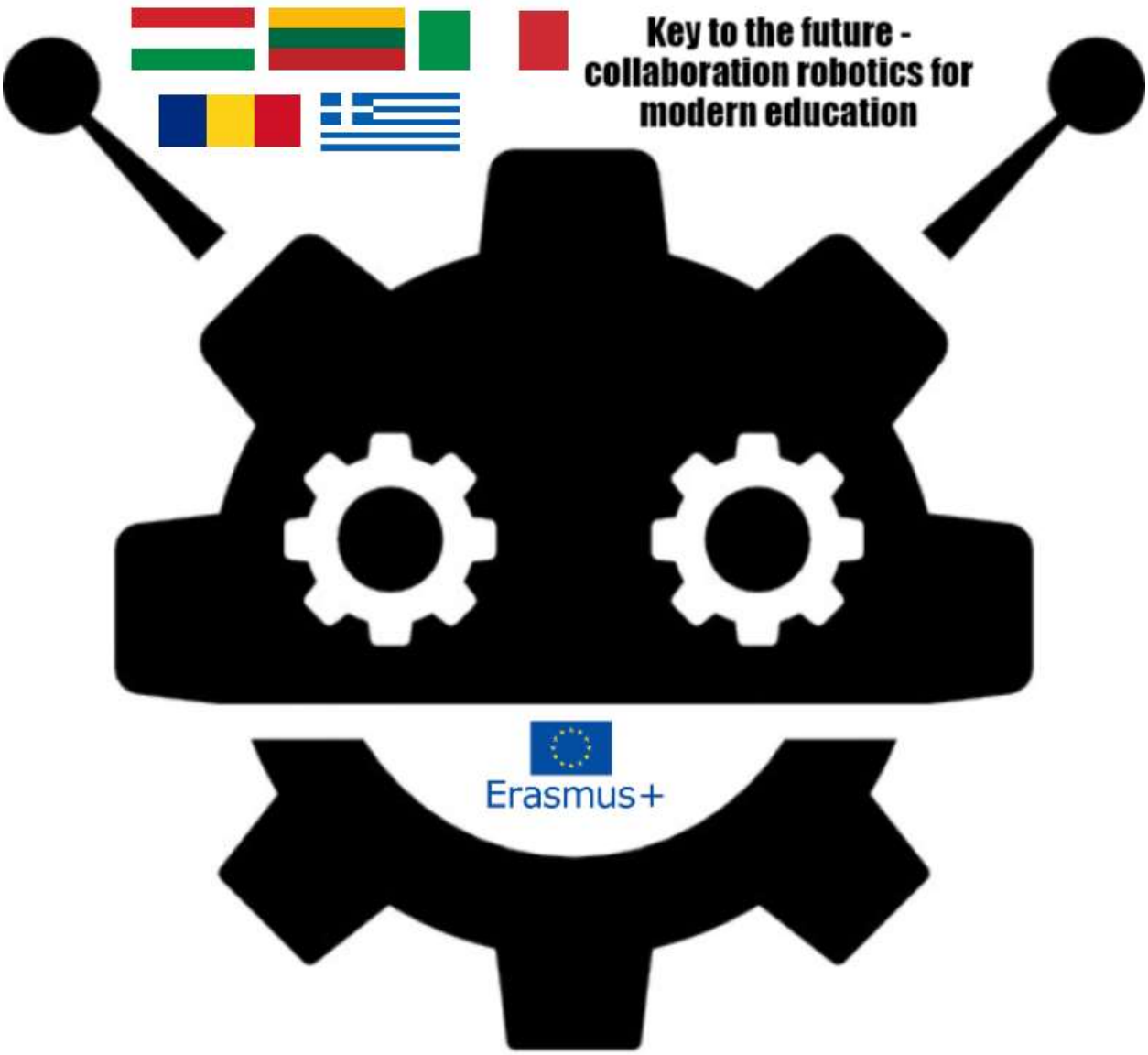
Erasmus+ Programme – Strategic Partnership
Project Nr:
2017-1-HU01-KA219-036001_3
Key to the Future- Collaboration in Robotics for Modern Education

Thematic plan to teach the basics of robotics



Overview of the basics of robotics
LESSON 1-2.

