then wide then round and down making a large circle in the air.
2. Hands go out to the sides and back together again
3. Hands push forwards together, then out to the side

One side of the body doing something different from the other e.g.

1. Actions using one arm or one hand only
2. Arm pushes outwards to side
3. Large windmill circle with one arm

Actions that cross the centre line of the body (imagine a line drawn from the middle of the forehead down the centre of the body) e.g.

1. One hand crosses body and touches the opposite knee while seated
2. Folding arms
3. Hand moves from one shoulder to the other
4. Scissoring arms in front of the body
5. High punches across the body

o The activity lasts until children can understand how to manage the game

Evaluation	Use a rubric and observe children
Expected Outcomes	o Children's observational, imitation and coordination skills are improved o Children can move their bodies using mirroring movements o Children can move their bodies in a variety of ways

Notes

o Start with simple actions and repeat o Introduce faster and slower movements o Introduce music and selection of small equipment – balls, beanbags, scarves o The game can progress to working in pairs sitting opposite each other o One child is the leader and makes the arm actions and the other to be the mirror and copy the actions o The pairs can follow instructions from the adult or make up their own o Children take turns being the leader and the mirror o Younger children can play this on their own, making movements and watching themselves in a mirror
ISTE/Curriculum Syllabus Reference and Further comments
Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application

Activity Number 5 - Physical-motor Activity 5			
Title	Follow the Leader/Conductor	Duration	20 mins
Topic	Following directions, directional language, avoiding obstacles, spatial awareness, imitation skills, balancing and coordination		
Objectives	Begin to follow directions, understand and use directional language, understand how to avoid obstacles, be aware of own and others' space, follow instructions and imitate others, increase balancing and coordination skills		
Key CT Elements	Abstraction, algorithms		
Age range	> 36 months		
Learning settings	Outdoors/indoors if space	Activity type	Physical-motoractivities/games
Resources/Materials	Music, cones, shapes		
Learning Process			

This activity could be introduced, imagining it as a touristic trip, or a walk or an adventure, where the guide or the leader leads you on the walk. But the path could be dangerous, and only the leader, conductor, guide knows how to travel safely.

1. We call the guide "Conductor or Leader". The conductor/leader takes the children on a journey/walk around the proposed area e.g. imaginary seaside
2. The conductor/leader is in front of the children and models the action, so the children can observe the conductor /leader and copy the actions
3. Children take turns being the conductor/leader

Actions aim to support body control and could include

- o Walking on tiptoes
- o Walking along lines on floors or chalked out markings
- o Balancing on one foot and then the other
- o Balancing on bottoms
- o Balancing on hands and feet
- o Moving using hands and feet – crablike
- o Balancing on one foot and one hand
- o Jumping forwards, sideways, zigzag
- o Walking backwards
- o Moving from low down to high up

Evaluation	Use a rubric and observe children
Expected Outcomes	o Children can follow directions o Children can understand and use directional language, o Children understand how to avoid obstacles, o Children are aware of own and others' space o Children follow instructions and imitate others o Children's balancing and coordination skills are improved
Notes	

Introduce different movements to ensure understanding before starting the activity Introduce different movements one at a time before including more into the game Make the playspace larger to make activity easier or smaller to make activity harder. Children work in own space to practice the actions before progressing to larger group space Practice the balances one at a time Move in different directions Include arrows/lines to direct pathways Add small equipment (bean bags/scarves/koosh balls) to create obstacles to move around Add small equipment (bean bags/scarves/koosh balls) to balance on parts of the body – shoulders, knees and elbows
ISTE/Curriculum Syllabus Reference and Further comments
Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application

Activity Number 6 - Physical-motor Activity 6			
Title	Heads, shoulders, knees and toes	Duration	20 mins
Topic	Explore sequences and loops, follow instructions		
Objectives	To be able to follow instructions, to follow a sequence and repeat		
Key CT Elements	Abstraction, algorithms		
Age range	> 36 months		
Learning settings	Indoors or outdoors	Activity type	Physical-motor activities/games
Resources/Materials	*"Head and shoulders, knees and toes"* music		

Learning Process

Teacher and children are standing in a circle together – listening and singing the song. The teacher asks children to touch and say the relevant parts of the body, called out in the song, using both hands. If necessary, children observe the adults completing the sequence first.

Text of the song:

Head and shoulders, knees and toes,
Knees and toes
Head and shoulders, knees and toes,
We all turn round together.

Eyes and ears and mouth and nose,
Mouth and nose, mouth and nose,
Eyes and ears and mouth and nose,
We all clap hands together.

Evaluation	Use a rubric and observe children
Expected Outcomes	o Children can follow instructions o Children can follow a sequence o Children can repeat a sequence

Notes

Lyrics can also be sung in reverse, (quite difficult) like this:

Toes, knees and shoulders, head, shoulders, head
Toes, knees and shoulders, head, shoulders, head
And nose and mouth and ears and eyes
Toes, knees and shoulders, head, shoulders, head.

Another version for progression could be leaving out a word and just touching the body part Each verse is repeated, with one word being omitted each time, just touching their body parts, without actually saying the word. *Verse 2* *----, shoulders, knees and toes...* *Verse 3* *----, ----, knees and toes...* *Verse 4* *----, ----, ---- ---- toes...* *Verse 5* *----, ----, ---- ---- ----...* This pattern continues until all the words are omitted. The last verse consists of no actual singing, just touching what would have been sung or singing all lyrics, but at a much faster tempo.
ISTE/Curriculum Syllabus Reference and Further comments
Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application

Concept of sequences and Pattern recognition

Activity Number 7 – Pattern Recognition 1			
Title	Pattern Recognition	Duration	20 minutes
Topic	Pattern Recognition		
Objectives	Understand the concept of sequencing and managing patterns		
Key CT Elements	Abstraction, algorithms, pattern recognition		
Age range	> 36 months		
Learning settings	Classroom	Activity type	Object manipulation
Resources/Materials	Objects of two different shapes (but same colour)		
Learning Process			
1. Two different objects are given to the children 2. An alternate sequence of the objects (i.e. square, circle, square, circle, square, circle, …), is shown to children (using the physical objects or a photograph of them). 3. Teacher asks children to guess what the next object in the sequence should be			
Evaluation	Use a rubric and observe children		
Expected outcomes	o Children are able to estimate how a given sequence will continue o Children are able to manipulate the objects		
Notes			
For this activity, you can use a wide range of objects, for example: construction bricks, wooden blocks, printed images, puzzle parts and so on. You can also use printed worksheets. -			
ISTE/Curriculum Syllabus Reference and Further comments			
Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application, Abstraction, Pattern recognition, Problem Solving, Algorithm, Linear Logic Structure At https://www.thingiverse.com/thing:4665104 is a set of 3D models that you can produce with a 3D printer and use for Pattern Recognition tasks. You can print them in different colours to increase the range of objects.			

Activity Number 8 – Pattern Recognition 2			
Title	Pattern Recognition	Duration	20 minutes
Topic	Pattern Recognition		
Objectives	Understand the concept of sequencing and managing patterns		
Key CT Elements	Abstraction, algorithms, pattern recognition		
Age range	> 36 months		
Learning settings	Classroom	Activity type	Object manipulation
Resources/Materials	Objects of three different shapes (but same colour)		

Learning Process

1. Three different objects are given to the children
2. An alternate sequence of the objects (i.e. square, circle, triangle, square, circle, triangle, square), is shown to children (using the physical objects or a photograph of them).
3. Teacher asks children to guess what the next object in the sequence should be

Evaluation	Use a rubric and observe children
Expected outcomes	o Children are able to estimate how a given sequence will continue o Children are able to manipulate the objects

Notes

For this activity, you can use a wide range of objects, for example: construction bricks, wooden blocks, printed images, puzzle parts and so on.

