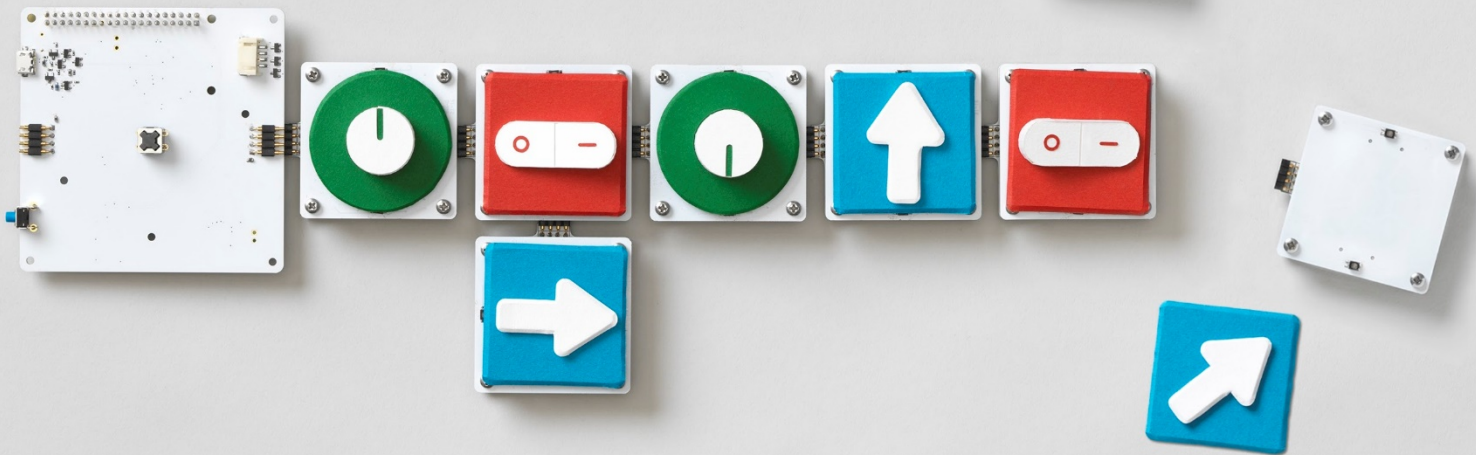


Tanglin

Tangible Programming & Inclusion

TEACHERS HANDBOOK

A GUIDE FOR UNDERSTANDING TANGIBLE PROGRAMMING AND THE IMPLEMENTATION OF THE TANGIN TOOLBOX OF RESOURCES



www.tanglin.eu

Consortium:



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1 What is tangible programming

There are different definitions for digital thinking and digital programming but, there is the frequent image association to describe it “as solving a puzzle”, in the way of recognizing patterns and breaking problems in smaller and simpler parts and organizing it in a logical and sequential way (Loureiro, Guerra, Cabrita, Moreira, Gonçalves and Queiroz, 2020) (Table 1). Tangible programming is then a way to use physical objects to make programming an activity that is appealing and accessible to the hands and minds of young children by making it more direct and less abstract.

Table 1 – Digital and computational thinking skills (Loureiro et al, 2020, p.2)

Skills	Definition
Abstraction	Representing/converting a subject/object (tangible or not) in a more understandable form by eliminating unnecessary detail. Prioritizing and choosing the most relevant descriptors by sorting them according to the degree of information (100% meaning that one characteristic is enough to describe the subject)
Decomposition	Coherently separating the logical parts of a subject/object and deconstructing them in simpler units/axioms until they can be understood, solved and evaluated separately but without losing crucial information on the original object/subject
Sequencing	Arranging the different parts of a problem in a certain order so as to create steps towards a solution
Automation	Recognizing patterns to find shortcuts and creating repetitive tasks and loops to save work and time and to improve the flow of information
Debugging	Predicting and verifying outcomes using a systematic approach
Generalization	The strategy of exploring and exploiting previous solutions to similar problems by finding connections and similarities

Why tangible programming?

Training pattern recognition, abstraction and spatial orientation, where we must transpose an object reality to oneself (robots right or left might be different from ours), are important skills that can be used not only as introductory concepts to programming/coding but, also, as a method of thinking and problem-solving to be applied virtually in any subject and level.

Tangible programming also contributes to foster inclusion: due to the interactive and physical nature of tangible programming, where groups of children come together to solve problems, there is a great opportunity to shorten differences in terms of previous exposure and motivation between different backgrounds and groups of children. Teamwork and group discussions can take place and, differently from a classical computer interface, more than one student can be in control of the input, which foster social negotiation and collaborative behaviours.

More clearly, tangible programming offers several advantages over graphic alternatives, such as:

- Facilitates collaborative peer-to-peer programming;
- Simplifies debugging processes;
- Helps to narrow gender differences of interest in computing;
- Promotes physical involvement and empathy. With more sensory input (touch, sight, hearing), it is easier to form a mental picture (abstraction) and the embodied experiences can lead to even more efficient ways of learning.

Complementarily to the three key-study areas (Mathematics, Sciences and Technology) explored in this project (to strengthen the STEM approach) (Guerra, Moreira, Loureiro, & Cabrita, 2020) and the promotion of inclusion and holistic student knowledge, some of the United Nations "Sustainable Development Goals"¹ (figure 1.), that are very related to the Tangible Programming dynamics, were purposively included in the framework of the development of the project resources (e.g.: lesson plan – Recycling; exploring the 3 R's: Reduce, Reuse, Recycle).



Fig. 1 – Sustainable development goals that are most applicable to the TangIn project

¹ Full list of United Nations Sustainable Goals is available at: <https://www.un.org/sustainabledevelopment/sustainable-development-goals/>

2 TangIn toolbox

The TangIn toolbox² consists on a set of lesson plans (table 2) that cover several subjects, such as Mathematics, Biology, Geography, Geology, integrated with tangible programming resources. Each lesson plan serves as a guideline for the teachers to explore a given subject using tangible programming. The plans should not be considered as immutable and air tight, as teachers must have the freedom to adapt them to the dynamics of the class and explore what they consider more relevant.

Table 2 – Lesson plans in the TangIn Toolbox (Loureiro et al, 2020, p.20)

Lesson Plan	Summary	Subjects
01_Intro Programming	Introduction to Computational Thinking, Programming and Robotics by using commands and role play dynamics. Simulate inputs and outputs and predict outcomes. Give examples of programming and algorithms in everyday life. Age group: all .	<ul style="list-style-type: none"> • Computational Thinking • Robotics & Algorithms • Itineraries
02_Introducing MI-GO³	MI-GO is a tool that embodies the tangible programming concepts. This session is aimed to the introduction of the story of MI-GO and the explanation on how it is programmed. The first part of the session is dedicated to the customization of MI-GO where students use their imagination and art skills to build a character. Students will also learn that the robot is programmed through the use of blocks and the function of each block. At the end of the session, they will be able to execute simple instructions. Age group: all .	<ul style="list-style-type: none"> • Robotics & Algorithms • Length measure • Rotation • Itineraries
03_Animal characteristics	Animal cards scattered around a grid. Using the BOT to travel to them according to specific characteristics Age group: 6-10 years old .	<ul style="list-style-type: none"> • Distinct Aspects • Classification • Probotic • Itineraries
04_Magic Square	Using the BOT to go to all squares without repeating in a chessboard using only the knight movement while doing it building magic squares. Age group: 9-12 years old .	<ul style="list-style-type: none"> • Calculus • Logical Reasoning • Probotic • Itineraries