Title	Objecvtives	Topic/Contents	Activity	Resources

Robot hardware	• Learners will be familiarized with basic robot types, their components and will understand how they work
	• They will acquire specific vocabulary to describe and talk about robots
		• The intelligent brick
		• Servo motors
		• sensors:
		  • light and colour
		  • touch
		  • sound
		  • ultrasonic
			• Presentation of basic robots
			• NXT
			• EV3
				• powerpoint presentations

Graphical NXT-G language	• Learners will gain understanding and knowledge of the programming language	• basic elements of the programming environment	• Presentation of the programming language	• PCs
	• Learners will apply their knowledge of how to program robots in order to make them perform simple movements using different sensors	• simple movements • use of sensors: • light and colour • touch • sound • ultrasonic	• tasks related to the topic	• 5 NXT robots • 1 EV3 robot
	• Learners will be familiarized with controlling structures	• cycle, loops structure • decsions	• tasks related to the topic	• 5 NXT robots • 1 EV3 robot
	• Learners will demonstrate their knowledge of robotics by preparing for a Robot sumo competition	• Robot sumo-wrestling competition	• Building a sumo robot • Creating the program • competition	• 5 NXT robots • 1 EV3 robot • Sumo ring

LESSON 3

THE TOPIC OF THE LESSON **Basics of Robot Control**

AIMS OF THE LESSON

- To acquire the basic knowledge about monitoring of Lego robots
- To get practical knowledge of programming Lego robots
- To make students aware about employment possibilities in robotized workplaces
- To develop logical thinking, problem- solving and cooperation skills

TARGET GROUP

Students of beginner and pre- intermediate level

DURATION
45 minutes

MATERIALS NECESSARY FOR THE LESSON

Computers, Lego MindStorms EV3 development environment, joiners to join sensors, motors, robots racing tracks, projector (the task must be presented with measured data and angles

WARM-UP

1. Frontal work (discussion)- What are robots? What do they do? How do they help people? (5 mins)

PRESENTATION

2. SENSORS. THE TYPES OF SENSORS (15mins)
   a) **Vision and proximity sensors**. The combination of these sensors allows the robot to determine the size, identify an object and determine its distance.
   b) Radio-frequency identification **(RFID) sensors**. They provide identification codes and

allow an authorized robot to acquire other information.

c) **Force sensors**. They provide the ability for the robot to pick up objects of different types without crushing or dropping them or activate external touch controlled switches.

d) **Microphones (acoustical sensors).** They help the robot to receive voice commands and identify unusual sounds in a familiar environment.

Application of sensors in a robot's construction.

PROCEDURE

3. PROGRAMMING THE LEGO ROBOTS
(20 mins)

Students are divided into groups.

Students make engines connected to B and C outlets according to the required sketch and a task drawn on the board. Each group has to discuss, prepare the development environment, try possible variants of programming robots with a help of a teacher.

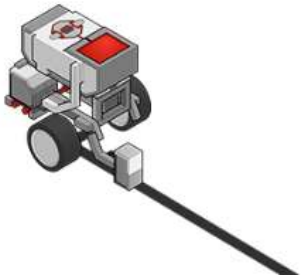
The teacher explains the meaning of numbers:
-which numbers mean the speed
-which numbers mean the rotations
-which numbers mean the stop
The teacher explains how the programming blocks should be switched one after the other.

Preparation for a robots race.

The track for robots racing is fixed. The obstacles are settled. The teacher explains the rules of the race. Destination and the types of obstacles the robots can face. All the necessary materials and robots are programmed and prepared for the race.

LESSON 4

THE TOPIC OF THE LESSON Line Follower



AIMS OF THE LESSON

-Properly select and fasten the required sensors for the prier robot;
-Be able to properly calibrate sensors, use sensor data to create a program;
-Make a turn by changing the speed of two wheels;
-Create a proper algorithm for the task;
-Use cycle and selection blocks in program creation;
-To develop logical thinking, problem- solving and cooperation skills

TARGET GROUP

Students having basic knowledge about robot sensors, key actions and blocks used in programming.