You can also use printed worksheets.

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ISTE/Curriculum Syllabus Reference and Further comments

Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application, Abstraction, Pattern recognition, Problem Solving, Algorithm, Linear Logic Structure

At https://www.thingiverse.com/thing:4665104 is a set of 3D models that you can produce with a 3D printer and use for Pattern Recognition tasks. You can print them in different colours to increase the range of objects.

Activity Number 9 – Pattern Recognition 3			
Title	Pattern Recognition	Duration	20 minutes
Topic	Pattern Recognition		
Objectives	Understand the concept of sequencing and managing patterns		
Key CT Elements	Abstraction, algorithms, pattern recognition		
Age range	> 36 months		
Learning settings	Classroom	Activity type	Object manipulation
Resources/Materials	Objects of three different shapes		

Learning Process

1. Two different objects are given to the children
2. An 1-1-2 sequence of the objects (i.e. square, square, circle, square, square, circle, square, square, circle, …), is shown to children (using the physical objects or a photograph of them).
3. Teacher asks children to guess what the next object in the sequence should be

Evaluation	Use a rubric and observe children
Expected outcomes	o Children are able to estimate how a given sequence will continue o Children are able to manipulate the objects

Notes

For this activity, you can use a wide range of objects, for example: construction bricks, wooden blocks, printed images, puzzle parts and so on.

You can also use printed worksheets.

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ISTE/Curriculum Syllabus Reference and Further comments

Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application, Abstraction, Pattern recognition, Problem Solving, Algorithm, Linear Logic Structure

At https://www.thingiverse.com/thing:4665104 is a set of 3D models that you can produce with a 3D printer and use for Pattern Recognition tasks. You can print them in different colours to increase the range of objects.

Activity Number 10 – Pattern Recognition 4			
Title	Pattern Recognition	Duration	20 minutes
Topic	Pattern Recognition and basis of sequencing		
Objectives	Understand the concept of sequencing and managing patterns		
Key CT Elements	Abstraction, algorithms, pattern recognition		
Age range	> 36 months		
Learning settings	Classroom	Activity type	Object manipulation
Resources/Materials	Objects of different shapes and colour		
Learning Process			
4. A set of objects is given to the children 5. A sequence of objects, that has to be reproduced, is shown to children (using the physical objects or a photograph of them) 6. Teachers asks them to put the given objects in the same order as demonstrated by the teacher.			
Evaluation	Use a rubric and observe children		
Expected outcomes	o Children are able to place the objects in the correct order o Children are able to estimate how a given sequence will continue o Children are able to manipulate the objects		
Notes			
For this activity, you can use a wide range of objects, for example: commonly used objects, construction bricks, wooden blocks, printed images, puzzle parts and so on. The larger the number of objects, the harder the task. To make the activity more challenging, you can use the same or a similar object many times. Once children can manage the activity, they can start playing in pairs, where one child demonstrates the sequence and then the other child must repeat it. After that they can exchange roles.			
ISTE/Curriculum Syllabus Reference and Further comments			
Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application, Abstraction, Pattern recognition, Problem Solving, Algorithm, Linear Logic Structure At https://www.thingiverse.com/thing:4665104 is a set of 3D models that you can produce with a 3D printer and use for Pattern Recognition tasks. You can print them in different colours to increase the range of objects.			

Activity Number 11 – Pattern Recognition 5			
Title	Pattern Recognition	Duration	20 minutes
Topic	Sequences, Pattern Recognition		
Objectives	Understand the concept of sequencing and managing patterns		
Key CT Elements	Abstraction, algorithms, pattern recognition		
Age range	> 36 months		
Learning settings	Classroom	Activity type	Object manipulation
Resources/Materials	Objects of different shapes and colours		
Learning Process			
1. A set of objects is given to the children (i.e. blue and red circles and squares) 2. A starting sequence is then shown to them (i.e. blue square, red circle, blue square, red circle) 3. Children must estimate what the rest of the sequence looks like			
Evaluation	Use a rubric and observe chilren		
Expected Outcomes	o Children are able to place the objects in the correct order o Children are able to estimate how a given sequence will continue o Children are able to manipulate the objects		
Notes			
For this activity, you can use a wide range of objects, for example: commonly used objects, construction bricks, wooden blocks, printed images, puzzle parts and so on. You can also use printed sequences and you can ask the children to draw/colour in each shape to complete the sequence. The larger the number of objects, the harder the task. To make the activity more challenging, you can use the same or a similar object many times. Once children can manage the activity, they can start playing in pairs, where one child demonstrates the sequence and then the other child has to replicate it. After that they can exchange roles.			
ISTE/Curriculum Syllabus Reference and Further comments			
Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application, Abstraction, Pattern recognition, Problem Solving, Algorithm, Linear Logic Structure			

Activity Number 12 – Pattern Recognition 6			
Title	Pattern Recognition	Duration	20 minutes
Topic	Sequences, Pattern Recognition		
Objectives	Understand the concept of sequencing and managing patterns		
Key CT Elements	Abstraction, algorithms, pattern recognition		
Age range	> 48 months		
Learning settings	Classroom	Activity type	Object manipulation
Resources/Materials	Construction bricks		

Learning Process

1. A set of construction bricks is given to the children
2. Then a construction is shown to children
3. Children must observe the given object, and then find how to replicate it with the given bricks

Evaluation	Use a rubric and observe children
Expected Outcomes	o Children are able to manipulate the objects o Children are able to build the construction in the correct order of colour o Children can build the construction in the correct order of shape o Children can build the construction in the correct position o Children can replicate the given construction

Notes

For this activity you can use all kinds of construction bricks (i.e. wooden bricks or commercial construction bricks, or recyclable materials as appropriate). It is better if they are varied sizes and colours.
The larger the number of bricks the harder the task.

To make the activity more challenging, you can give more bricks than are necessary, or do not give the construction to be replicated but only show it briefly or show a picture of it.

Once children can manage the activity, they can start playing in pairs, where one child demonstrates the sequence and then the other child has to replicate it. After that they can exchange roles.

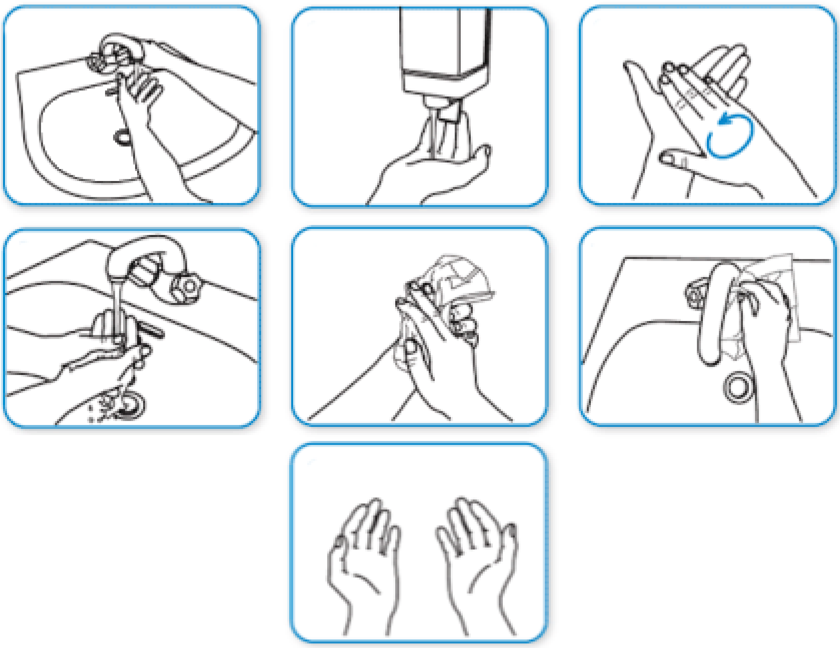
ISTE/Curriculum Syllabus Reference and Further comments

Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application, Abstraction, Pattern recognition, Problem Solving, Algorithm, Linear Logic Structure

Activity Number 13 – Sequences 1			
Title	Explore sequences	Duration	20 minutes
Topic	Sequences, time succession, timelines		
Objectives	Understand how events are done in sequences, understand the concept of sequences, analyse sequences, divide a complex task into a chain of more straightforward actions, abstraction.		
Key CT Elements	Abstraction, algorithms, pattern recognition, decomposition		
Age range	> 48 months		
Learning settings	Classroom	Activity type	Coding and Sequences
Resources/Materials	Paper and pencil		
Learning Process			
1. The teacher talks about everyday tasks with the children that are usually done in sequences (i.e. washing hands, washing teeth, having a shower) and the steps which must be followed. 2. Then children draw their own storyboards to reflect the sequences of the basic actions to be completed (i.e. if the job is washing your hands, the storyboard could be drawn with seven steps: turn on the water, wet hands, take soap, rub hands together, rinse the hands, turn off the water, dry hands). 3. Then children are to think about the concept of sequences and discuss that some different sequences lead to the same result. However, some steps cannot be swapped (i.e. while having a shower, there is no difference if I wash my head or my body first, but I cannot rinse my head before using the soap).			
Evaluation	Use a rubric and observe children		
Expected Outcomes	o Children can draw the simple actions that they do to complete a task o Children can understand sequences drawn by the teacher o Children can understand each other's drawings o Children can put the steps into the correct order o Children can divide a complex task into simpler actions		
Notes			
The creation of a sequence to complete a task is a sort of abstraction. Moreover, it is an approach of the codification process and of computational thinking. Notice how we execute everyday actions in sequences. We need to draw them according to a given timeline (evolution time direction), i.e. from left to right and/or from top to bottom. With younger children the teacher could give them a deck of cards with pictures that represent the simple actions, and then these actions must be ordered to show the complex task.			
ISTE/Curriculum Syllabus Reference and Further comments			
Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application, Abstraction, Problem Solving, Linear Logic Structure			

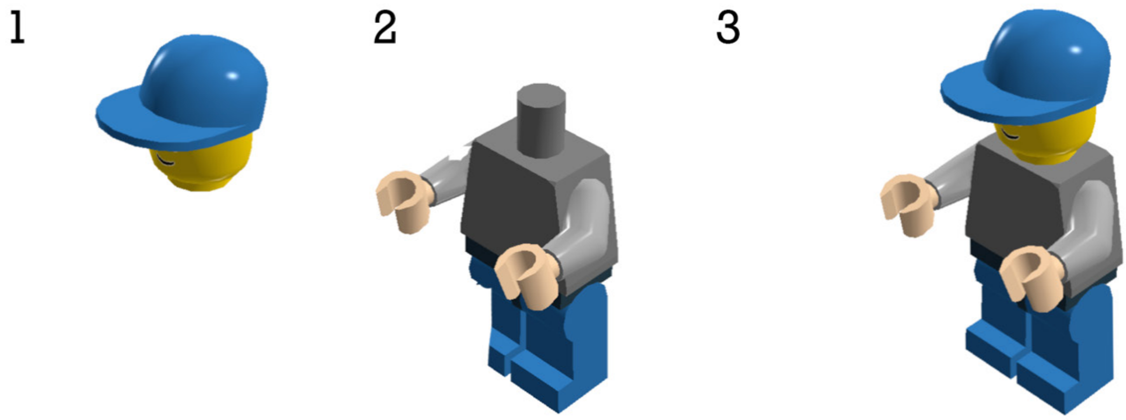
In Appendix I you will find a storyboard template that you can print and use, modifying if necessary.

Here is the storyboard of washing hands (in this example the step “turn on water” is merged into the step “wet hands”)



Storyboard of the action of washing hands - Original Image from Giacomo Baldon - Released under CC-BY-SA 4.0 international license
Edit by authors

A similar activity is using a sequence of drawings, following the instructions that they give to you. An excellent example of this is how to build something. For example, see below the instructions for building with constructions bricks.



Construction bricks building instructions

Activity Number 14 – Sequences 2			
Title	Coding and stories	Duration	20 minutes
Topic	Coding, abstraction, sequences, time succession		
Objectives	Understand how events are done in sequences, understand the concept of sequences, analyse sequences, divide a complex task into a sequence of simpler actions, abstraction, codification of sequences.		
Key CT Elements	Abstraction, algorithms, pattern recognition, decomposition		
Age range	> 60 months (5+)		
Learning settings	Classroom	Activity type	Storytelling/Coding
Resources/Materials	Cards and grid for unplugged robotics		

Learning Process

1. A simple story where a character must move from a starting point to another, could be read to the children (e.g. there is a grumpy cat, called Mike, that is grumpy because it is hungry! Mike wants to get to the bowl to drink the milk, maybe the children could help Mike?) and then invite children to create their own story.
2. The children have to draw or to build with recycled material (i.e. plastic bottle, caps, cardboard, etc) or select a puppet of the main character (in our example the cat) and the endpoint (the bowl of milk).
3. Children place the created character (the cat) and the endpoint (the bowl of milk) onto two distant squares of the grid.
4. Children have to observe the position of the characters and then use the cards to code the movements of the character from the starting point to the goal or end point.
5. After that the puppet of the cat must be moved according to the code to check if it is correct. A challenge could be to write a code for another group or to check instructions written by others. Another challenge could be to add a third point to the story that has to be reached.

Evaluation	Use a rubric and observe children
Expected Outcomes	o Children can modify the story o Children can understand what the start and the end points are o Children can create a code to move the character o Children can put the instructions in the correct order o Children can divide a complex task into more simpler actions

Notes

The creation of a sequence to complete a task is a sort of abstraction and it is a first approach to the coding process and to computational thinking.
Notice how we have to define the meanings of our “code symbol” to make it understandable (i.e. a right arrow could mean “turn right 90º” but also “turn right 90º and move forward one step”). Notice that different codes lead to the same goal. This activity could be done also using paper and pencil drawing the code or using an educational robot such as Bee Bots, Cubetto or mTiny.

ISTE/Curriculum Syllabus Reference and Further comments

Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application, Abstraction, Problem Solving, Algorithm/Coding, Linear Logic Structure, Unplugged Coding, Physical Coding, Block-Based Algorithm.

Unplugged robotics usually use cards to define the movements of a character. Each card, with an unambiguous drawing has a clear meaning, that is a basic instruction to create a code for the character's movements. Unplugged Cards are often used placing the characters on a printed or physically built grid, and each movement card usually means "move one step", so onto the next position on the grid.

In Appendix II is a printable set of cards. You can print them out and then cut out how many cards you need and use them. A description of the cards is below. Or you can build or buy your own cards.
At https://www.thingiverse.com/thing:4665096 you will find the 3D printable model version of the cards, if you want to produce them physically using a 3D printer. In Appendix III is a 6x6 cells empty grid while in Appendix IV is a 6x6 grid with a scenario printed on it, that you can use to do your unplugged activities. You will find some instructions on how to build your mat, and our printable one, at
https://www.instructables.com/UnpluggedPlugged-Robotics-Carpet/.

Our advice – if you decide to use 2D version of the cards - is to print/create cards and/or grids on paper or cardboard and laminate them before use.