² For more information visit <http://www.tangin.eu/lesson-plans-toolbox/>

³ For more information visit <https://migobot.com/>

05_Maps and Traffic signs	<p>Learn that maps are a representation of reality on a different scale. Use coordinates to find the correct correspondence between the small and big scale. Identify traffic signs and what they mean. Age group: 6-10 years old.</p>	<ul style="list-style-type: none"> • Scales • Coordinates System • Traffic Signs • Probotic • Itineraries
06_Minecraft	<p>Using the BOT to mine minerals in the correct sequence according to their properties. Age group: 8-12 years old.</p>	<ul style="list-style-type: none"> • Minerals • Seriation • Probotic • Itineraries
07_Multiplication	<p>Multiplication Tables are not only about memory there is a logic behind it, and fun also. With the BOT's help, we will build them by counting squares (areas). Age group: 7-9 years old.</p>	<ul style="list-style-type: none"> • Area model • Coordinates • Probotic • Itineraries
08_Recycling	<p>Learn about the different types of waste and where they should be placed. Plastic, metal, glass and organic waste are valuable resources that must be reused and recycled. With the help of the robot, students sort different types of waste and put it in the correct recycling bin. Age group: 6-10 years old.</p>	<ul style="list-style-type: none"> • Natural Resource • 3R's Policy • Trial and Classification • Probotic • Itineraries
09_Symmetry	<p>Finding the symmetry plan of geometrical figures drawn by MI-GO and divide into halves. Age group: 7-10 years old</p>	<ul style="list-style-type: none"> • Reflection Symmetry • Probotic • Itineraries
10_Triangles	<p>Locate and group different triangles in a geometrical figure drawn by MI-GO. Age group: 9-12 years old.</p>	<ul style="list-style-type: none"> • Triangle Classification • Decomposition of figures • Golden ratio • Probotic • Itineraries
11_Patchwork	<p>Areas puzzle. Rotating Tetris like pieces to see where they fit. Some puzzle requires the teamwork of different groups to solve it. Age group: 9-12 years old.</p>	<ul style="list-style-type: none"> • Paving • Rotation • Scales • Probotic • Itineraries
12_Circulatory System	<p>Drawing the circulatory map, connecting organs while separating venous and arterial blood flows Age group: 7-9 years old.</p>	<ul style="list-style-type: none"> • Human Circulatory System • Probotic • Itineraries •

13_Angles	First introduction to angles, and distinguish between a right angle, acute and obtuse. Age group: 6-10 years old.	<ul style="list-style-type: none"> • Regular Geometric Figures • Internal and External Angles • Probotic • Itineraries
14_Connecting Dots	Some puzzle to train/introduces loops that increase gradually the level of complexity. Ideal to assess the current level of proficiency. Age group: 8-12+ years old.	<ul style="list-style-type: none"> • Regularities and Patterns • Loops • Probotic • Itineraries
15_Space Train	Activity to create circuits and time-tables using the solar system as a theme. Age group: 6-10 years old.	<ul style="list-style-type: none"> • Uniform velocity • Time tables • Loops • Probotic • Itineraries
16_Water Cycle	Competitive game with the water cycle as a theme. Age group: 6-12 years old.	<ul style="list-style-type: none"> • Water Cycle • Probotic • Itineraries
17_Words	Scrabble-like game using MI-GO to create words for a subject at choice. Age group: 6-12 years old.	<ul style="list-style-type: none"> • Multiple subjects • Loops • Probotic • Itineraries
18_Constellations	Drawing constellations with MI-GO and using scaled cards/maps to measure angles and lengths and convert to the <i>Set</i> dimensions. Age group: 9-12 years old.	<ul style="list-style-type: none"> • Constellations • Angles • Scales • Probotic • Itineraries
19_Calculations	Matching cards with basic arithmetic operations and numbers on the <i>Set</i> as possible solutions Age group: 8-10 years old.	<ul style="list-style-type: none"> • Operations and Properties • Algebraic Expressions • Probotic • Itineraries

<p>20_Countries and Flags</p>	<p>Matching flag cards with countries and capitals. Age group: 6-10 years old.</p>	<ul style="list-style-type: none"> • EU Countries Characteristics • Maps • Citizenship • Length and angles • Probotic • Itineraries
<p>21_Measuring Units</p>	<p>Using MI-GO to measure the classroom and use the data to create maps at scale. 8-10 years old.</p>	<ul style="list-style-type: none"> • Length measurement • Scales • Velocity • Floor plan • Probotic • Itineraries

The cover of each lesson plan (figure 2) states the name of the session, the age range for which the lesson plan is more suitable and the main subjects covered.

The structure of each lesson plan is as follows:

- **Summary** – A short summary gives an overview of the subjects that are covered by the lesson plan;
- **Learning Outcomes** – States what the students are expected to achieve. In addition to specific competences in the various disciplines, transversal competences are considered, involving enhancement of STEM areas; problem-solving, communication and reasoning; skills related to probotics and reading, interpreting and building itineraries; group work skills, namely, to respect and favor the inclusion of all elements, regardless of gender, culture, etc;
- **Links with curriculum topics** – Relates the lesson contents plan with curricular topics;
- **Notes for teachers** – Gives some remarks and advices for teachers;
- **Lesson Plan** – Provides a step-by-step description of each stage of the session;
- **Resources List & Support Material** – Lists the resources needed to implement the session as well as printing material (when applicable).



Figure 2 – Main page of each lesson plan

Tips (first lessons)

- Start without the *Bot* (see lesson plan 01_Intro Programming). Rationalize in the “others” perspective.
- Introduce *Bot* by storytelling and character building (see lesson plan 02_Introducing MIGO), and let the students to get familiar with it.
- Choose an order of lesson plans but be able to adapt according to results

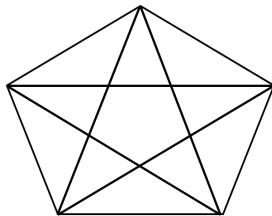
Tips (for using all the lesson plans)

- Make sure the groups are heterogeneous and everyone is active, to foster the integration of all students.
- Establish clear rules in terms of group work, to avoid the most active children assumes the lead and the quitter ones only observe.
- Include other elements of dynamics by assigning different roles to students and switching between them (inside each group).
- Circulate through the various groups to support the activities and the dynamics of each one. In the end of the lesson, promote a collective discussion of the main issues focused and the constraints and difficulties experienced.
- Progressive evolution: start with only direction functions, if suited then introduce loops, and finally angles

Dynamics examples

- Using angles does not mean you need to know them

- Example (see lesson plan n° 09/10 – Triangles/Symmetry): while using the Bot to draw the figure below, the code is given, the challenge will then be to find as many triangles as possible. The Bot here would only be a drawing tool, but even without understanding the code, the concept of angle being different of normal rotation will start to be embedded in them.



Solving different parts of the same puzzle

- Example: (see lesson plan n° 04/06/11 - Magic square/Patchwork/Minecraft) The puzzle is divided into different pieces or tasks and each group will work to solve his part and then come together to share and put the whole puzzle together. Each group has a different task/assignment and in the end, they come together to discuss their findings

Adapt to your own reality

- Example (see lesson plan n° 08 - Recycling): different countries have different colour codes for recycling. Make sure you adapt it to your reality.

Create your own puzzle and switch roles

- Example (see lesson plan n° 05 - Maps and traffic signs): recreate your own map/way to your school. Some might be putting signs other roads other building the code... and make them switch.

Competition

- Examples (most of the lesson plans): try to give points or some kind of reward system for their missions. Does not need to be win or lose but keep them motivated.

3 Resources

3.1 Summary

MI-GO robot kit, provided by C&A, was chosen as the main resource. It is a 100% tangible platform able to reach younger and older kids with the same tool kit (5-12 years old). Thought not only for young minds but also for teachers, it is extremely versatile and simple to use with only one button and unique features such as the LED feedback system, and loops, decimal and angle programming blocks.

It also presents the advantage of the programming blocks being completely independent of the robots allowing them to be shared, mixed and passed around between different groups and robots as needed, thus leveraging resources and stimulating interaction and group dynamics and hence inclusion.