DURATION
45 minutes

MATERIALS NECESSARY FOR THE LESSON

Computers, Lego MindStorms EV3 development environment, joiners to join sensors, motors, robots racing tracks, projector (the task must be presented with measured data and angles)

WARM-UP

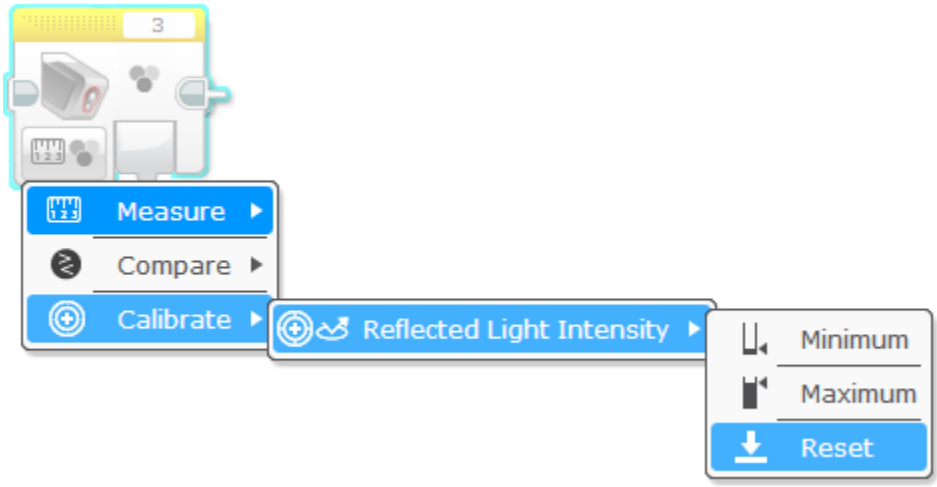
Frontal work (discussion) – Where can practically be applied action when a robot can

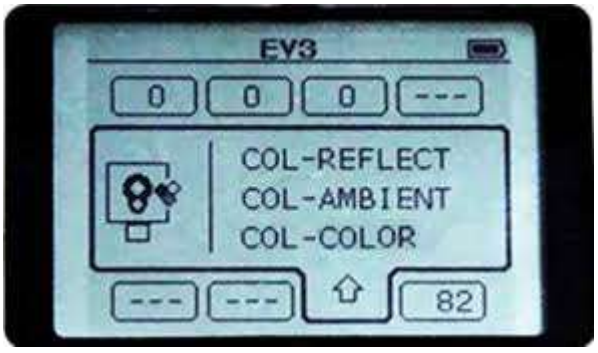
automatically follow the path? What kind of help is necessary (sensors) that the robot could follow the line? How to force a robot not to drop a line? What programming blocks should the robot keep moving, rotating, turning in one direction or another, depending on sensor values? (5 minutes)

PRESENTATION

Color sensors. Sensor readings. Cycle and selection blocks. (15mins)

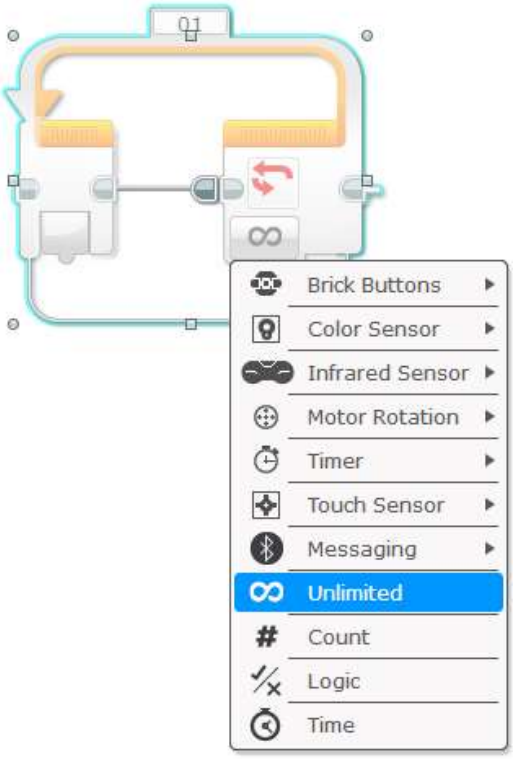
a) Color sensors. Calibration of sensors, use of readable values in programming. Setting the light tones for the line and around the existing texture.



