



ROBOESL PROJECT

ROBOTICS-BASED LEARNING INTERVENTIONS FOR PREVENTING SCHOOL FAILURE AND EARLY SCHOOL LEAVING

Erasmus+ 2015-1-IT02-KA201-015141

Output 1: Curricula for 10 exemplary interdisciplinary robotics projects

Curriculum 7: What's the number

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¹ EDUMOTIVA stands for 'European Lab for Educational Technology

Declaration

This report has been prepared in the context of the ROBOESL project. Where other published and unpublished source materials have been used, these have been acknowledged.

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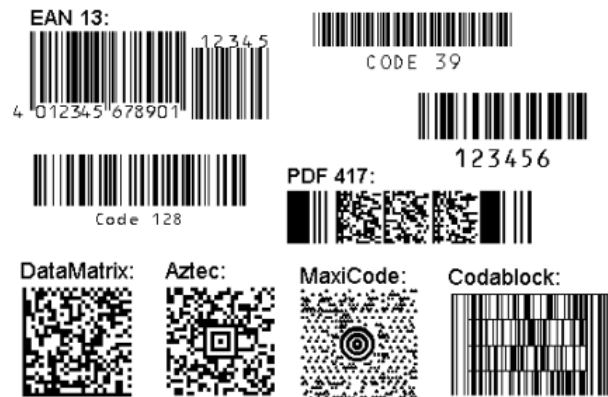
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Abstract

This document contains the description of the Curriculum n. 7, entitled ‘What’s the number’ which is part of the Intellectual Output 1 (Curricula for 10 exemplary interdisciplinary robotics projects) developed and tested in teacher training courses within the context of the ERASMUS+ ROBOESL project. In this Curriculum we discover how numbers can be hidden (i.e. coded) behind non immediately understandable (for humans) representations which can be used to communicate these information to robots.

Chapter 1: Short description and scenario (O1.1)



(source: add-in-world.com)

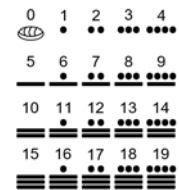
The robot discovers the number which is hidden in a code and acts accordingly.

1.1 The scenario

Particularly when numbers must be elaborated automatically, they are represented in a way which can be difficult for us humans to decode but are more suitable for a computer-based device. This is the case of different types of barcodes. Nowadays we are used to interpret Arabic numerals but other ‘languages’ have been proposed, and actually used, which are understandable by humans like the semaphore alphabet and the international maritime flag code. The basic experiment of this curriculum is based on a 4 bits code to represent a number between 0 and ten. The code is printed on a paper sheet and the robot recognize the code by means of its color sensor and reproduces ‘vocally’ the number. If you want, you can also associate the recognition of the number to a specific action like moving forward, backward or turn.

1.2 Connections with subjects

1. History: ancient civilizations used other systems of signs to represent numerals: for example, the Maya numeral system is rather interesting with its vigesimal set of digits.



2. Artificial languages: the semaphore alphabet (fig. 1a) is a language to code letters and digits using a couple of flags kept in a position with respect to the body which represents the code. The international maritime flag code includes different flags for each letter and digit (in fig. 1b the section regarding digits). Both are used for visual transmission of information. The International Morse Code had been used for decades to code letters and digits in a way easy for long distance air transmissions: the code includes a section for the usual ten arabic digits.