As a tangible programming tool, MI-GO kit has two different types of inputs and outputs (table 3):

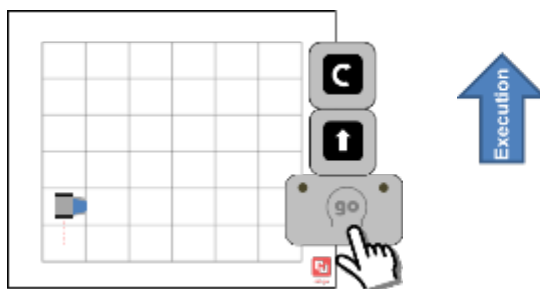
Table 3 – MI-GO inputs and outputs

inputs		outputs	
Blocks		Steps (grid)	
Functions (directions & loop)	Numbers & angle (0-9)	Normal (10cm)	Decimal (1 cm)
Colors (sensor)		Drawing (markers)	
Red (STOP)		Permanent (paper)	Temporary (cleanable set)

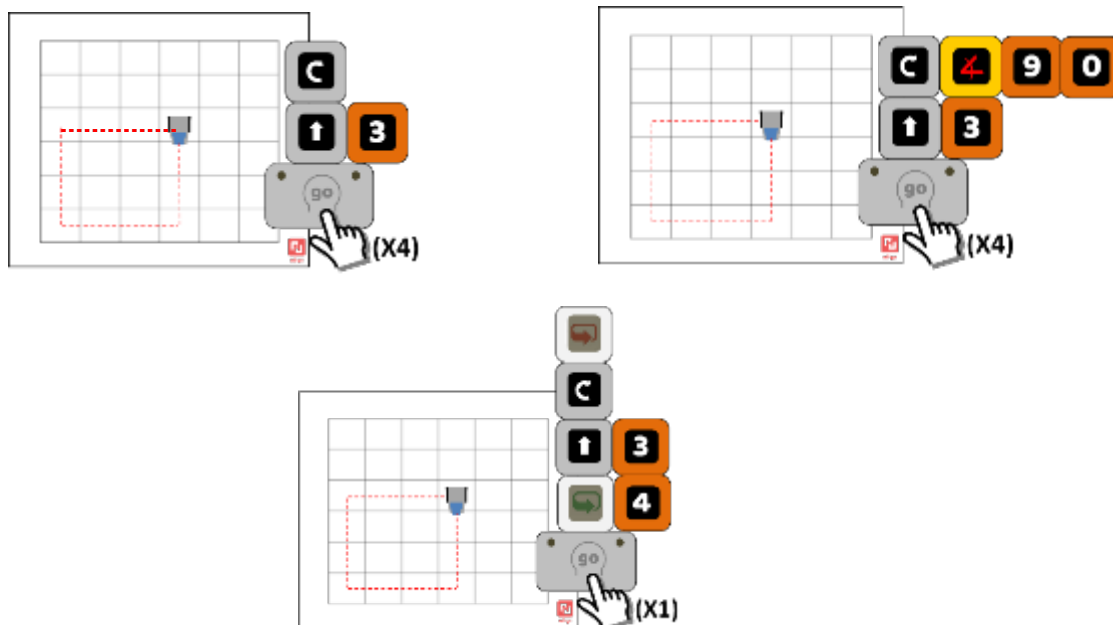
Inputs

Programming blocks: divided by functions and numbers, those are the basic units to build with as a code of instructions to the robot:

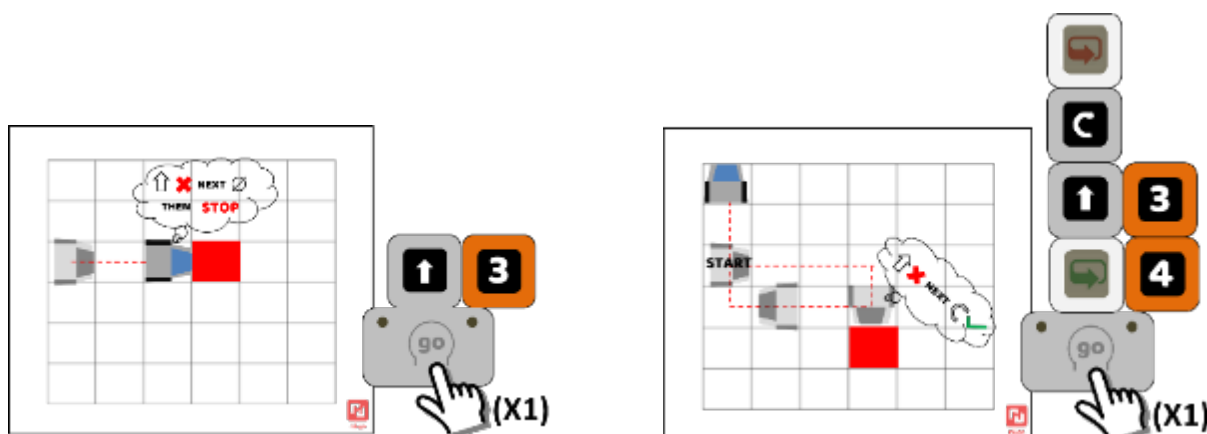
- Functions (see section 3.2 Kits - Blocks) are logic commands such as Move Forward and Rotate Right and connected starting at the Main (see section 3.2 Kits - Main) from first to last instruction in a sequential way in what will be the main body of the code. Fifteen is the maximum number of functions possible in a single code.



- Numbers from 0 to 9** (see section 3.2 Kits - Blocks) can be added to give values to the functions and connected to the right-hand side of the intended function, as a single or multiple (max 4) blocks of numbers. In this category, it is also included the *Angle* block which can be connected to a Rotate *Right* or *Left* function to change the rotation from the default 90° to an angle of choice by adding number blocks to its right.



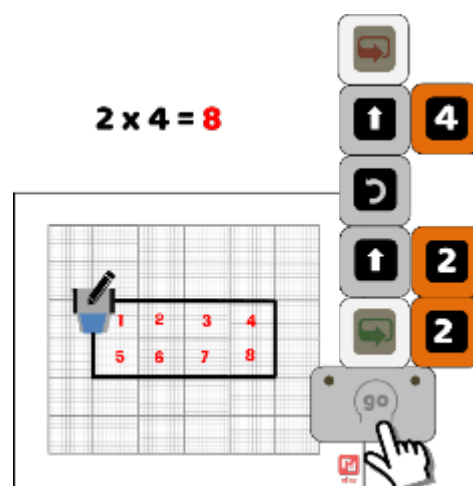
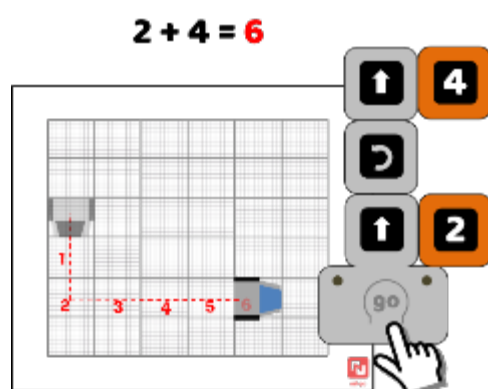
- Colours** (optional): The *Bot* has an inbuilt colour sensor that can be activated (see section 3.3 Instructions – Colour sensor). This option allows new dynamics with colours acting as *IF -> Then* functions. For the moment, only red can be detected as a *STOP* function. Therefore, when the *Bot* finds red in his way (moving forward), he will skip to the next function until being able to get rid of the “obstacle” or else remain in place. The colours can be either drawn directly in the *Set* or placed as a card on top or underneath.



Outputs

- **Steps:** counting the number and direction of the *Bot* steps is a quantifiable output and, with the help of a grid, can be used to set a specific trajectory/point as goals and solving mathematical/logical puzzles with the number of squares covered or contained. It can also be used to measure distances and areas directly on the floor.
 - Normal: Steps of 10 cm (larger squares) and its multiples using *Forward* blocks.