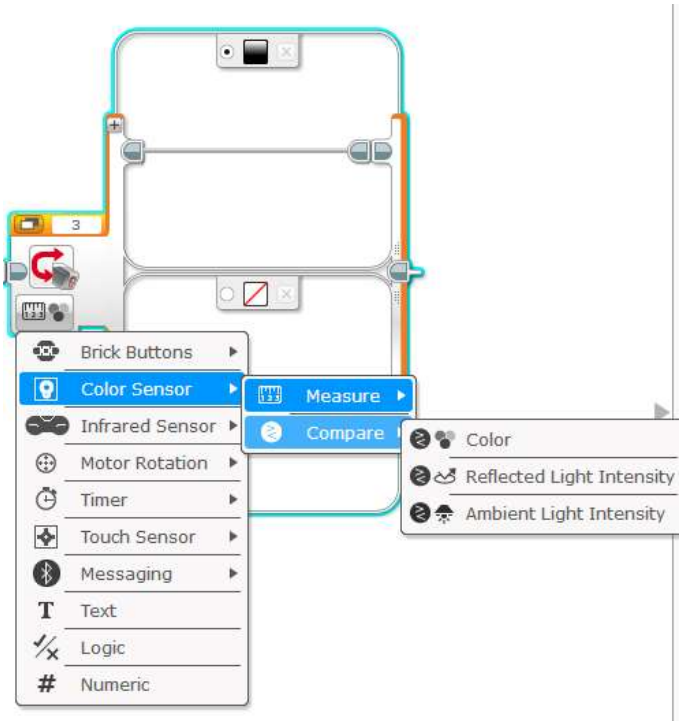


b) Engines. Turning by varying the speed of each engine.

c) Use Loop. Using a block of cycle to move the robot forward. Possible end of cycle conditions.



d) Using Switch. Perform different actions depending on the original data.



PROCEDURE

4. PROGRAMMING THE LEGO ROBOTS
   (20 mins)

Students are divided into groups.

Students attach color / light sensors to the robot.

Checks data:

A sensor directly on the line to be followed by the robot;

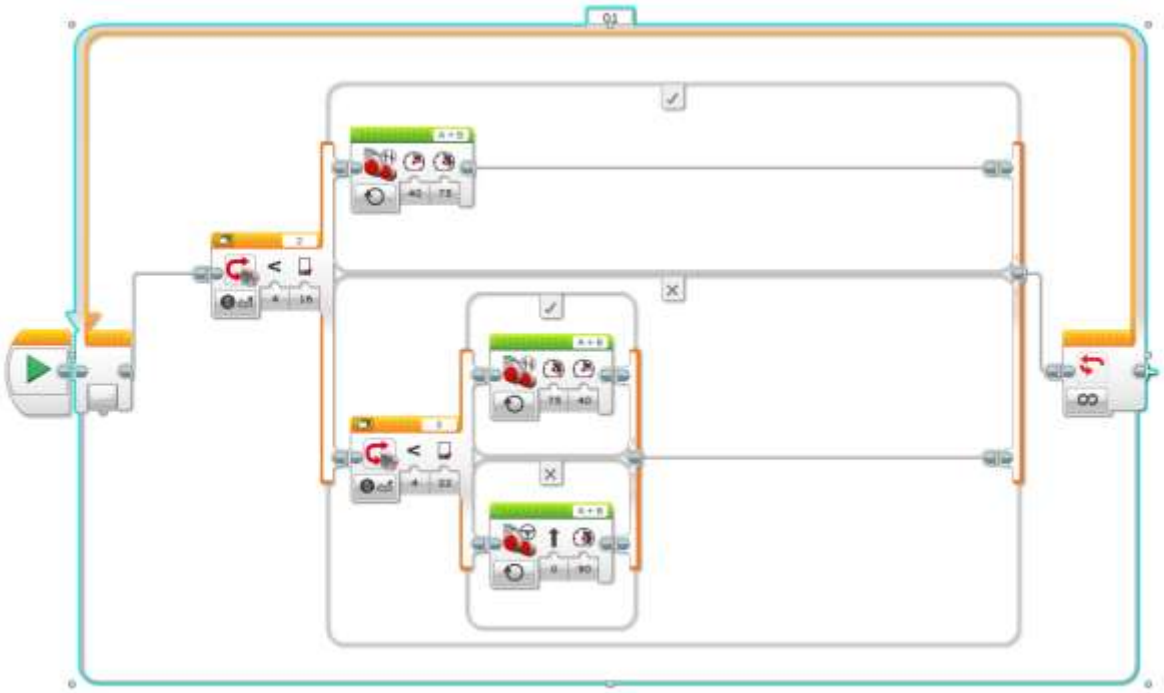
The sensor illuminates half the line, half of the field near the line;

Sensor next to the line.

