

LEGO® MINDSTORMS® Education EV3

Coding Activities Second Edition



Introduction

LEGO® Education has developed this materials in order to help teachers facilitate exciting classroom lessons designed around the relevant technology topic of driverless vehicles.

Our intention is to enable students to develop their computational thinking skills as they program solutions in a real-world context.



Target Group

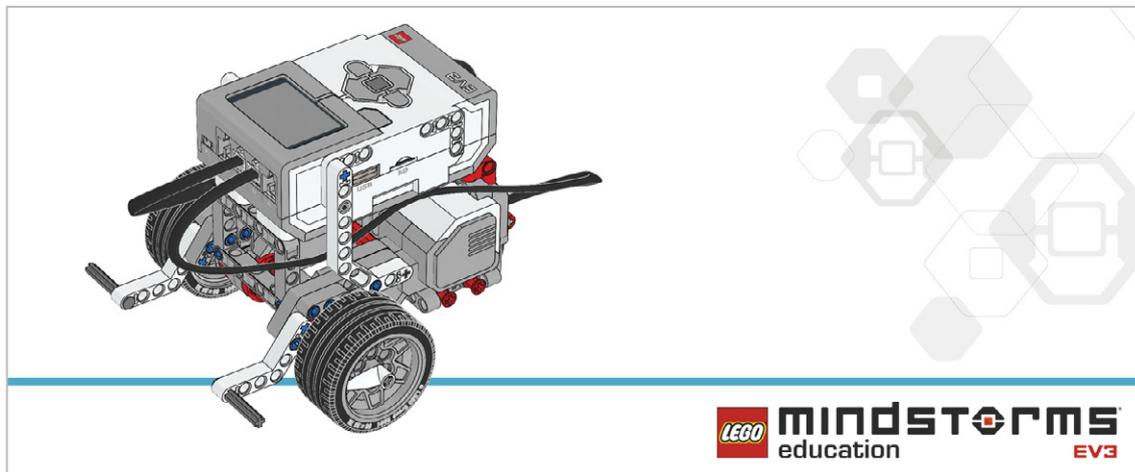
This Material will help teachers to introduce their students to computer programming concepts using a mixture of direct teaching, exploration, and tutorials from the LEGO® MINDSTORMS® Education EV3 Software and Programming app.

This material is aimed at students in grades 6-8, but it can easily be adapted for older students.

Structure of the Lessons

These lessons has been primarily written to address key programming concepts through the exploration of real life problems linked to the theme of autonomous cars. Over the course of these lessons, students will develop their design and computational thinking skills. This material includes many cross-curricular opportunities that can impact other subject areas such as science, mathematics, and engineering design technology.

All lessons are based on the Robot Educator base model and its extensions. Any driving base design can be used. It is a good idea to provide students with many different building experiences in order to develop their design skills.



Each lesson includes a discussion about the structure and design of the program.

Robot Educator Tutorials

Each lesson will require the students to have a good understanding of the EV3 Software or Programming app. This can be achieved by having them complete the basic Robot Educator tutorials. This, supported by direct teaching and exploration, will ensure that students gain the skills and understanding necessary to carry out most tasks given in the lessons.

Activity Flow

There are many ways in which to use the EV3 Coding Activities in your classroom. The material have been organized based on an increasing level of complexity in the programming concepts covered. However, you may organize them in whichever way best suits your classroom needs. You also have the freedom to adapt the lessons to fit the the time you have available.

Each lesson will last approximately:

- 60 minutes, using a pre-built robot with a focus solely on programming
- 90 minutes (2 x 45 minutes), including building, documenting, and sharing
- 135 minutes (3 x 45 minutes), including building, documenting, sharing, and a text-based program comparison.

Text-Based Programming

For this set of activities, LEGO® Education has opted to use ROBOTC as an example of text based programming language. You may choose to use other EV3 compatible text-based programming languages. This material is not intended to teach teachers and students how to use a text-based language, but rather how EV3 programs are the visual equivalent to a text-based solution. For everything you need to know about ROBOTC, go to: <http://www.robotc.net/>

Where possible, the ROBOTC programs will emulate the EV3 Programs exactly. However, due to the nature of using two different programming languages there will be slight inherent differences. Any differences that have been identified will be highlighted in the relevant ROBOTC program using green text.