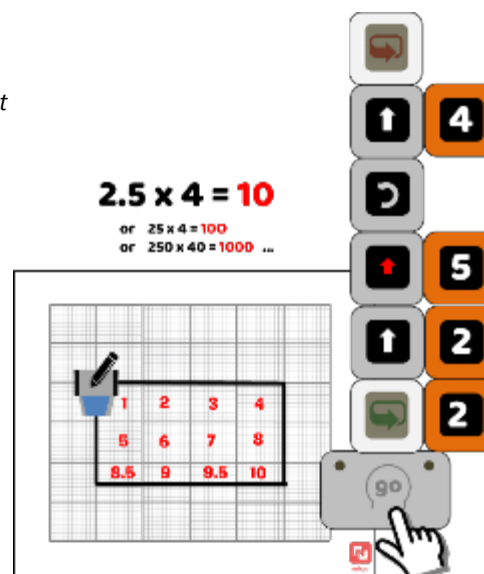
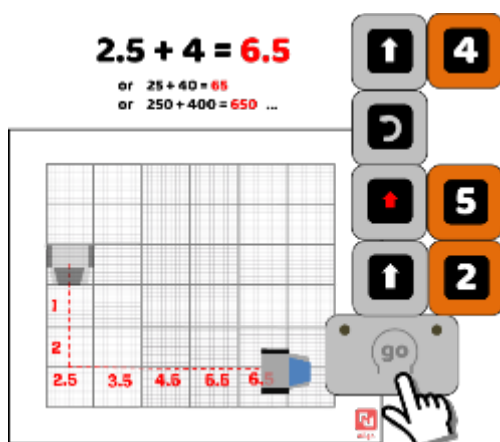
Addition operations by counting squares **covered** by the Bot



Multiplication operations by counting squares **contained** in a perimeter drawn by the Bot (area)

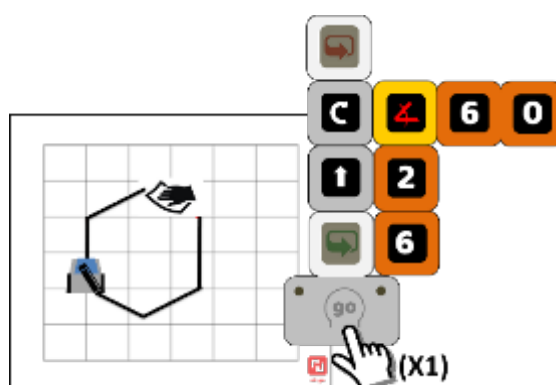
- Decimal: Steps of 1 cm (smaller squares). With the *Decimal* block, one is not limited to lengths with whole numbers. However, it does not necessarily have to be decimal, it represents a tenth of the normal step and, thus, can be used as decimal vs unit, unit vs ten, ten vs hundred, etc.

Addition operations by counting squares **covered** by the Bot

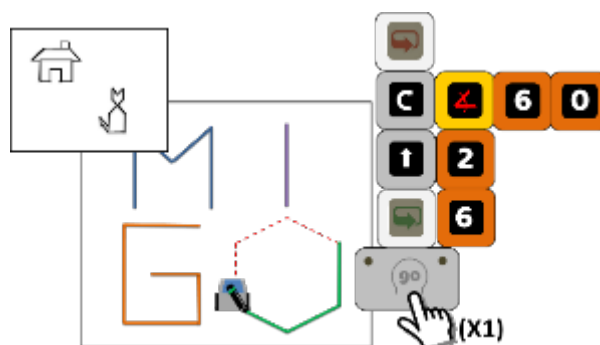


Multiplication operations by counting squares **contained** in a perimeter drawn by the Bot (area)

- **Drawing:** The *Bot* has a cavity that cuts through its axis that can be used to fix the most common commercial markers (15 mm). This capability, allows to trace the *Bot's* route and drawing geometrical or any figure composed of straight lines.
 - Temporary: Using the provided *Set* made of a translucent vinyl material, it is possible to remove/erase any trace or drawing made by markers (with permanent ones use alcohol, (see section 3.2 Kits - *Set*). This allows the constant reuse of the *Set*, not only with drawings made by the *Bot* but also by hand to create different activities and games.



- Permanent: the action is not limited to the *Set*, with color markers and big sheets of paper, one can use MI-GO to create real pieces of art. Creativity is the limit!



3.2 Kits

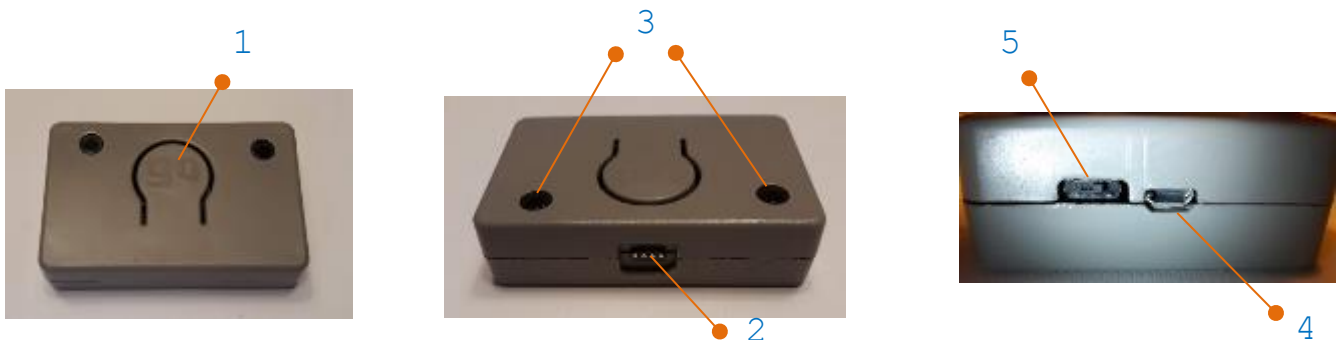
Bot

The *Bot* executes precisely (<1° precision) the instruction from the Blocks (via Main – see below). Components: hole to fix a marker (1); translucent lens allowing PCB view and LEDs feedback (2); colour sensor & white LEDs (3); pair button (4); precision sphere for rotations (5); wheels (6); ON/OFF switch (7); a power mini-USB entry (8); removable cupula (9); cavity to fix robot face card (10).



Main

The main is responsible for blocks reading and power supply (own batteries) and communicating (wireless) instructions and receive feedback from the *Bot* (~5-7 metres range). Components: multi-function GO button (1), one female connector (2) to connect the first block (Function) of the code; Two Lens for LEDs feedback (3); a power mini-USB entry (4) and a ON/OFF switch (5).



Main's top perspective

Main's front perspective

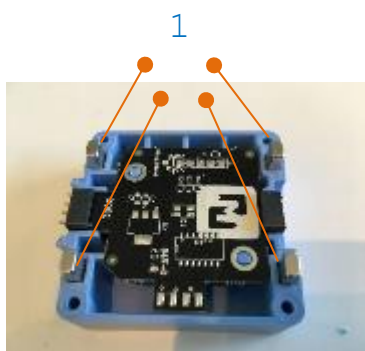
Main's lateral perspective

Blocks

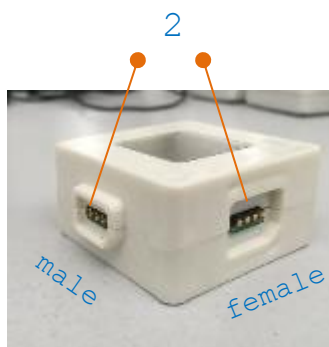
The blocks are single units with specific commands to be combined for the desired code of instructions. Components: 4 magnets (1) to make it easier to connect the blocks in the correct position (and repulse when it's wrong); connectors (2); functions have 3 (2 females & 1 male) with the exception of *End Loop* (1 male and 1 female, in the vertical axis); numbers have 2 in the horizontal axis (1 female and 1 male); translucent lens (3) for feedback with LEDs (4 colours).



All blocks except decimal



Block's inside



Block's connectors



Top view lens

- Forward and Decimal:** both will instruct the *Bot* to move forward one step. If there is a number(s) connected on the right side it will instead instruct that exact number of steps forward. If the number is 0 then it will skip it. The *Forward* step is 10 cm, the *Decimal* step is 1 cm. Connectors: (1) Male, connects with the *Main* or another *Function*; (2) Female, connects with another *function*; (3) Female, connects with a *Number* block (not angle).