If you want to use robots like Blue Bots, mTiny, Cubetto, etc… you have to create your grid, in line with the step length of the robot (i.e. 15 cm – about 5.9 in – for the Bee-Bot). The online version of the grid in Appendix IV is set to be printed on a 90 cm square sheet and used with BeeBots.

The basic cards for this lesson are the four-movement cards.
The two cards below are the "move forward" and "move back" card, and they make the character of the story move one step on the grid.

Unplugged robotics move forward and backward cards

These other two cards are the "turn cards"

Unplugged robotics turn cards

Note how each card is painted in a different colour, to be as clear as possible to children.

The “turn cards” do not have only one meaning: i.e. the first one could mean, for example:

- “turn left 45º”
- “turn left 90º
- “turn left 90º and move one step”
- “move one step then turn left 90º”

So, a precise meaning has to be agreed for each card in order to be clearly understandable. The standard meaning, according to commonly used Educational Robotics kits is “turn left 90º, without moving to another cell. In the same way, the second turn card means “turn right 90º”.

Another important card is the “start card”, which shows the start point of the code

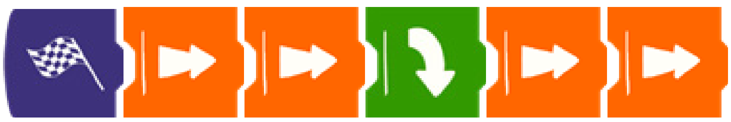
Unplugged robotics start card

There are more cards in the second page of Appendix II to be used in the following lessons.

These basic cards make a code, creating a complex sequence.

Note that the cards are colour-coded by typology of actions (Violet means start; red, orange, blue and green means movements, pink and light blue means flow control, yellow means conditions). This colour-coding is very important because it makes the code much easier to understand. Further, it is important to differentiate the directions by colour to help children in managing proprioception and spatial awareness.

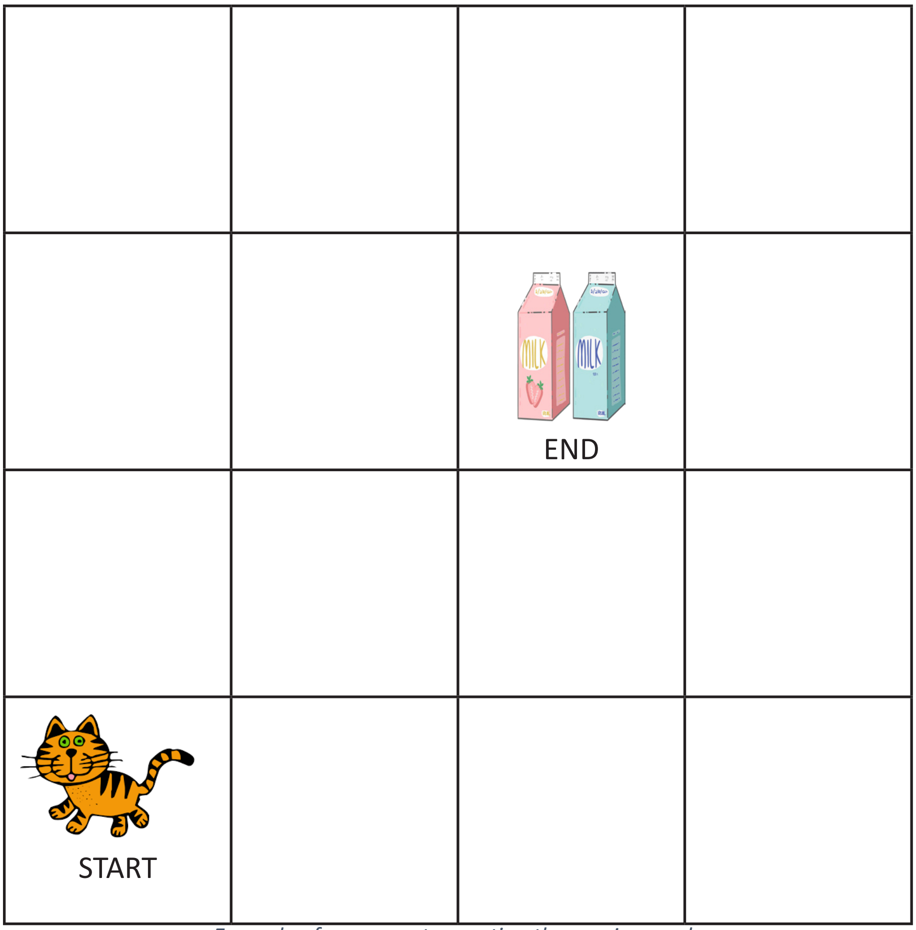
In the example grid below, a correct movement from the start point to the endpoint is illustrated by the following code.



A program written using unplugged robotics cards

This code means: move forward two times, turn right, move forward two times.

Remember that the concept of left and right is related to the front of the character.



Example of movement executing the previous code

Note how a different sequence could lead to the same goal.

You can use an empty grid and put items on it, or you can use a grid with a background ambience painted on it. An interesting activity with children is to use a grid printed on a white sheet and let the children paint their own background for the story. Also, some pre-printed grids exist that you can buy, also in the form of mats. Another interesting option is using a grid printed on a transparent sheet, so that it can used on every drawing.

Other options are the use of backgrounds painted on some puzzle cards, so that the ambience can be built by the children, or an ambience created in 3D using recycled materials.

This lesson can also use an Educational Robot, such as the Bee Bots or mTiny. In this case the robot moves from the starting point to the end point using the programming. A combination of Unplugged Cards and robotics can be used. For example, if you use a robot such as Bee Bots,

Illustration of a Bee Bot

It is programmable only in movements using the arrows on its back. The problem with this choice is that the sequence of instructions is not visible, but memorized by the robot, so it is easier to integrate it with the cards that are only a visual aid. An interesting procedure is to firstly code using the unplugged robotics cards and then use this to transfer the code to the robot (in this case you need to push the buttons on the Bee Bot according to the cards).

Other robots, such as mTiny and Cubetto, provide you with an integrated Unplugged and Robotics system, because the kits include an Unplugged Coding system that directly transfers the code to the bot. For example, the mTiny robot uses a pen that is capable of reading special unplugged cards included in the kit.

A robot mTiny on a wooden grid. The robot is being coded using its own unplugged cards