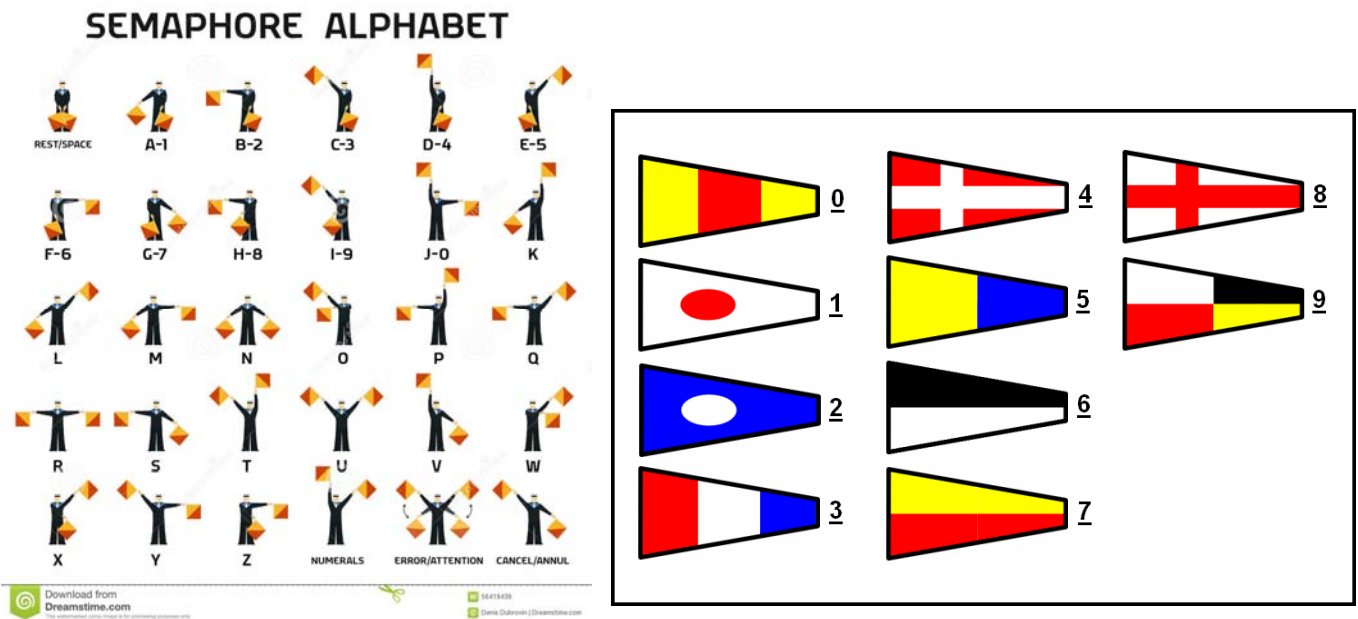


Figure 1. a) Semaphore alphabet (source: Dreamstime.com) - b) International maritime flag code (source: Kronenberg's)

3. Informatics: in computers, numbers and all other information are binary coded. The binary representation is a special case of the positional notation when the base is 2. While such a notation is directly usable to represent natural numbers, for all the other type of information (integers, fixed and floating point numbers, text characters, screen colored pixels etc.) a specific code, able to represent such information in a sequence of binary digits, is defined and used. Representing information in a computer in this form makes the elaboration easier, more efficient and less error-prone.
4. Physics: defining time units, measuring speed and time between events.

Chapter 2: **Pedagogical objectives (O1.2)**

2.1 General objectives

- To provide students with a stepwise approach for a step by step acquisition of technical skills in using robotic technologies (hardware and software) building on existing knowledge and skills.
- To offer the robotics benefits for all children, especially those at risk of school failure or early school leaving
- To engage students in STEM related subjects through interaction with the robotics technologies
- To support self-directed action allowing learners to learn independently.
- To engage students in robotic constructions and problem solving through an interdisciplinary scenario that reflects aspects of real-life problems and situations.
- To align the robotics project to learners' needs and interests through tasks that derive from the initial activity but introduce new levels of complexity and difficulty.
- To translate the principal of information coding into a robotic constructionist and algorithmic experiences.