Forward block



Decimal block connected to Main

- **Rotate Right & Left:** will instruct the *Bot* to rotate in its axis 90° (by default). If a number is connected to its right (see center image), it will rotate 90° that number of times (if 0 nothing happens). If, instead, it is an angle block following by number blocks, it will instruct the Bot to rotate exactly those exact (numbers) degrees. Connectors: **(1)** Male, connects with the *Main* or another Function; **(2)** Female, connects with another function; **(3)** Female, connects with a



Number or angle block.

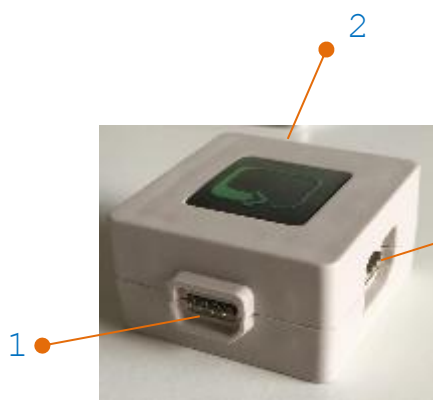


Rotate left block

Code with rotate left 2 times 90°

Code with rotate left 95°

- **Start & End Loop:** will instruct the *Bot* to repeat as many times the code between *Start Loop* and *End Loop* as the number connected to *Start Loop*. If it is 1, then It will simple do the code one time (no repetition; if it is 2, then it will do the code 2 times and so on... If there is no number, it will also do the code one time. The same for number 0 (it will be updated to skip the entire code between the loop blocks for a matter of consistency). Connectors: **(1)** Male, connects with the *Main* or another Function; **(2)** Female, connects with another function; **(3)** Female, connects with a Number block (not angle); **(4)** Female, in this case (*End Loop*) there is supposed to be no block connected (connector is there for a question of mass production economy). If one block is connected, the code will not be executed (see error "Syntax" in Table 6).



Start Loop



End Loop



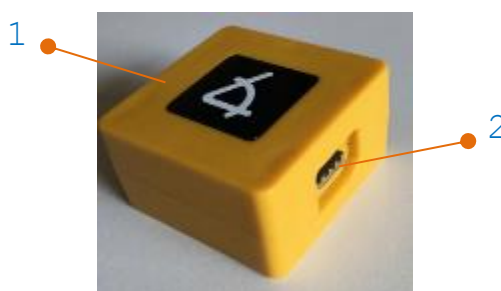
Code with four loops

- Numbers:** have to be associated/connected to functions, giving a value to them. Any combination of 3 digit numbers in a single function is possible, more than that and the *Bot* will not execute and the *Main* will give an error feedback (see error "Syntax" Table 6). Connectors: (1) Male, connects with a Function or another Number (including *Angle*); (2) Female, connects with another Number (excluding *Angle*).



Number Two block

- Angle:** has to be associated/connected to a *Rotate* (right/left) function on its left and a number on its right or else the *Bot* will not execute and the *Main* will give an error feedback (see error "Syntax" Table 6). It will change the rotation angle of *Rotate* blocks from the default 90° to the number/s connected to it. Connectors: (1) Male, connects with a *Rotate* (left/right); (2) Female, connects with a Number.



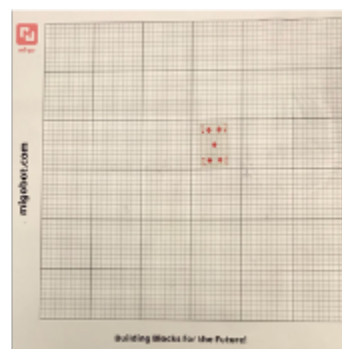
Angle block

- Set:** 6x6 vinyl grid set. Features: Big squares 100 cm² (1); small squares 1cm² (2); translucent (3); foldable (roller) and reusable*

* board markers: Recommended, to clean use dry cloth/tissue/cotton to wipe. If using permanent markers, you need to soak the tissue/cloth/cotton with alcohol. DO NOT use solvent glues (UHU, tube...). You can use duct tape on the corners but try to avoid it because it will accumulate dirt and erode along the time. To straighten it faster use a hair blower.



Grid Set on a white table



Grid Set with a card underneath

Kits

Because of different frequency of use and simultaneous need (blocks can be shared by different groups), the kits will have relatively more functions than numbers. For instances, to start the pilot in the TangIn Project, each partner had a 3 *Bot kit* (Table 4, green column).

Table 4 – the different kits options and the number of elements in each

		Kits					
<i>Bot</i>		1	2	3	4	5	6
<i>Main</i>		1	2	3	4	5	6
Blocks	<i>Functions</i>	7	13	22	28	35	41
	<i>Forward</i>	2	4	6	8	10	12
	<i>Decimal</i>	1	1	2	2	3	3
	<i>Right</i>	1	2	4	5	6	7
	<i>Left</i>	1	2	4	5	6	7
	<i>Start Loop</i>	1	2	3	4	5	6
	<i>End Loop</i>	1	2	3	4	5	6
	<i>Numbers</i>	11	15	26	32	43	49
	<i>Angle</i>	1	2	3	4	5	6
	0	1	1	2	2	3	3
	1	1	1	2	2	3	3
	2	1	2	3	4	5	6
	3	1	2	3	4	5	6
	4	1	2	3	4	5	6
	5	1	1	2	3	4	5
6	1	1	2	3	4	5	
7	1	1	2	2	3	3	
8	1	1	2	2	3	3	
9	1	1	2	2	3	3	
<i>Set</i>		1	2	3	4	5	6

3.3 Instructions


Pair

1. Make sure both the *Bot* and the *Main* are turned ON. You will see a white led blinking and then a blue one, on the Bot; and a green Led coming out of the GO button on the *Main*.
2. Press the "go" button on the *Main* for about 3-5 seconds (A). A blue/cyan LED will appear on the *Main* (B) and in all *Bots* (C) that are "listening". Stop pressing the "go" button.
3. You have then 5 seconds to press a small button (D) underneath the *Bot* you want to pair. If it is successful, both the *Bot* and the *Main* will turn a green LED at the same time (E), if not, the *Main* will show a pink LED and go back to previous state (connected to another *Bot* or not paired)
4. You only have to do it once (unless you want to pair another *Bot*), it will remain paired even after switched OFF.

1.



2.

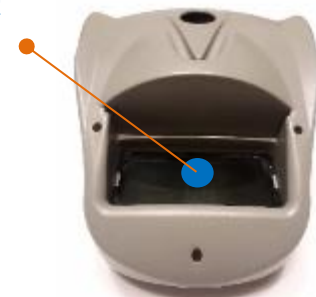
A  (3-5 seconds)



B



C



3.

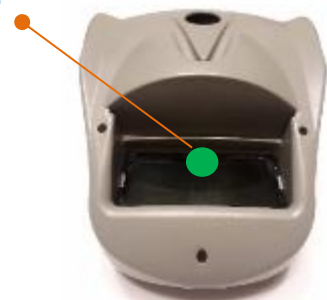
D



E



E



Code assembly, initiate and execution & feedback

1. Assembly the code starting from the *Main* facing GO to yourself. Connect the first function to be executed and progress from there in sequence of consecutive steps.
2. Press GO one time
3. a) the *Main* will read the blocks (each turn blue at a time) and then execute while giving feedback of the step by turning the current function green
- b) the *Main* will read the blocks (each turn blue at a time) and find a syntax error and blink red four times while the blocks until the error also blink.

1.



2.