The data is used in the selection blocks. According to the chosen algorithm, they try to force the robot to return to the line if a robot starts to move away from it. This is done by changing engine speeds depending on the color sensor data.

Students test at least two program algorithms to achieve results. They valuate what algorithm is more reliable, by which the robot can move the algorithm faster and more accurately.

After trying with a single sensor, the test results could be improved using two color sensors. The algorithm is edited.



<u>Recommendations</u>

Using one sensor:

- let the robot so that the sensor sees the edge of the line;
- use and manipulate the line and the line edge data;

Using two sensors:

- attach them so that they are on the side of the line;
- use and manipulate data on the edge of the line and the field data which is next to the line.

Line Follower.

The line track is prepared: the line is drawn and glued. Several tracks are possible, creating sharper and steeper turns. Teams are trying to beat the track as soon as possible.

LESSON 5.

LESSON DETAILS

MAIN THEME OF THE LESSON: Pick and Place

AIMS OF THE LESSON:

- acquiring the basics of controlling Lego robots
- experiencing the practical use of mathematical knowledge
- practicing writing algorithms

RECOMMENDED AGE GROUP: 15-18

DURATION: 90 minutes

CONNECTIONS

- solving problems
- solving robot control and graphic tasks with the help of development system
- basic notions of robot control

CROSS-CURICULAR CONNECTIONS: mathematics

DESCRIBING THE ACTIVITY

Design, build, and program a robot that can pick up an item (for example Cuboid) from one location and place it in another location.

Necessary tools :

- Computer (one per a 3-member group)
- Lego MindStorms EV3 development environment
- Projector
- Lego Mindstorm EV3 robot assembled according to the assembly manual. Furthermore, there is need for Gyro Sensor, Grabber and Turntable motor. It can be solved with one robot, but the best is if each group has one robot tracks
- Tape-measure

Prior knowledge for teachers
The teacher has to be familiar with the basic controls of the Lego MindStorm EV3 robot, the use of arithmetical calculation and the steps of creating an own block.
Prior knowledge for students
Students should know how to create and download a program, and how to program a motor. Being familiar with Logo or Scratch related recommendations

LESSON PLAN

1. Student's motivation

The teacher can use youtube video or other web pages with robotic systems that used in order to carry big or small items.

Discussion with students in onder to:

- Connect students to real-life robotic systems
- Consider how robotic systems are made up of smaller subsystems
- Inspire students to create their own robotic systems

2. Describe the activity

- **Design Brief**

Design, build and program a robotic system that can pick up the Cuboid from one location and place it in another location.

- **Brainstorm**

Discuss different solutions to the design brief. Think about:
• What kind of motorized mechanism can be used to pick up the Cuboid?
• How can the robot move the Cuboid?
• How can the robot place the Cuboid in another location carefully and accurately?

- **Select the Best Solution**

Describe the solution that you have agreed to build and program.

3. Construct the robot

The teacher uses the projector in order to show the instructions of constructing the robot. Furthermore, the teacher can share the document with students. (**Lesson1_instructions.pdf**)

4. Sample Solution Program

- Turns on Turntable Motor B to move the arm back into position
- Waits until the Touch Sensor is pressed
- Resets the Gyro Sensor
- Turns on Grabber Motor C for 0.5 seconds so it closes to grab the Cuboid
- Waits 1 second
- Turns on Turntable Motor B at 25% power and turns to the left
- Waits until the Gyro Sensor measures -45°
- Turns off Turntable Motor B
- Waits for 1 second
- Turns on Grabber Motor C for 0.5 seconds so it opens to release the Cuboid
- Waits 1 second

- Loops an unlimited number of times

5. Test Set Up and Procedure

Materials needed: Large sheet of graph paper or paper with gridlines, colored pencils (3 or more different colors).

- Lay down your paper with 1 cm x 1 cm gridlines on a flat surface.
- Position your robot on the paper and mark the edges so you can keep it in the same position.
- Next, mark the location (e.g., color the squares on your graph paper) to show where the robot should position the Cuboid. Make a dot to show the center of that expected location.
- Run your program.
- Mark the location in a different color to show where the robot actually placed the Cuboid. Make a dot to show the center of the actual location. How far away from the expected location is the actual location?
- Repeat at least three times.