2.2 Specific objectives

More specifically, upon successful implementation of the activities described in this curriculum students will achieve the following objectives:

- Measure the reflected light using the color sensor
- Measure the robot speed
- Make paper sheets with the synchronized binary code
- Represent a natural number with a binary code and vice versa
- Calibrate and instruct the robot to recognize the binary code
- Correct any possible errors and improve any imprecision during the experiments
- Associate audio files with numbers

Chapter 3: Suggestions for learning methodologies (O1.3)

The activity starts with the delivery of the scenario to the students. The teacher explains the scenario making reference to different types of barcodes used in everyday life. Then, a special worksheet is given and used as a reference and supporting tool for learners. The students are invited to work in groups following the worksheet. The teacher acts as a scaffold and facilitator of the learning process. S/he provides feedback without revealing solutions and probing students through key questions to overcome emerging problems and difficulties.

The students are called to create paper sheets with the synchronized binary code, the environment into which the robot will operate based on the scenario of the activity and to equip the robot with a color sensor. The teacher provides all the necessary information regarding the way the color sensor operates and especially how it detects the reflected light, and encourages learners to do some practical experimentation by the students using the color sensor on their paper sheet.

First, the students are called to find the linear speed of their robot for a certain motor power. Then, they are encouraged to discuss the given problem/scenario in their groups and to form a methodology to enable the robot to recognize the binary digits by means of its color sensor and to display them on its screen.

Students write down in their worksheet their programming solution in their own words for further discussion.

Then the teacher explains the binary number system's 0 and 1 and how a binary number can be translated into a decimal number. Then tips are provided for programming the robot to make this translation from binary to decimal system allowing students to realize the final programming solution.

Finally, students are challenged to create audio files naming the decimal numbers and to program their robot to reproduce 'vocally' the decimal number associating each number with the proper audio file.

A. The role of the students

Students first discuss the problem through a free dialogue in their group and after that they devise an action plan to solve it. They work in groups following the worksheet and the discrete feedback they receive from the teacher. The final solutions of the groups are presented in the class, are discussed and evaluated with students reflecting with critical mind on their work, expressing their views and recording their experiences in a diary or questionnaire.

Students may extend their work to variants suggested in this curriculum or devised by students themselves.

B. The role of the teacher

In the constructivist learning framework described above, the teacher does not function as an intellectual "authority" that transfers ready knowledge to students but rather acts as an organizer, coordinator and facilitator of learning for students. S/he organizes the learning environment, raises the questions / problems orally and through a worksheet, offers hardware and software necessary for students' work, discreetly helps where and when necessary, encourages students to work with creativity, imagination and independence and finally organizes the evaluation of the activity in collaboration with students.

Chapter 4: Technical guidelines (O1.4)

4.1 Building instructions

For implementing this curriculum, the usual *tribot* structure must include a color sensor to read code printed on a paper sheet.

4.2 Illustrative solution

Let's imagine to have prepared a paper sheet similar to the fig. 2. For preparing this layout it is sufficient to use a word processor, insert a table with rows of the same height, for example 1.7 cm, and fill the background of some of them in black. The first row is always black and it is used for synchronization purposes, while the following rows express the binary code, white for 0 and black for 1.



Figure 2. The code paper sheet to prepare

The first action is to establish the amount of time corresponding to the 1.7 cm step which is the space between the middle point of one row and the one of the successive row. For this purpose, ask the students to make the robot execute one straight-line motion for 2 s at a relatively low power, for example 20, (see fig. 3) and measure the spanned space: with a simple proportion they can calculate the time necessary to move one step. Just for an example, if in 2 s the robot moves for 19 cm, the proportion is:

$$19 : 2 = 1.7 : T$$

giving:

$$T = 3.4 / 19 = 0.18 \text{ s}$$

Observe that $19/2=9.5$ cm/s is the linear speed of the robot in this example with power=20. Obviously this evaluation is rather rough and the T unit must be further calibrated during the next steps.