(X1)

3a)



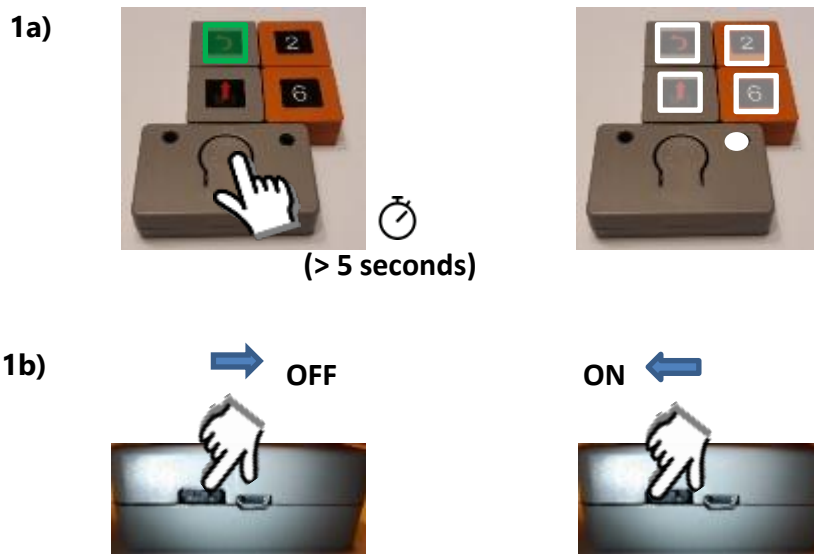
3b)



Reset code (Main)

Rarely needed, used to erase the memory of the previous code in case it gets stuck (see error "" in the Table 5). *Bot* and *Main* will still remain paired after it.

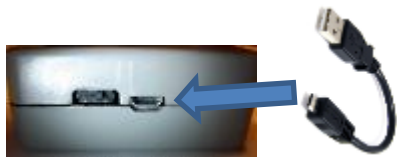
1. **a)** Press the GO button for more than 5 seconds until a white LED blinks on the *Main* and blocks.
- b)** Switch OFF (slide with your finger) the *Main* and turn ON again (slide with your finger).



Charging


1. **a)** When the *Main* starts missing lights during the feedback it is probably lacking charge. Usually the autonomy is in the range of days (2-4) with constant use. Plug a micro-USB charger and a red LED will turn on (ON or OFF does not matter).
- b)** When the battery is full it will turn off the red LED, it usually takes less than 2 hours.
2. **a)** When the *Bot* starts accumulating errors like skipping functions and making discontinuous steps (e.g. 1+1 instead of 2), it is most likely in need of charging. Plug a micro-USB charger and a red LED will turn on (ON or OFF does not matter).
- b)** When it is full it will turn off the LED, it usually takes between 1-3 hours. However, the *Bot* can become unstable (see troubleshooting and error "Too much charge" in Table 6) with too much charge so we recommend leaving it only 45 minutes which is sufficient for a 1-2 days of constant use.

1. a)

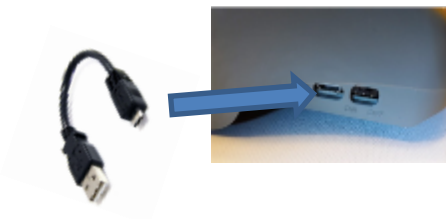


b)





(< 2 hours)

2. a)



b)




(45minutes – 1 hour)

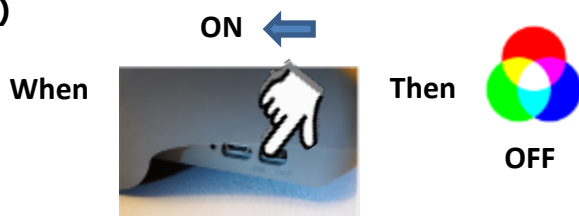
Colour Sensor (Turn OFF/ON is the same procedure)

1. a) When *Bot* switches ON the colour sensor is OFF by default.

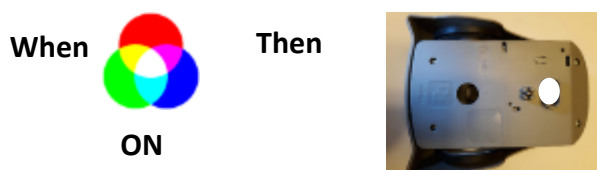
b) When the colour sensor is ON, the *Bot* will have white LEDs on its bottom (near the sensor).

2. To change the status of the sensor (ON/OFF), press and hold the PAIR button for one second, a yellow LED will appear in the *Bot* and then change to blue to confirm the change of status.

1. a)



b)



2.



Feedback System

As described, there is a Feedback System of Colours (with LEDs) for all instructions (Table 5). It is a great feature for the kids (and not only) to do code debugging (watching the action of the *Bot* and matching with the Blocks) but also helpful to see if the components are performing as expected and which mode/s are currently ON or OFF

Table 5 – Feedback map for instructions

Feedback System - Instructions Map								
Goal	Action	Duration	LEDs					Blocks
			Main		Bot			
			Left	Right	Bottom	Top	Side	
Turn ON Bot & Main	ON switch (side)	-	-	-	-	-	-	-
Pairing	press & hold GO button (Main)	3-5 seconds	-	-	-	-	-	-
	press PAIR button (Bot bottom)	before 5 seconds	-	-	-	-	-	-
Initiate code	press GO (Main)	one time	-	-	-	-	-	-
Following execution (debugging)	-	-	-	-	-	-	-	-
Reset	press & hold GO button (Main)	> 5 seconds	-	-	-	-	-	-
Charging Bot & Main	micro usb cable on power entry (side)	15 minutes	-	-	-	-	-	-
Turn ON/OFF color sensor	press & hold PAIR button (Bot)	1 second	-	-	-	-	-	-
Detecting color	-	-	-	-	-	-	-	-

3.4 Troubleshooting

Table 6 – Feedback map for errors

Feedback System - Troubleshooting Map							
Error	LEDs					Blocks	Action
	Main		Bot				
	Left	Right	Bottom	Top	Side		
Syntax	-	-	-	-	-	-	Code debugging
Too much charge (LED disappears)	-	-	-	-	X	-	If many errors, Turn OFF/ON Bot and let it roll for a while
Feedback but Bot does not move	-	-	-	Stop	-	-	Turn OFF/ON Bot
Feedback and Bot frozen	-	-	-	Stop	-	-	Turn OFF/ON Main
Skipping function	-	-	-	-	-	-	Turn OFF/ON Bot or charge
GO with no Pair or OFF Bot	-	-	-	-	-	-	Pair with Bot or check if ON
Bot unstable & or discontinuous steps	-	-	-	shaky	-	-	Charge Bot
No Main feedback	-	-	-	-	-	-	Charge Main

Q & A

If the batteries are low, what happens?

Main: starts missing LEDs during the feedback. It is possible to freeze in a function during execution.

Bot: keeps accumulating errors like skipping functions and making discontinuous steps (e.g. 1+1 instead of 2)

How much time should I charge them?

One hour each is more than enough. Too much charge may cause the *Bot* to be unstable in the first hour. If so, let it go for a few spins, by making it rotate for 120 times and leave it ON to rest a little bit.

How long does the Bot and Main last without charge?

The autonomy is in the range of days, depending on how many executions, if very busy (>50 execs) it will last 2-3 days before losing performance.

How do I know the Main is turned ON?

Besides the ON/OFF switch position (see image *Reset 1b* in the *Instructions* section), you will see a green light coming under the GO button.

Can I use any block and Main for any Bot?

Yes! If you pair the *Main* and the *Bot* you want, all blocks available are up for grabs.

After switching OFF Main &/OR the Bot, will they still be paired after switched back ON?

Always. Unless you find another Pair for it. Like relationships...

If I do not remember which Bot is connected to which Main what should I do?

No worries it happens to everyone. Stay calm and press GO (and see which one is your friend).

What is the maximum number of blocks I can execute in a single code?

The number of functions is limited to 15, and then you can add as many numbers you want. Well not really, you are limited to a maximum of 3 numbers digits, and assuming all the functions can have numbers, the answer would then be 45. Well not really, if you would be willing to build a code only with *Rotate* functions, then you could also have an angle block + 3 numbers, so the final number would be 60, and extremely fun to watch (please send video).

How do I know one block is defective/malfunctioning?

When you first connect and also while the Main is reading the code, you will see all the blocks responding with a light (see image *3a-b Assembly Code and initiate...* in *Instructions* section). This means energy and information is passing through it. If so, try to connect again.

How many combinations of loops is it possible to make?