Depending on the students' skill level, they can use Cartesian coordinates to indicate the expected and actual coordinates (e.g., Expected (x, y) Actual (x1-5, y1-2)). You could even challenge students to identify a Cartesian system on the graph paper and get very specific describing the range of motion, depending on the type of robot that they students created.

6. Test and Analyze

How well does your solution satisfy the design brief?
Use a table to record data. Name the columns and rows, such as **Trial Number**, **Expected position**, **Actual position**, **Difference** and **Changes**.

7. Review and Revise

Take a moment to reflect on your robot solution.

- Can the robot movement be made more accurate?
- What are some ways that others have solved the problem?

Encourage students to look back at the design brief and at their own brainstorming notes and test data. Encourage a peer-review process so that each group is responsible for evaluating their own and others' projects. This review process can help students develop skills in giving constructive feedback as well as sharpening analysis skills and the use of objective data to support an argument.

8. Distribute the results

Some ideas to suggest to students:

- Create a video of your project, especially your final presentation and your robot's performance.
- Explain some important features of your software program.
- Produce a building guide for your model by taking a series of photographs as you deconstruct it.
- Include an image of your program with comments.

LESSON 6.

LESSON DETAILS

MAIN THEME OF THE LESSON: Object Detection

AIMS OF THE LESSON:

- acquiring the basics of controlling Lego robots
- experiencing the practical use of mathematical knowledge
- practicing writing algorithms

RECOMMENDED AGE GROUP: 15-18

DURATION: 90 minutes

CONNECTIONS

- solving problems
- solving robot control and graphic tasks with the help of development system
- basic notions of robot control

CROSS-CURICULAR CONNECTIONS: mathematics

DESCRIBING THE ACTIVITY

Design, build, and program a robot that avoids objects

Necessary tools :

- Computer (one per a 3-member group)
- Lego MindStorms EV3 development environment
- Projector
- Lego Mindstorm EV3 robot assembled according to the assembly manual. Furthermore, there is need for Ultrasonic Sensor. It can be solved with one robot, but the best is if each group has one robot tracks.

Prior knowledge for teachers
The teacher has to be familiar with the basic controls of the Lego MindStorm EV3 robot, the use of arithmetical calculation and the steps of creating an own block.
Prior knowledge for students
Students should know how to create and download a program, and how to program a motor. Being familiar with Logo or Scratch related recommendations

LESSON PLAN

1. Student's motivation

The teacher can use youtube video or other web pages with cars that hit or avoid an obstacle.

Discussion with students about:

- In what driving situations can a car hit an obstacle?
- What factors are crucial to be aware of in order to avoid collisions with obstacles?
- What causes traffic jams in high density areas?

2. Describe the activity

- **Design Brief**

Design, build, and program a robot that avoids objects

- **Brainstorm**

Discuss different solutions to the design brief. Think about:
• What kind of sensors can be used to avoid an obstacle?
• How can the robot avoid the obstacle?

- **Select the Best Solution**

Describe the solution that you have agreed to build and program.

3. Construct the robot

The teacher uses the projector in order to show the instructions of constructing the robot. Furthermore, the teacher can share the document with students. (**Lesson2_instructions.pdf**)

4. Drill and Practice

- Introduce the simple use of the Ultrasonic Sensor.
- Demonstrate the Wait Block and how to use it with the Ultrasonic Sensor.
- Ask the students how they could make a program to detect any obstacles that might appear while the wheeled robot is moving forward (or backward).
- Students will create a program that makes the robot stop at a given point based on a distance measured by the Ultrasonic Sensor.

5. The plan

On the road, when a driver sees an object, they slow their car down before coming to a full stop.
Ask the students to program their robots with the same behavior.
If the Ultrasonic Sensor:
Detects an object less than 10 cm away, make the robot stop
Detects an object between 10 and 20 cm away, make the robot slow down
Does not detect any object, continue to move at full speed

6. Sample Solution Program

- Start the program.
- Turn both motors on at speed 50.
- IF the Ultrasonic Sensor detects an obstacle at a distance of less than 10 cm, turn both motors off.
  ELSE
- IF the Ultrasonic Sensor detects an obstacle at a distance of less than 20 cm, turn both motors on at speed 10.
  ELSE
- Turn both motors on at speed 50.
- Repeat steps 3 to 7 forever.