Conditional structure and concept of "if, if/else" in coding

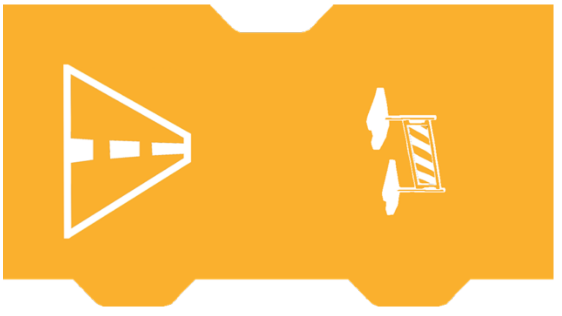
Activity Number 15 – Conditional statements			
Title	Coding and stories	Duration	20 minutes
Topic	Conditional statements, coding, abstraction, sequences, time succession		
Objectives	Understand conditional statements if and then or else, understand how events are done in sequences, understand the concept of sequences, analyse sequences, divide a complex task into a sequence of simpler actions, abstraction, codification of sequences.		
Key CT Elements	Abstraction, algorithms, pattern recognition, decomposition		
Age range	> 60 months (5+)		
Learning settings	Classroom	Activity type	Storytelling/Coding
Resources/Materials	Cards and grid for unplugged robotics		
Learning Process			
This activity must be done after Activity 14 - Sequences 2. 1. In Activity 14 - Sequences 2 a simple story has been developed by the children. In this lesson children are invited to modify the scenario, introducing an obstacle between the main character and his goal. In our example story the obstacle could be a barking dog that scares our cat. Children have to help their character to avoid the obstacle (the barking dog), and finally reach the bowl of milk. 2. Children have to draw the obstacle (the barking dog) and to put it in the pathway that the character of our story followed in the Activity 11 - Sequences 2 3. Due to the presence of the obstacle the path has to be modified to override it. The concept conditional statement (**if** the path is free **then** move straight, otherwise **if** the path is not free **then** choose another way) has to be introduced and discussed with children. Some examples of 'if and then' statements can be done (i.e. if it rains then let's take the umbrella, otherwise let's go out without it; if I'm hungry then I eat a sandwich; if I feel cold then I wear my coat, or else I do not). Children could be asked to give another example. 4. Children have to create a new code to lead the character of the story to his goal, overriding the obstacle. 5. Again as in the previous activity the code could be tested by moving the puppet			
Evaluation	Use a rubric and observe children		
Expected Outcomes	o Children can modify the story o Children can understand the concept of if, then, or else and create an example o Children can create a code to move the character o Children can put the instructions in the correct order o Children can divide a complex task into more simpler actions		
Notes			
It is interesting to define an instruction that means "if this then that, otherwise/or else do another option" instead of simply changing the code. For example you can define, using unplugged cards or drawings, a card that has two outputs which means "if there is an obstacle in front of the robot", then do the first output and the code flow from this point, otherwise/or else do the second output. This activity could be done also using paper and pencil to draw the code or using an educational robot such as Bee Bots, Cubetto or mTiny.			
ISTE/Curriculum Syllabus Reference and Further comments			
Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application, Abstraction, Problem Solving, Algorithm/Coding, Linear Logic Structure, Unplugged Coding, Physical Coding, Block-Based Algorithm			

This Activity is a modification of the previous one. Here the concept of conditional instructions is introduced, so an instruction can check a condition and then make a selection.

The widely used conditional instruction in coding are the "if" and 'then' or the "if/or else" instruction. Examples of this are

- *If it rains, then take an umbrella or else do not take it*
- *If you are hungry then eat a sandwich or else do not eat it*
- *If the path is free, then go ahead or else avoid the obstacle*

We designed an if/or else card with the condition "if the path is free", that you can see below and print from the second page of Appendix II.



Unplugged robotics if card

The program flow through the input connection (in this image on the bottom) to one of the two outputs (on the top). One output is activated if the path in front of the robot is free (the right one in the picture), the other one if there is an obstacle.

You can create your own selection card with different conditions/cases. Note that Educational Robots designed for Early Years children usually do not have a selection card.

Concept of wait and loops in coding

Activity Number 16 - Loops			
Title	Coding and stories	Duration	5 modules, 20 min each
Topic	Wait and loops, conditional statement, coding, abstraction, sequences, time succession		
Objectives	Understand the concept of loops and/or wait, understand conditional statements if and if/else, understand how events are done in sequences, understand the concept of sequences, analyse sequences, divide a complex task into a sequence of simpler actions, abstraction, codification of sequences.		
Key CT Elements	Abstraction, algorithms, pattern recognition, decomposition		
Age range	> 60 months (5+)		
Learning settings	Classroom	Activity type	Storytelling/Coding
Resources/Materials	Cards and grid for unplugged robotics		
Learning Process			
The lesson must be done after Activity Number 15 – Conditional statements. 1. In Activity Number 15 – Conditional Statements, a simple story has been developed and an obstacle inserted. Now we can suppose that the obstacle disappears if we wait long enough. I.e. in our story we can suppose that once we encounter the dog it goes away if we wait, let's suppose 5 seconds, because it gets hungry and goes to eat. In this lesson children are invited to change the code so that the character (the cat) waits the correct time. A single wait card could mean "wait 1 second" so you have to repeat the action the correct number of times. 2. Children have now to modify the story 3.Children have to modify the program/code to make the character wait 4. Children have to create a new program/code to lead the character of the story to his goal, overriding the obstacle. 5. Again, as in the previous activity the program/code could be tested by moving the puppet			
Evaluation	Use a rubric and observe children		
Expected outcomes	o Children can modify the story o Children can understand the concept of if, then, if/or else and create example o Children understand the concept of waiting o Children can understand how many times they have to use the wait card o Children can create a code to move the character o Children can put the instructions in the correct order oChildren can divide a complex task into more simpler actions		
Notes			
A "wait card" has to be defined (i.e., a card with a sandglass drawn on it). The meaning of this card has to be clear. Instead of using multiple cards to repeat the instructions, a "loop" card can be used (i.e. a card, or a couple of cards that mean "repeat it N times"). This activity can also be done using paper and pencil drawing the code or using an educational robot such as Bee Bots, Cubetto or mTiny.			
ISTE/Curriculum Syllabus Reference and Further comments			
Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application, Abstraction, Problem Solving, Algorithm/Coding, Linear Logic Structure, Unplugged Coding, Physical Coding, Block-Based Algorithm			

This Activity is only an integration of the previous one. In this lesson we introduce the concept of "wait" and the concept of "repeat". We are providing you with two cards that can be used to assign a code to these concepts.

The first one is the "wait card", with a sandglass painted on it.

Unplugged robotics wait card

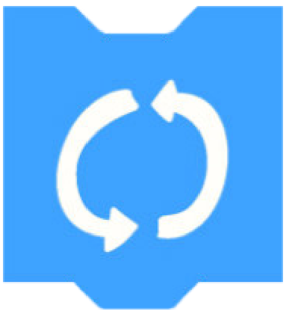
We do not assign a unique meaning to it, but you will have to do this. For example, the card could mean to wait an exact time, according to a given example. This is an easier way, but not so pedagogically useful. Instead, you could use a card saying, "Wait 1 second (minute, hour, year...)". If you have to wait more than 1 second you can:

- use as many cards as you need
- add another card with the specification of repetitions
- write on the card the number of times it is repeated
- use the repeat card.

Another option is to modify the card, providing cards with an amount of time to wait written on them.

To help children to understand the concept of time, a real sandglass could be used to quantify the exact time that each card means: when the wait card is encountered the sandglass has to be activated and the execution stop until the sand is finished.

The other card we provide is the "repeat card"



Unplugged robotics repeat card

This is used to repeat a sequence of actions. The same arguments given to the meaning of the "wait" card above have to be applied here. In this case you have to define what the group of actions are that have to be repeated. A simple meaning could be "repeat all the actions that are given before the repeat card for the number of times that the repeat card is presented".

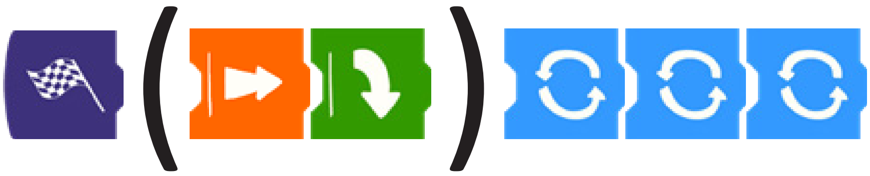
For example, the sequence below could mean "repeat the action - move forward 3 times".

Unplugged code that uses repeat card

A more complex situation can happen when more actions are used. In the sequence below the repeat cards can be applied to the cards "move forward and then turn right" or only to the card "turn right". To avoid this misunderstanding a clear meaning has to be assigned to the card before the experience.