If we are talking about the number of repetitions one *loop* function can make then the limitation is only the maximum number allowed in general (3 digits, so the precise answer is 999). If we are talking about multiple *Loop* functions, one after the other, the limitation is then the number of *Loop* blocks you have in your arsenal. If we are talking about loops inside/within loops then the maximum is 2!

I press again the GO button before the code is finished, what happens?

Nothing really.... both *Main* and *Bot* will ignore you 😞

If I take a block from the code after it started, what happens?

If it is still reading (green light on the *Main*) then it will give and red/purple error light and will reset. If after executing that step, then nothing happens. If it is before execution... then it depends on who's faster to get to it, you or the *Bot*. An old fashion duel, good luck Lucky Luck!

I pressed GO with a code that I do not want to finish, what should I do?

Two options: you hold the *Bot* and switch OFF, disadvantage – you must chase and reach it; you turn OFF the *Main*, disadvantage – it will only stop when the current function (already read) is finished. If in a live-or-die decision (like going to fall from a table), go for the first option...

I pressed GO but there is no Bot paired or it is turned OFF...

The *Main* will wait a couple of seconds for an answer, if none, will give a red-light error (see Table 6) and reset the code. Nobody likes to be ignored.

Some blocks were not well connected, will the Bot explode?

Calm down soldier, it will probably retrieve a red signal error on the *Main* and nothing else happens. Make it right and try it again.

If I press GO simultaneously in different Main's what happens?

Excellent question Mr Random Person! And also, a tricky one... Even if every *Main* generates a different channel for its messages, the chances of something going wrong increases because of interference. One *Bot* might be not able to receive the message while other skips a function during the execution. Interference in general might happen occasionally, and the best strategy to avoid it is to keep some distance from *Main* to *Main*.

How do I know the Colour Sensor is turned ON?

You have not been paying attention to the rest of the document (see Colour Sensor, Instructions section) have you Mr. Random? No problem, always better to ask. The default state of the sensor is OFF, meaning every time you switch OFF your *Bot*, he goes back to the default state and so the sensor will be OFF when you turn the *Bot* ON again. One way to be sure is to check if the white LEDs on the bottom of the *Bot* are turned ON. Pay attention, if it is turned ON and you are not aware, the *Bot* might start to show some strange behaviours.

If the Blocks are giving feedback during execution but the Bot is not moving, what should I do?

It is definitely an error! Most likely might be either too much or too less battery, that causes the *Bot* to be unstable. Like computers, turn OFF turn ON (the *Bot*) is always the answer. Unless you have the colour sensor unintentionally ON...

If the Bot stops and the feedback freezes in one block?

Something wrong happened, and you must reset the *Main*. Turn OFF turn ON (*Main*) is still the answer.

If the Bot skips one function during execution, what should I do?

Not much, besides trying again. If persists, try turn the *Bot* OFF and ON. If it does not get better than most likely it is either *Main's* or *Bot's* time to refill.

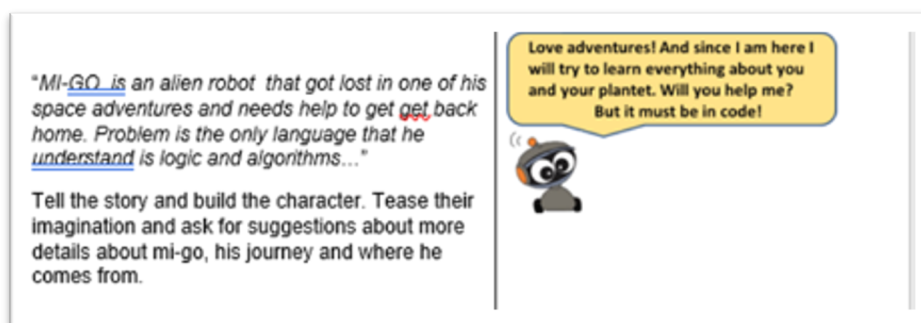
Are there safety concerns?

No. Voltage & radio frequency are tested and certified and all the materials are children-safe. Batteries and electronics are concealed (connectors are the exception but are well contained and not harmful) and resistant to shock. No small pieces to swallow. And the blocks are not heavy enough to make substantial damage (but avoid throwing it). For durability try to avoid too much elements exposure (rain, sun...) and water in general.

3.5 Useful tips & Code examples and geometries

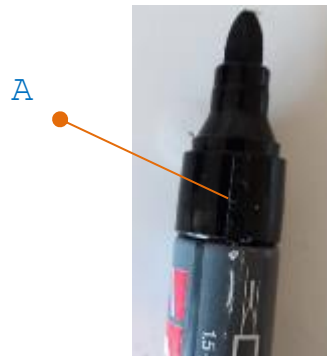
Tips

- 1) **Storytelling** and **character building** are important for the children to relate and empathize with the Bot, and in consequence motivate them to help it complete its mission.



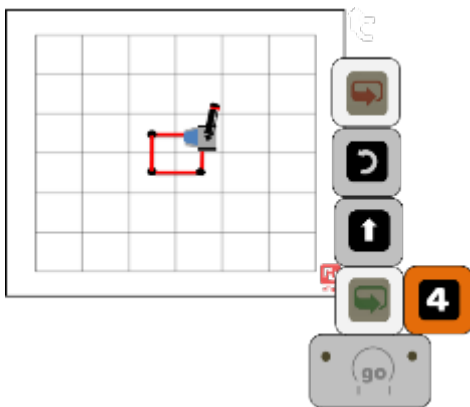
- 2) Promote **sharing** of blocks and solutions between groups. Tangible Programming and MI-GO in particular is all about social skills (negotiation, compromise, team-work, problem solving...)
- 3) *Bot* executes the functions **continuously** (e.g.: *forward: two times* at once instead of $1+1$). If you want to do it **discretely** use loops (e.g.: *loop two times: forward*)
- 4) Explore the **decimal** block it gives you unlimited potential for any unit of irregular shape
- 5) Try to **evolve** the groups along time, start with basic functions and then introduce loops and eventually angles according to the age group.
- 6) Less is more! Find **solutions** for your **limited blocks** problems. E.g. *Rotate Right = 3x Rotate Left; Forward = Decimal x 10*
- 7) If not, **enough Bots** adapt activities and share tasks
- 8) **Customize** and adapt the **Set**. Draw, use cards (on top and underneath), build obstacles, imagination is the limit!

- Use any marker you want but, non-permanent board marks are more convenient to clean. The size is commercially standard but if using *eddying* markers you will have to cut a little salient (A) close to the tip to let it fit the hole.