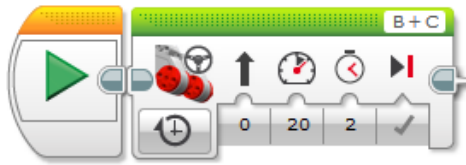


Figure 3. How to evaluate the robot linear speed

Now ask the students to imagine the robot moving on a straight line over the white beginning area of the sheet towards the black rows: when the color sensor detects the first transition from white to black, we know that the first synchronizing row, 1.7 cm wide, ‘begins’ at that moment. Because all the rows have the same height on the paper, after about $1.5 \cdot T$ seconds the sensor is in the middle point of the first coding row and it can detect whether it is white (bit 0) or black (bit 1). The process can be repeated other 3 times every T seconds for detecting the other bits (fig. 4).

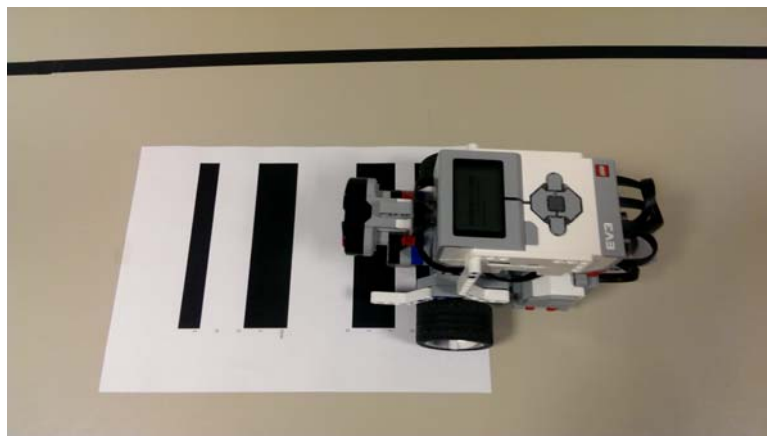


Figure 4. Reading the sequence of bits

Assuming that these bits are read from the Most Significant Bit (MSB) to the Least Significant Bit (LSB), the robot knows the code in binary form. Fig. 5 shows the program to read 4 bits in synchronized form as described above: the first part is responsible for putting the robot in the middle of the synchronizing row, while the rest is the loop in which every bit is read.

To accumulate the coded value, we use the simple formula:

$$\text{val} = a_3 \cdot 2^3 + a_2 \cdot 2^2 + a_1 \cdot 2^1 + a_0 \cdot 2^0 = (((0 \cdot 2 + a_3) \cdot 2 + a_2) \cdot 2 + a_1) \cdot 2 + a_0 \cdot 2^0$$

In this form, call ‘factorization’, the value is obtained repeating the same operation with the current read bit, a multiplication by 2 of the accumulated value and a possible sum of 1 when the bit is 1.