7. Test, Analyze and Review

Take a moment to reflect on your robot solution.

- How well does your solution satisfy the design brief?
- Can the robot movement be made more accurate?
- What are some ways that others have solved the problem?

Encourage students to look back at the design brief and at their own brainstorming notes. Encourage a peer-review process so that each group is responsible for evaluating their own and others' projects. This review process can help students develop skills in giving constructive feedback as well as sharpening analysis skills and the use of objective data to support an argument.

Differentiation option
Bring all of the teams together.
Tell the students to place their robots in a vertical line with varying amounts of space between them (just like cars in a traffic jam). Ask them to start their programs at the same time and watch what happens.

Ask the students to refine their programs so that all of the robots continue driving at the same speed with equal distances between them (like well-flowing traffic on a road).

8. Distribute the results

Some ideas to suggest to students:

- Create a video of your project, especially your final presentation and your robot's performance.

- Explain some important features of your software program.
- Produce a building guide for your model by taking a series of photographs as you deconstruct it.
- Include an image of your program with comments.

LESSON 7.

LESSON DETAILS

MAIN THEME OF THE LESSON Basics of robot control

AIMS OF THE LESSON

- acquiring the basics of controlling Arduino robots
- experiencing the practical use of mathematical knowledge
- practicing writing algorithms

RECOMMENDED AGE GROUP 16 years old

DURATION
45 minutes

CONNECTIONS

- solving problems
- solving robot control and graphic tasks with the help of development system
- basic notions of robot control

CROSS-CURRICULAR CONNECTIONS: mathematics, computer science and physics

PHASES OF DEVELOPING COMPETENCES

The lesson sets the purpose of developing the following skills: algorithmic thinking, coding and robotics, Arduino coding environment, problem solving and cooperation.

DESCRIPTION THE ACTIVITY

Introduce a problem to students: we can only measure the rotation time of wheels and we can use the functions to move the machine and to travel a pre-defined closed path.

Necessary tools: computer(one per a two group) - Smart Robot Car Kit and development environment.

- projector
- Smart Robot Car Kit assembled according to the assembly manual. There is several sensors and four motors. The robot can move by programming the motors and acquiring data from the sensors

- To hold a session the teacher has to be familiar with the basic controls of the Arduino Software that allows you to write programs and upload them to the board.

LESSON 8.

1 The motion of robot car – a whole group discussion (10 min.)

It is shown how to use the Arduino ide and it is shown and all forms of movement are shown after talking about it to see the robot properly.

We show an example. We inform the students that the aim of the lesson is to direct the robots along a route. We explain the principle of moving the robot: the robot has four wheels, which can separately be moved with the help of four engines. We con programming the single motors to move the car.

The students answer questions:

How do you have to move the wheels so that
- the robot could go forwards
- the robot could move backwards
- the robot could rotate?

It is advisable to discuss two examples concerning the rotation:
- if the left wheels are stopped and the right wheels go forward the car rotates to the left, otherwise it turns to the right
- the wheels are turning in the opposite direction, in this case the robot is rotating around its axis.

2. The algorithm of the first circuit and the sizes (5 minutes)

If weare short of time or we think that the students are not able to create a plan like this on their own, we can discuss it as a whole group.
First we should mark the starting point where the robot should leave from. It is necessary that the students measure the length of the tracks.
I fit is easier for them, they are allowed to write programs and upload them to the board with Arduino, so that they can check the algorithm.
We must form 2 groups. Each group should create an algorithm to go along the first circuit. Ask them questions to help:
- When and how long should it go on?
- When and how long should I turn?

3. Rotating with wheel – whole group discontinued [5 MINUTES]

The rotation method is used when the robot car rotates around one or two of its wheels. To do this, the wheel speed must be set to 0 or power off the motors of wheels.
Let's talk to the students that we can now turn the time of power off motor into wheel rotation.
Also ask which wheel we need to stop for the robot to rotate in the right direction?

4. Programing the Robot Car-discussion in the whole group (5 minutes)

First, we have to check if the engines are connected to the Board and if the car work. Each group must start the development environment, they should not only focus on the teacher's explanation. We should start the development environment together with the students and open a new project. Show the students some different settings of speed with the help of the robot car.
When the group finished to write the code, it is necessary to connect the car to the computer and uplading the program. Then let's try the code.