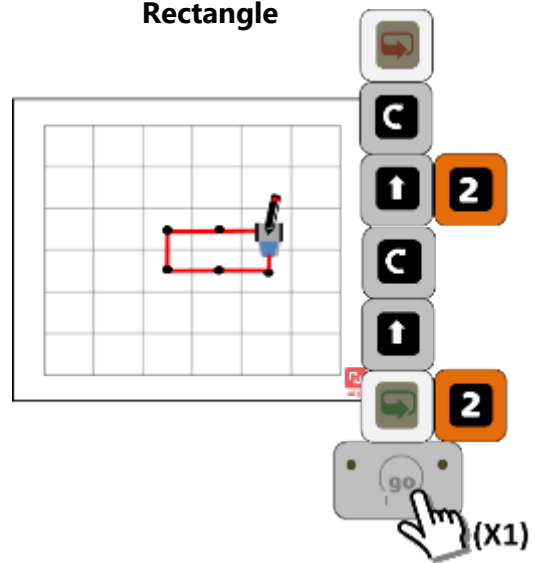


Examples

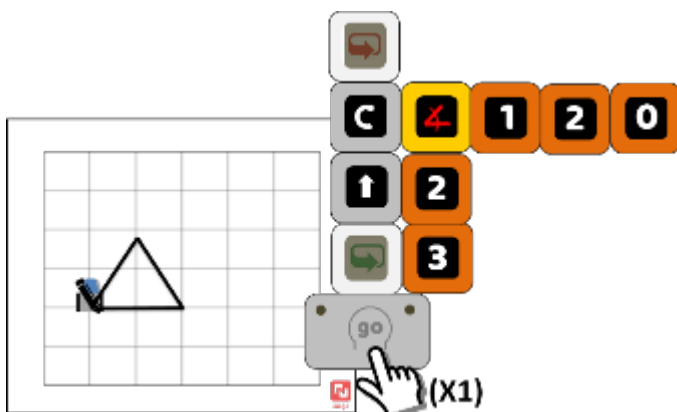
Square



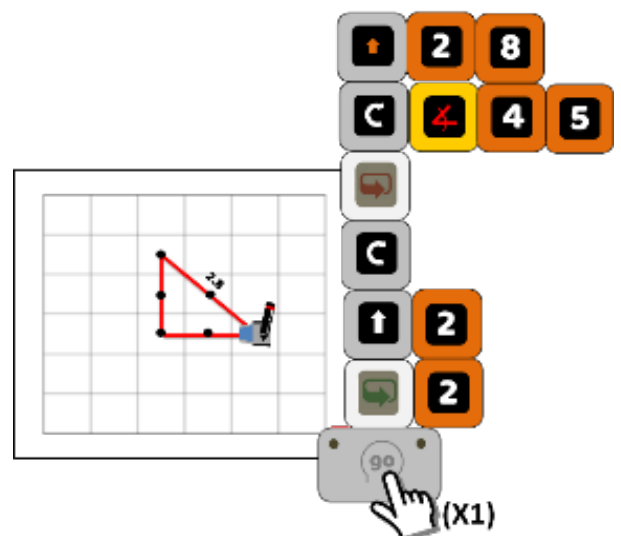
Rectangle



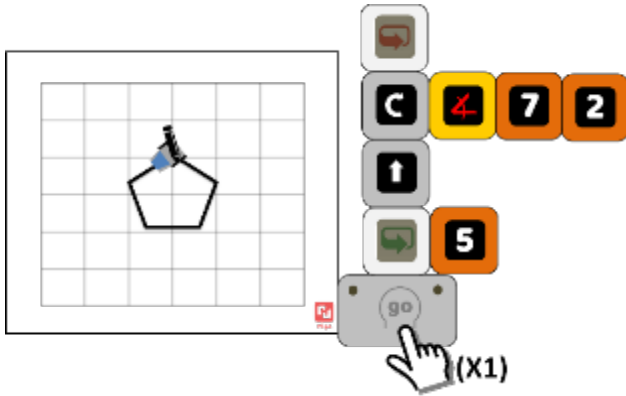
Equilateral Triangle



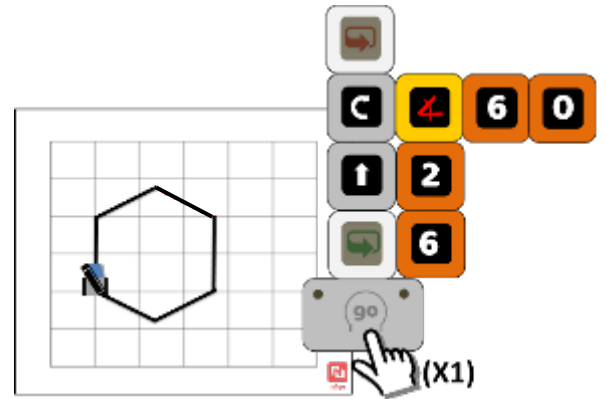
Right Triangle



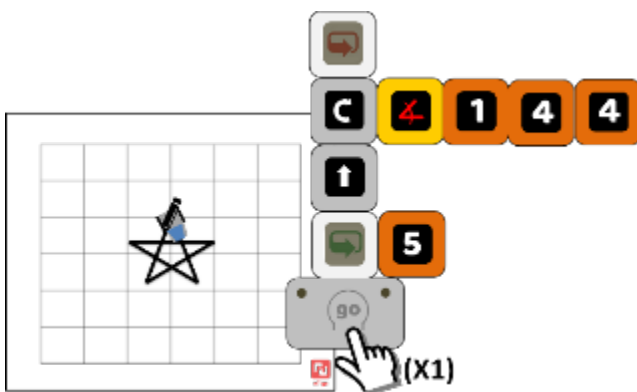
Pentagon



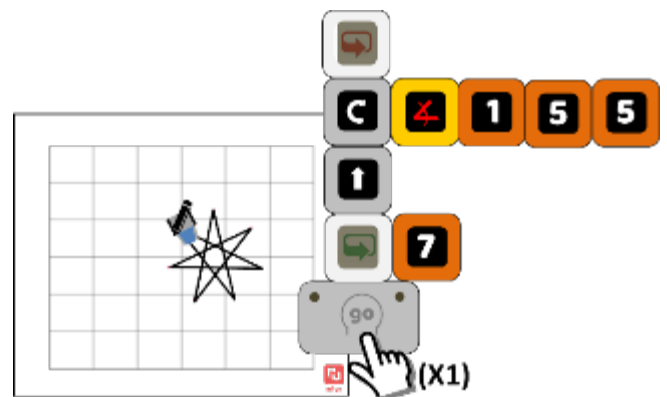
Hexagon



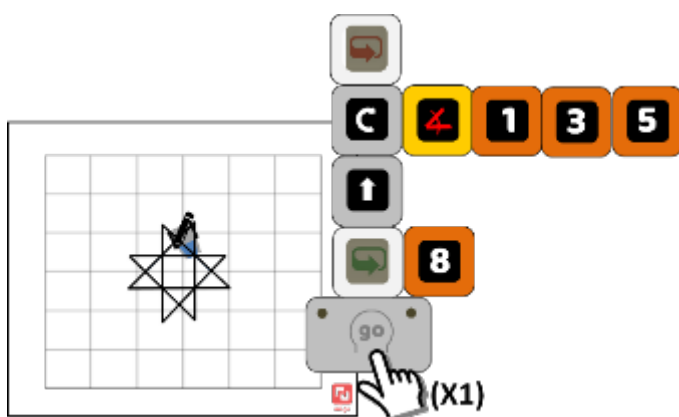
5 point Star



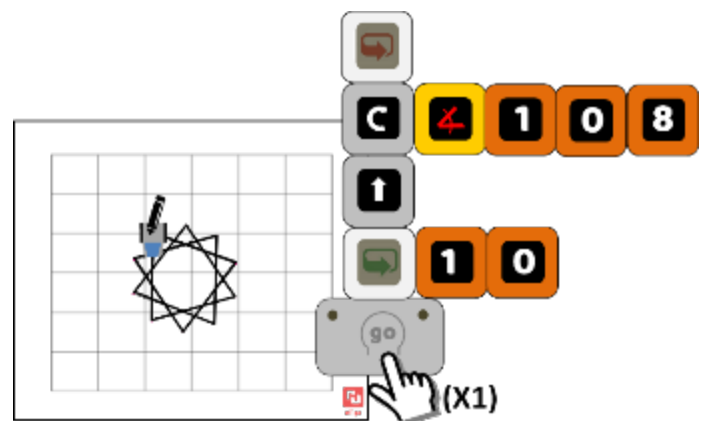
7 point Star



8 point Star



10 point Star

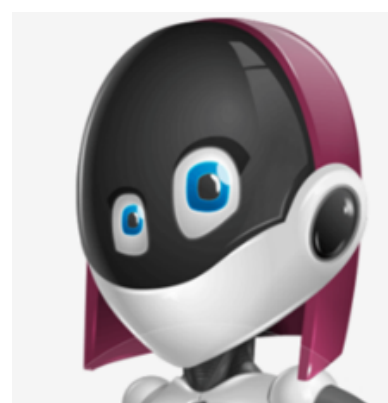


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- Loureiro, M. J., Guerra, C., Cabrita, I., Moreira, F. T., Gonçalves, D., & Queiroz, J. (coords.) (2020). *Teachers' training handbook: tangible programming and inclusion in educational context*. Aveiro: Universidade de Aveiro. ISBN: 978-972-789-631-8. Disponível em <http://hdl.handle.net/10773/27302>

Annexe

Robot faces



TangIn

Tangible Programming & Inclusion



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