Unplugged code that uses repeat card – sometimes it could be ambiguous

With older children, an option is to create two "parenthesis" cards that binds the actions together that have to be repeated. This option is only for older, more experienced children.



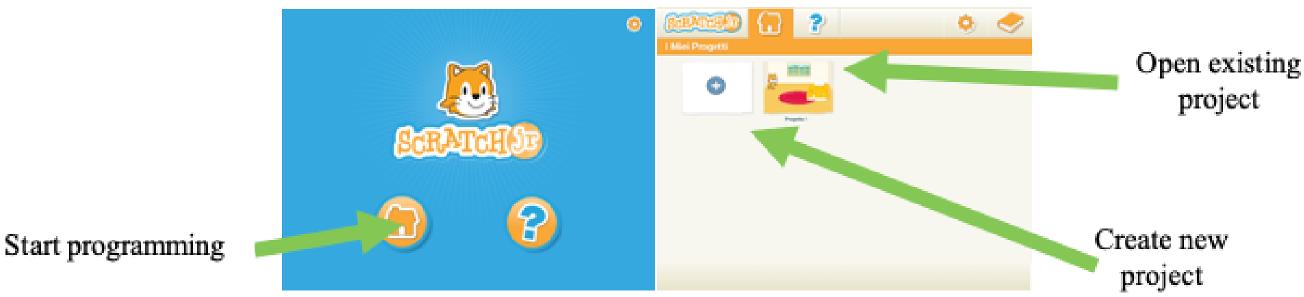
Unplugged code that uses repeat card – solve ambiguity using parenthesis

Screen-based devices

Activity Number 17 – Screen Based Devices			
Title	Coding and stories	Duration	20 minutes
Topic	Coding, abstraction, sequences, time succession		
Objectives	Understand how events are done in sequences, understand the concept of sequences, analyse sequences, divide a complex task into a sequence of simpler actions, abstraction, codification of sequences.		
Key CT Elements	Abstraction, algorithms, pattern recognition, decomposition		
Age range	> 60 months (5+)		
Learning settings	Classroom, ICT Lab	Activity type	Storytelling/Coding
Resources/Materials	Tablets with Scratch Jr		
Learning Process			
1. In Activity Number 11 – Sequences 2, a simple story was developed. Now you can use Scratch Jr to animate the story. Scratch Jr can be gradually introduced – see in the pages below a brief overview of Scratch Jr. 2. Children have to draw in Scratch Jr the main character of the story and a background where the goal is visible. 3. Children select a start point for the character (it is better to start from a straight path and then move to a path which includes turns) 4. Children have to code the character to move it from a start point to the goal			
Evaluation	Use a rubric and observe children		
Expected Outcomes	o Children can understand what the start and the end point are o Children can create a code to move the character o Children can put the instructions in the correct order o Children can divide a complex task into more simpler actions		
Notes			
Note that here the meanings of each symbol cannot be defined by the user, because each instruction has a pre-defined and unique meaning. Note that this Activity is a different application of Activity Number 13 – Sequences 2. You can, in the same way, use Activity Number 15 – Conditional Statements using Scratch Jr.			
ISTE/Curriculum Syllabus Reference and Further comments			
Computational Thinking, Decomposition, Play Based learning, Computational Thinking Application, Abstraction, Problem Solving, Algorithm/Coding, Linear Logic Structure, Plugged Coding, Block-Based Algorithm, Screen Based Algorithm			

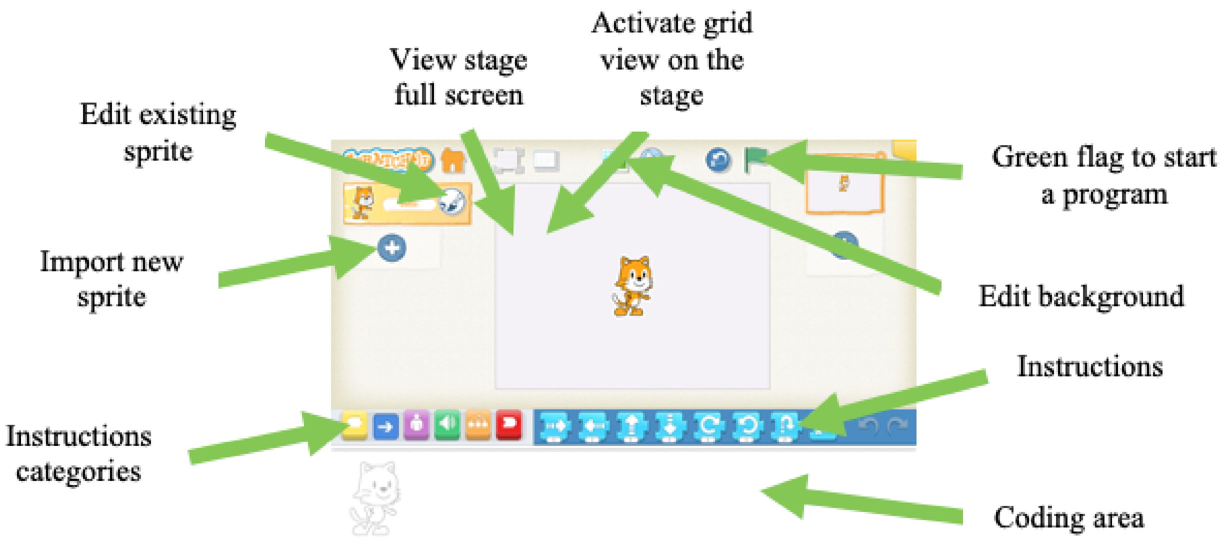
This Activity is a repetition of the previous one, using a different tool and a screen-based device. We advise you to use Scratch Jr, because it is very easy, understandable, modular and explicitly designed for early years education, but you can use other tools such as: code.org, Snap Jr, Blue Bot App…

If you only use a simple story you have to open Scratch Jr and create a new project.



Scratch Jr main screens

Then you have to create/import two Sprites (the main character and the goal) and a background, selecting a nice position for the sprites. Finally, you have to code your main character which will move according to the instructions to the code area.



Scratch Jr – Programming screen

In the following picture you can see the story of the "the cat wants to go to sleep".

Scratch Jr – Our example

The following is the code given to the cat (that is the selected Sprite) and which means: "when the green flag is hit move 13 steps to the right".

Scratch Jr – The code to move a sprite when the green flag is hit

more directions, to make it more challenging. Furthermore, you can use a repeat cycle or play a challenge where the App selects a starting and an ending point on the mat, eventually adding an obstacle.

Bibliography and further readings

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Empty Activity Plan template

In this section are empty templates of the Activity Plan. Please use them to create your own personal activities. We hope our lessons will inspire you to create interesting and new ones.

There are a limited number of templates which can be printed multiple times, so you can keep a blank one to be copied when needed.

Otherwise at www.earlycoders.org in the IO-2 section is a digital editable version of the template.

Remember to cite the original authors, so please leave the attribution disclaimer in the notes section.

Please, share your own activity plans with other teachers and educators!