5. Programming the first track - activity in small groups (20 minutes)

While the students are programming, they should connect the robots to the computers, since it could take a while for the PCs to recognize the robots.
At the end of the lesson, we should spare a minute to try a program, even if there will be no time to try all of them.
All the groups should write the program according to the algorithm. When a group is ready, they can try their program on the tracks, and correct their mistakes if needed.

LESSON 9.

LESSON DETAILS

MAIN THEME OF THE LESSON Creative practice in robotics

AIMS OF THE LESSON

- acquiring the creativity and technical competencies
- experiencing the practical use of STEM knowledge
- practicing writing a program for the mission of self-designed robot

RECOMMENDED AGE GROUP 13-17

DURATION 90 minutes

CONNECTIONS

- solving problems
- solving technical problems and robot control
- basement of robot planning

CROSS-CURICULAR CONNECTIONS mathematics, physics

FOCI OF DEVELOPING COMPETENCES

The lesson sets the purpose of developing the following skills:

creativity, technical sense, knowledge application, cooperation, goal-oriented activity

DESCRIBING THE ACTIVITY

Introduce a problem to students: Design and build your own robot in 4-member groups

- planning
- construction
- programming
- testing
- application

necessary tools:

- Makeblock Ultimate 2.0 robotics developer kit (each group has one robot)
- computer for planning and programming (one per a 4-member group)
- projector
- batteries

Recquired content and prior knowledge for acquiring necessary skills:
for teacher has to be familiar with the basic controls of the Makeblock robot, the use of arithmetical calculation and the steps of creating an own blockprogramm.
for students Being familiar with Scratch related recommendations
It is advisable to move the robot on the ground or on a big framed table.

LESSON 10.

1. **Base of STEM Education and Robotics --- a whole group discussion (10 min.)**

It is appropriate to demonstrate the base of robotics after having talked about them.

We show an example.
We inform the students that the aim of the lesson is to construct an own robot.

We explain the principle of design the robot: the robot has frame, engines, mechanics, controller and sensors.

2. **The plan of a robot – small team activity (10 minutes)**

We have to form smaller groups of 3-4 students
Each group should create an own robot.

Every robot has a special mission and is designed on that basis.

Each group must find a mission and construct their robot for this basis.

If we are short of time or we think that the students are not able to create a plan like this on their own,we can discuss it as a whole group

When the groups are ready, they should discuss the plan together and the targeted mission and data of the robotic device. It would be appreciated to record these data for example to write them on the board
If the mission slightly differ from group to group, it does not matter as they can design on with their planned data and in the end we will test whose robot was the most exact.

3. The construction of own robot – small team activity (40 minutes)

The groups start to construct the structure and the teacher just supervises the work.
It is important to adhere to accident prevention standards and prevent the loss of small parts.
When the creation is ready, first, we have to check if the engines and batteries are connected to controller. Each group has to start the testing if the connections are ready. They should not only focus on the teacher's explanation.
First operation testing
In this case, the best way to direct control the robot is using bluetooth with smartphone.

4. Base of programm development --- a whole group discussion (10 min.)

If the students can use the Sctratch, it is enough to refer to the fact that the programming blocks should be switched one after the other. If they cannot use the Scratch, it would be useful to spend more time with explaining them how to use the blocks.
We should start the development environment together with the students and open a new project.
Discuss what the necessary blocks mean, which we can set in this blocks.
Show the students some different settings of blocks with the help of the robot.

5. Programming the first track of own robot - activity in small groups (20 minutes)

Create a simple algorithm to accomplish the set task and code in mBlock.
While the students are programming, they should connect the robots to the computers, since it could take a while for the PCs to recognize the robots.
At the end of the lesson, we should spare a minute or two to try a program, even if there will be no time to try all of them.

6. Testing the first track of own robot - activity in small groups (8 minutes)

All the groups should write the program according to the algorithm.
When a group is ready, they can try their program on the tracks, and correct their mistakes if needed.

7. Distributing the homework (2 minutes)

Their homework is to create an algorithm for the own robot**.** They can write it on a piece of paper or use the Scratch program. These are the tracks the robots have to follow during the next lesson.