Ev3 Programming App

Each of the EV3 Coding Activities can be solved using the EV3 Software or the EV3 Programming App (a tablet environment with only basic programming capabilities). The following table indicates which lessons can be solved using the example code provided with each programming resource.

Lesson	Autonomous Parking	Reversing Safely	Automatic Headlights	Line Detection	Object Detection	Unlocking a Car	Cruise Control	Roaming Vehicles
EV3 Software	X	X	X	X	X	X	X	X
EV3 Programming App	X	X	X	X	X			X
Robot C	X	X	X	X	X	X	X	X

The Variable Block and Array Block required to complete lessons Unlocking a Car and Cruise Control are not yet available in the EV3 Programming App.

Science, Computational Thinking, Coding

While the science and engineering fields originated in the early ages of humankind, computer science has a much younger history. Nevertheless, this young discipline has influenced not only the way in which we approach science and engineering, but also how we live our lives.

Computer Science is a STEM discipline, sharing attributes with science, technology, engineering, and mathematics. All STEM disciplines present opportunities for students to develop a mindset and a lifelong set of practices. Among these practices are the ability to ask questions, to design solutions, and to communicate results.

Computational thinking is another one of these practices. It is a way in which we can think and it is a way in which everybody can solve problems. Computational thinking can be described as a group of skills, one of which is algorithmic thinking. “Code” or “coding” can be used to describe the action of creating an algorithm.

Coding is therefore one vehicle by which to develop students’ computational thinking within a STEM context.

STEM Disciplines

Science, Technology, Engineering,
Mathematics, Computer Science

Develop a mindset and life long set of practices

1. Ask questions and solve problems.
2. Use models.
3. Design prototypes.
4. Investigate.
5. Analyze and interpret data.
6. Use computational thinking.
 - a. Decompose
 - b. Abstract
 - c. Think algorithmically (code)
 - d. Evaluate
 - e. Generalize
7. Engage in argument from evidence.
8. Obtain, evaluate, and communicate information.

What is Computational Thinking?

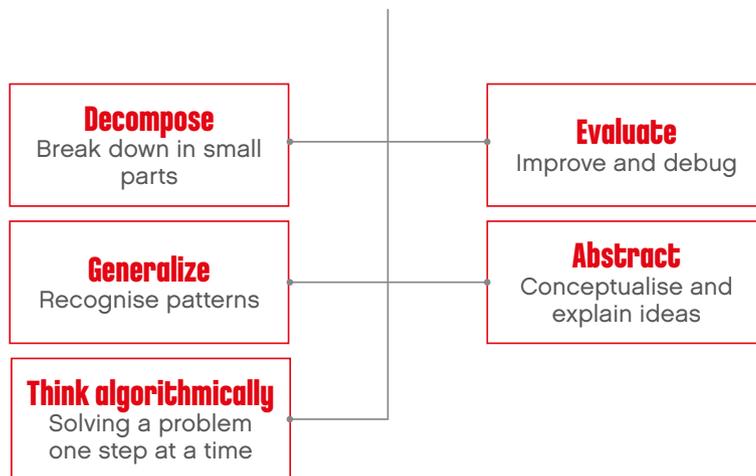
The expression “computational thinking” was first used by Seymour Papert, but Professor Jeannette Wing is known to have popularized the idea. She defined computational thinking as:

“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, 2011)

Computational thinking is used in various fields and situations, and we use it in our daily lives. Computational thinking skills are present in science, engineering, and mathematics. These skills can be defined as the following:

Computational thinking

Ways we solve problems



Decomposition

Decomposition is the ability to simplify a problem into smaller parts in order to ease the process of finding a solution. By doing so, the problem becomes easier to explain to another person, or to separate into tasks. Decomposition frequently leads to Generalization.

Example: When going on vacation, the preparation (or project) can be separated into subtasks: booking the airfare, reserving a hotel, packing a suitcase, etc.

Generalization (Pattern Recognition)

Generalization is the ability to recognize the parts of a task that are known, or have been seen somewhere else. This frequently leads to easier ways of designing algorithms.

Example: Traffic lights work by repeating the same series of actions forever.

Algorithmic Thinking (Coding)

Algorithmic Thinking is the ability to create an ordered series of steps with the purpose of solving a problem.