Empty Activity Number 1			
Title		Duration	
Topic			
Objectives			
Key CT Elements			
Age range			
Learning settings		Activity type	
Resources/Materials			
Learning Process			
Evaluation			
Expected Outcomes			
Notes			
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Empty Activity Number 2

Title		Duration	
Topic			
Objectives			
Key CT Elements			
Age range			
Learning settings		Activity type	
Resources/Materials			

Learning Process

Evaluation	
Expected Outcomes	

Notes

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ISTE/Curriculum Syllabus Reference and Further comments

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Title		Duration	
Topic			
Objectives			
Key CT Elements			
Age range			
Learning settings		Activity type	
Resources/Materials			
Learning Process			
Evaluation			
Expected Outcomes			
Notes			
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ISTE/Curriculum Syllabus Reference and Further comments			

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Topic			
Objectives			
Key CT Elements			
Age range			
Learning settings		Activity type	
Resources/Materials			
Learning Process			
Evaluation			
Expected Outcomes			
Notes			
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ISTE/Curriculum Syllabus Reference and Further comments			

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Title		Duration	
Topic			
Objectives			
Key CT Elements			
Age range			
Learning settings		Activity type	
Resources/Materials			
Learning Process			
Evaluation			
Expected Outcomes			
Notes			
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ISTE/Curriculum Syllabus Reference and Further comments			

Empty Activity Number 6			
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Topic			
Objectives			
Key CT Elements			
Age range			
Learning settings		Activity type	
Resources/Materials			
Learning Process			
Evaluation			
Expected Outcomes			
Notes			
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ISTE/Curriculum Syllabus Reference and Further comments			

Empty Activity Number 7			
Title		Duration	
Topic			
Objectives			
Key CT Elements			
Age range			
Learning settings		Activity type	
Resources/Materials			
Learning Process			
Evaluation			
Expected Outcomes			
Notes			
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ISTE/Curriculum Syllabus Reference and Further comments			

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Title		Duration	
Topic			
Objectives			
Key CT Elements			
Age range			
Learning settings		Activity type	
Resources/Materials			
Learning Process			
Evaluation			
Expected Outcomes			
Notes			
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ISTE/Curriculum Syllabus Reference and Further comments			

Empty Activity Number 9			
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Objectives			
Key CT Elements			
Age range			
Learning settings		Activity type	
Resources/Materials			
Learning Process			
Evaluation			
Expected Outcomes			
Notes			
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ISTE/Curriculum Syllabus Reference and Further comments			

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Topic			
Objectives			
Key CT Elements			
Age range			
Learning settings		Activity type	
Resources/Materials			
Learning Process			
Evaluation			
Expected Outcomes			
Notes			
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ISTE/Curriculum Syllabus Reference and Further comments			

Black&White Activity Plan Empty Table – Activity Number:			
Title		**Duration**	
Topic			
Objectives			
Key CT Elements			
Age range			
Learning settings		**Activity type**	
Resources/Materials			
Learning Process			
Evaluation			
Expected Outcomes			
Notes			
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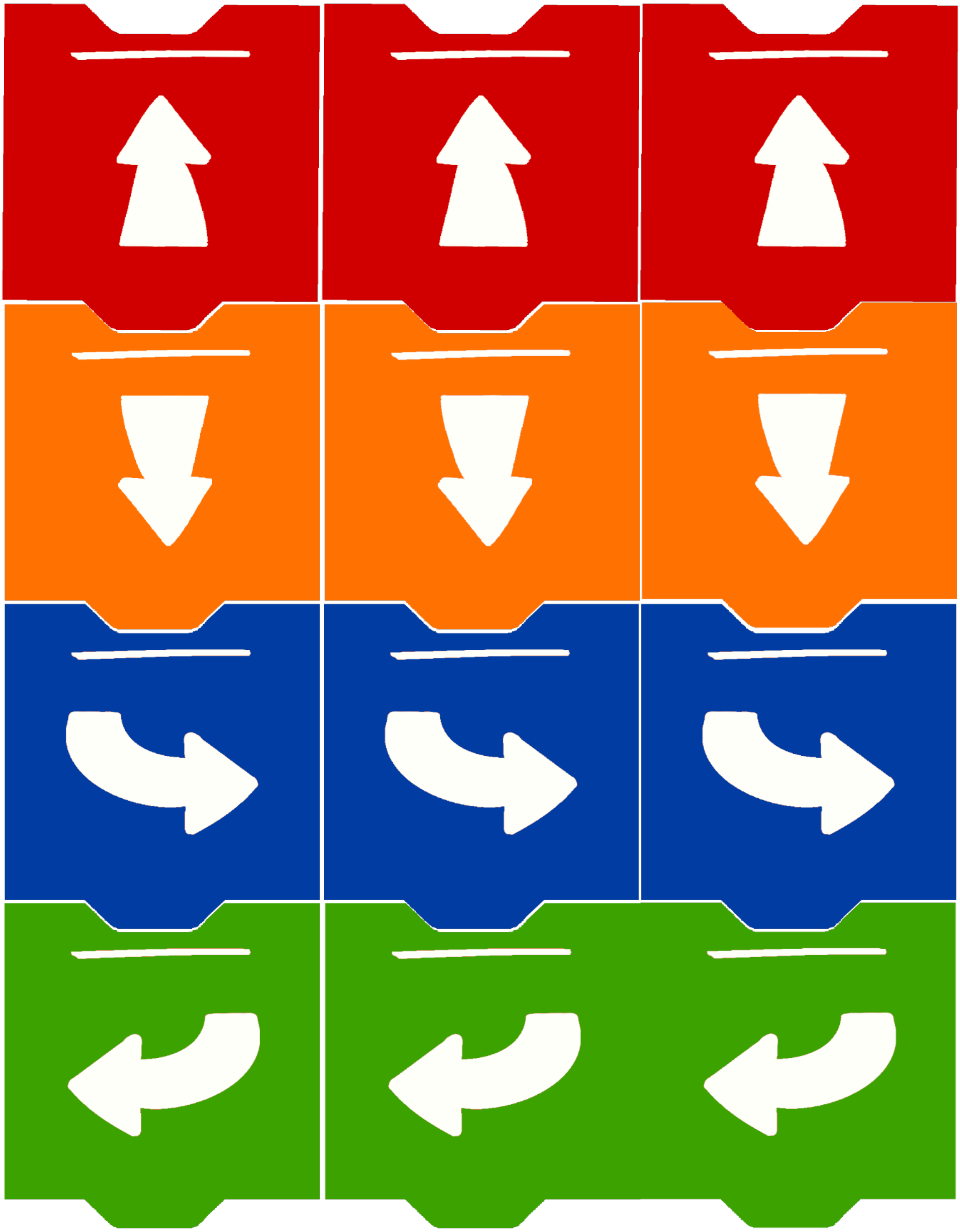
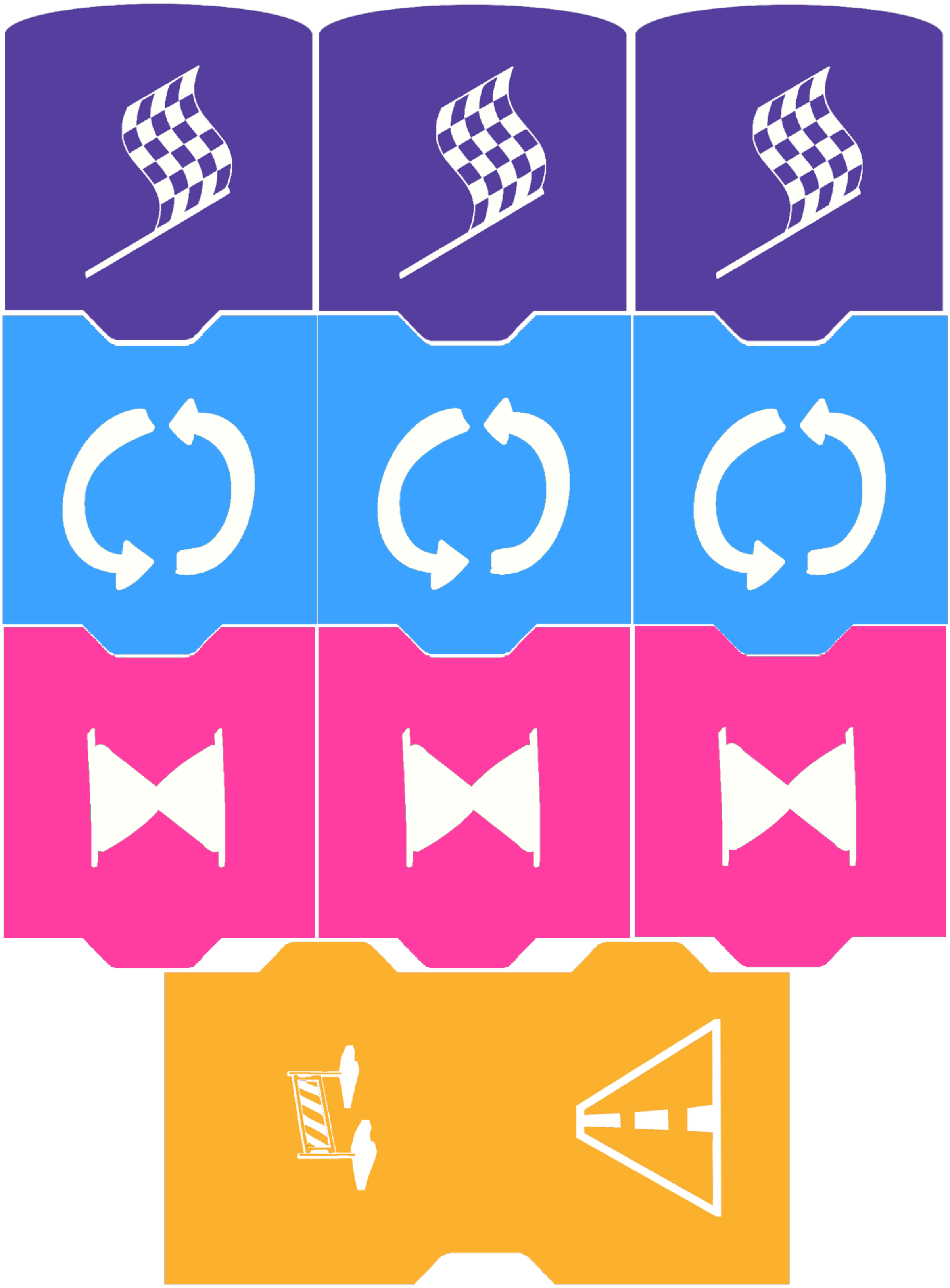
ISTE/Curriculum Syllabus Reference and Further comments			