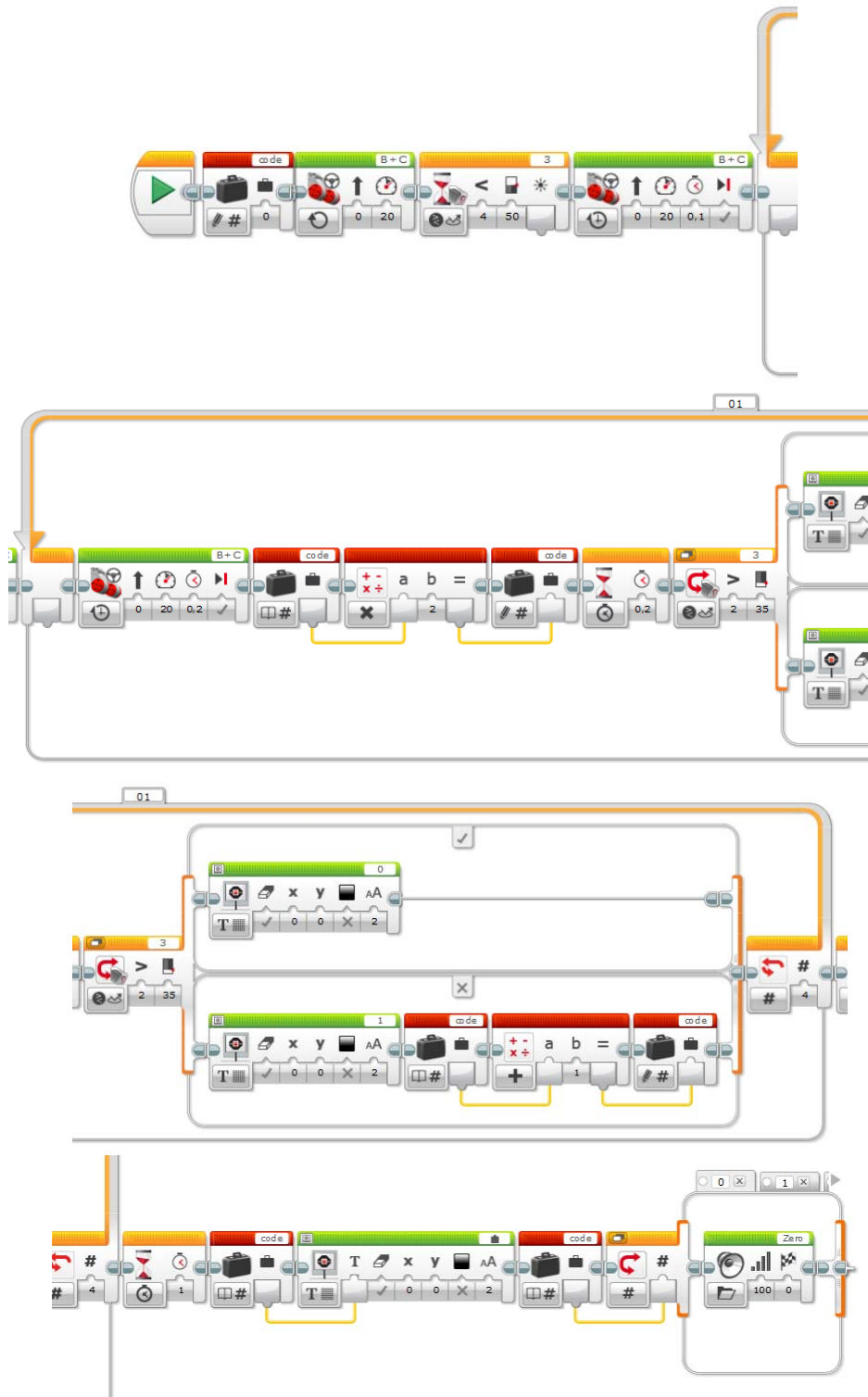


Figure 5. The complete program

Some comments to the program. The `code` variable stores the accumulated value and therefore it must be initialized to 0. Experimentally the T unit has been set to 0.2. The `wait` command of 0.2 s was added to assure a stable reading with the robot completely stopped. According to the read bit (the `Switch` command is based on the reflected light level), a 1 is added or not to the accumulated value. The `Display` commands are added only for diagnostic purposes. The last commands make the robot pronounce the recognized value (from Zero to Nine), using the provided audio files. Every value in this range is associated with the corresponding audio file using the numeric variant

of the **Switch** command. Because 4 bits can code values greater than 9, a default case is added when a value out of the range is recognized.