Example one: when we cook from a recipe, we are following a series of steps in order to prepare a meal.

Example two: when using computers, we can code a sequence of actions that tell the computer what to do.

Evaluating or Debugging

This is the ability to verify whether or not a prototype works as intended, and if not, the ability to identify what needs to be improved. It is also the process a computer programmer goes through in order to find and correct mistakes within a program.

Example one: when we are cooking, we will periodically taste the dish to check whether or not it is seasoned correctly.

Example two: when we look for spelling mistakes and missing punctuation in our written work, we are debugging it so that it can be read correctly.

Abstraction

Abstraction is the ability to explain a problem or a solution by removing unimportant details. In other words, being able to conceptualize an idea.

Example: When describing a bicycle, we use only some details to describe it. We might mention its type and color, and add more details for someone who has a real interest in bikes.

A Process For Developing Computational Thinking Skills

Using an Engineering Design Process

When looking for solutions to a problem, engineers use a design process. They go through a series of phases that guide them toward a solution. During each of these phases, some of their skills are used or developed. It is those skills that we refer to as “computational thinking skills”.

The students will follow a similar process as they complete the EV3 Coding Activities:

Defining the Problem

Students are presented with a topic that guides them to a problem or to a situation they wish to improve. Sometimes, a problem can be very detailed. To make it easier to solve, the problem can be broken down into smaller parts. By defining the problem in a simple way and by identifying some success criteria, students will develop a skill called “Decomposition”.

In other words:

- Is the student able to explain the problem by themselves?
- is the student able to describe how they will evaluate whether or not they were successful in solving the problem?
- Is the student able to break down the problem into smaller and more manageable parts?

Planning

Students should spend some time imagining different solutions to the problem, and then make a detailed plan for executing one of their ideas. They will define the steps they will need to go through in order to reach the solution. By identifying the parts of the task they might have seen before, they will develop a skill called “Generalization”.

In other words:

- Is the student able to make a list of actions to program?
- Is the student able to identify parts of existing programs that they could use?
- Is the student able to reuse parts of programs?

Trying

Each student is then tasked with creating the final version of their solution. In this phase of the process, they use iconic programming language to activate their LEGO® models. As the students code their ideas, they develop their Algorithmic Thinking skills.

In other words:

- Is the student able to program a solution to a problem?
- Is the student able to use sequence, loops, conditional statements, etc.?

Modifying

Students will evaluate their solution according to whether or not their program and model meet the success criteria. Using their evaluation skills, they will determine whether they need to change, fix, debug, or improve some part of their program.

In other words:

- Is the student making iterations of their program?
- Is the student fixing problems in their program ?
- Is the student able to judge if the solution is linked to the problem ?

Communicating

Students will present the final version of their solution to the class, explaining how their solution meets the success criteria. By explaining their solution in the right level of detail, they will develop their Abstraction and communication skills.

In other words:

- Is the student explaining the most important part of their solution?
- Is the student giving enough detail to enhance comprehension?
- Is the student making sure to explain how their solution meets the success criteria?

Developing Computational Thinking through Coding

In order to develop their Algorithmic Thinking, students will be introduced to some programming principles. As they develop their solutions, they will organize a series of actions and structures that will bring their models to life.

The most common programming principles students will use are:

1. Output

Output is something that is controlled by the program students are writing. Examples of outputs for MINDSTORMS are sounds, lights, display, and turning motors on and off.

2. Input

Input is information that a computer or device receives. It can be entered through the use of sensors in the form of a numeric or text value. For example, a sensor that detects or measures something (such as distance) converts that value into a digital input signal so it can be used in a program.

3. Events (Wait For)

Students can tell their program to wait for something to happen before continuing to execute the sequence of actions. Programs can wait for a specific length of time, or wait for something to be detected by a sensor.

4. Loop

Students can program actions to be repeated, either forever or for a specific amount.

5. Functions

Functions are a group of actions that are to be used together in specific situations. For example, the group of blocks that can be used to make a light blink would together be called, “the blink function”.

6. Conditions

Conditions are used by students in order to program actions that are to be executed only under certain circumstances. Creating conditions within a program means that some part of the program will never be executed if the condition is never met. For example, if the Touch Sensor is pressed, the motor will start, and if the sensor is released, the motor will stop.