Appendix I

1	2	3
4	5	6

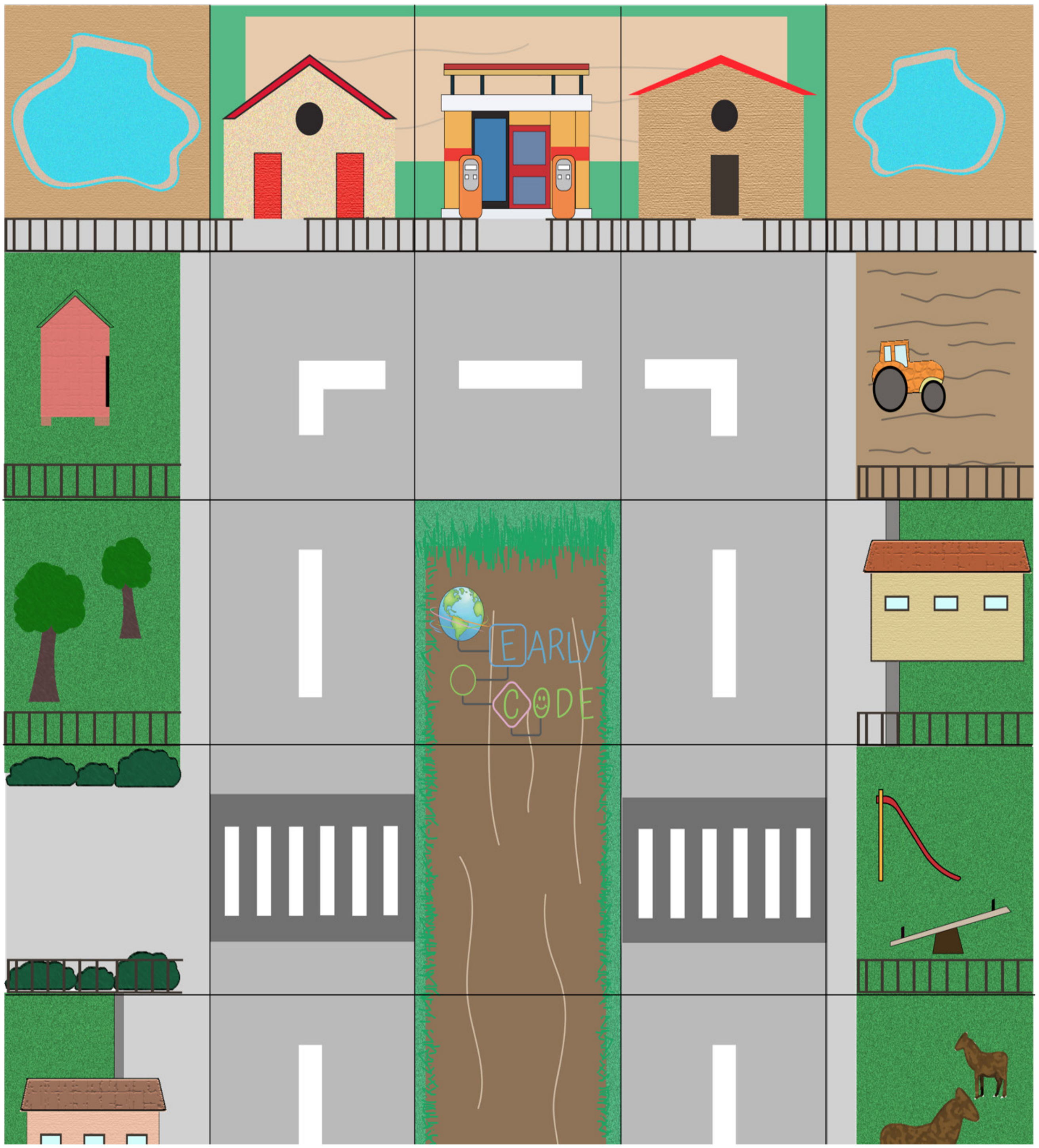
Appendix II





Appendix III

Appendix IV



Additional educational resources

Here is a list of public educational resources, you can use to enhance your teaching/learning expe rience.

- US Department of Education - Early Education resources https://www.ed.gov/early-learning/resources
- NSTA Creating a Preschool Computational-Thinking Learning Blueprint to Guide the Development of Learning Resources for Young Children - https://www.nsta.org/connected-science-learning/connected-science-learning-april-june-2020/creating-preschool)
- Google for Education – Computational Thinking resources - https://edu.google.com/resources/pro grams/exploring-computational-thinking/
- Smith, Kimberly, S.M. (Kimberly Ann) Massachusetts Institute of Technology - New materials for teach ing computational thinking in early childhood education - https://dspace.mit.edu/handle/1721.1/112546
- Scratch Jr for Teachers - https://www.scratchjr.org/teach/activities
- Learn Scratch Jr - https://www.scratchjr.org/learn/interface
- code.org – Also includes materials for early education
- https://edurobots.eu/ - Developed in the European Project EARLY, contains a database of educational robots, and related learning scenarios
- Archive of resources for early learning - http://resourcesforearlylearning.org/

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