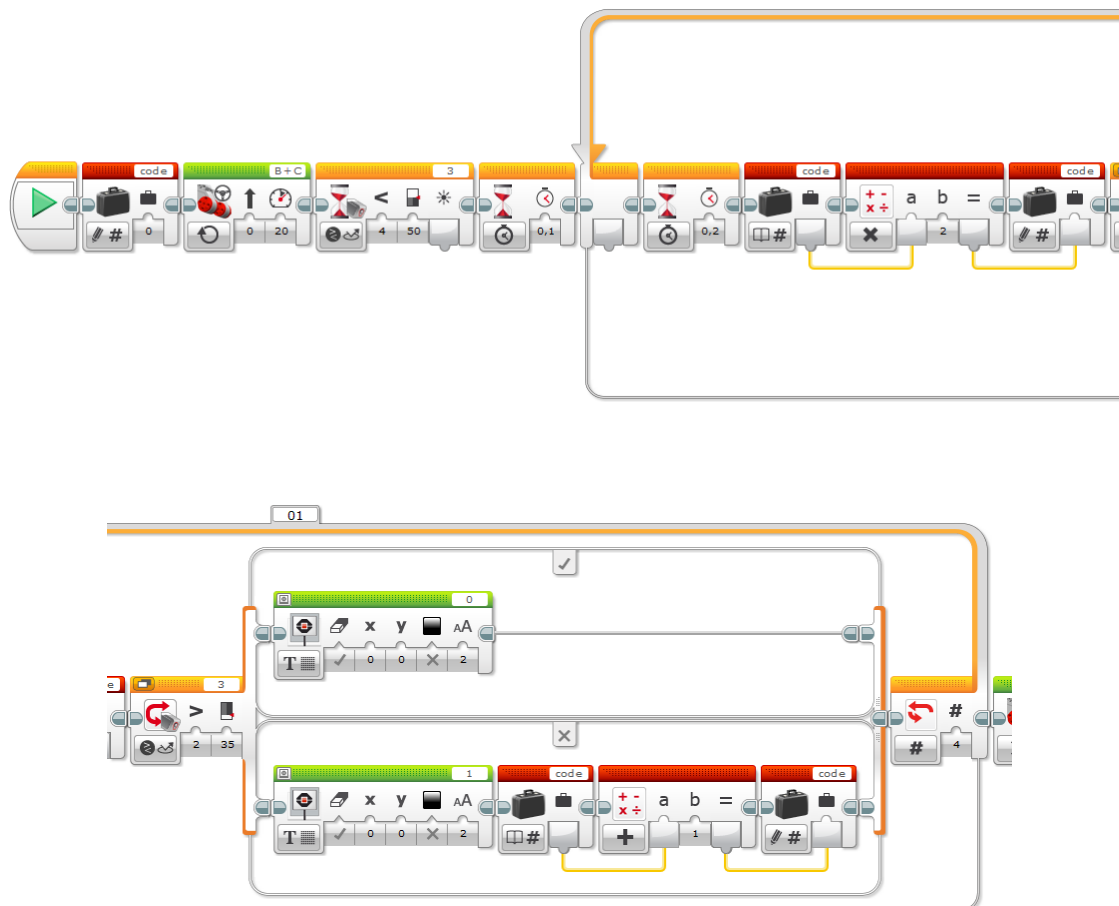
4.3 Implementation suggestions

The success of a correct recognition is essentially based on the calibration of the T unit, as explained above. Some reading errors are always possible but the awareness of this risk is part of the experimentation. It is suggestible to give a brief summary of how to code a natural value in binary form before proceeding with the experiment. Some further comments can be also dedicated to recall basics on kinematics (space, time, speed), present in the background in the first curricula.

4.4 Extensions and variants

4.4.1 Variant a: Continuous motion [medium]

In this variant, the robot is started at the beginning and stopped only when the whole code has been recognized. The sampling of reflected light is time synchronized on the basis of the estimated T unit without stopping the robot (fig. 6). This solution is visually more effective because the observer does not perceive any variation during the motion though the code is acquired on-the-fly. On the other hand, this solution can be more critical and error-prone.



Chapter 5: Evaluation tools (O1.5)

Use the rubric below to evaluate your students' achievement in each specific objective of this curriculum.

Name of student (or group of students):

upon completion of the activities described in this curriculum students achieved the following objectives	Evaluation score 0 = not attempted 1 = attempted without success 2 = partial success 3 = completed with teacher's help 4 = completed without teacher's help
Measured the reflected light using the color sensor	
Made paper sheets with the synchronized binary code	
Measured the robot speed	
Calibrated and instructed the robot to recognize the binary code	
Corrected any possible errors and improved any imprecision during the experiments	
Translated a binary code into decimal number and vice versa	
Associated audio files to the recognized number	

