Teacher's guide for the programming pack

Do you plan to introduce your students to the mission objectives and goals at the start of the preparatory training or just in time on mission day? Whichever option you choose, you'll find the supporting introductory content on p. 2.

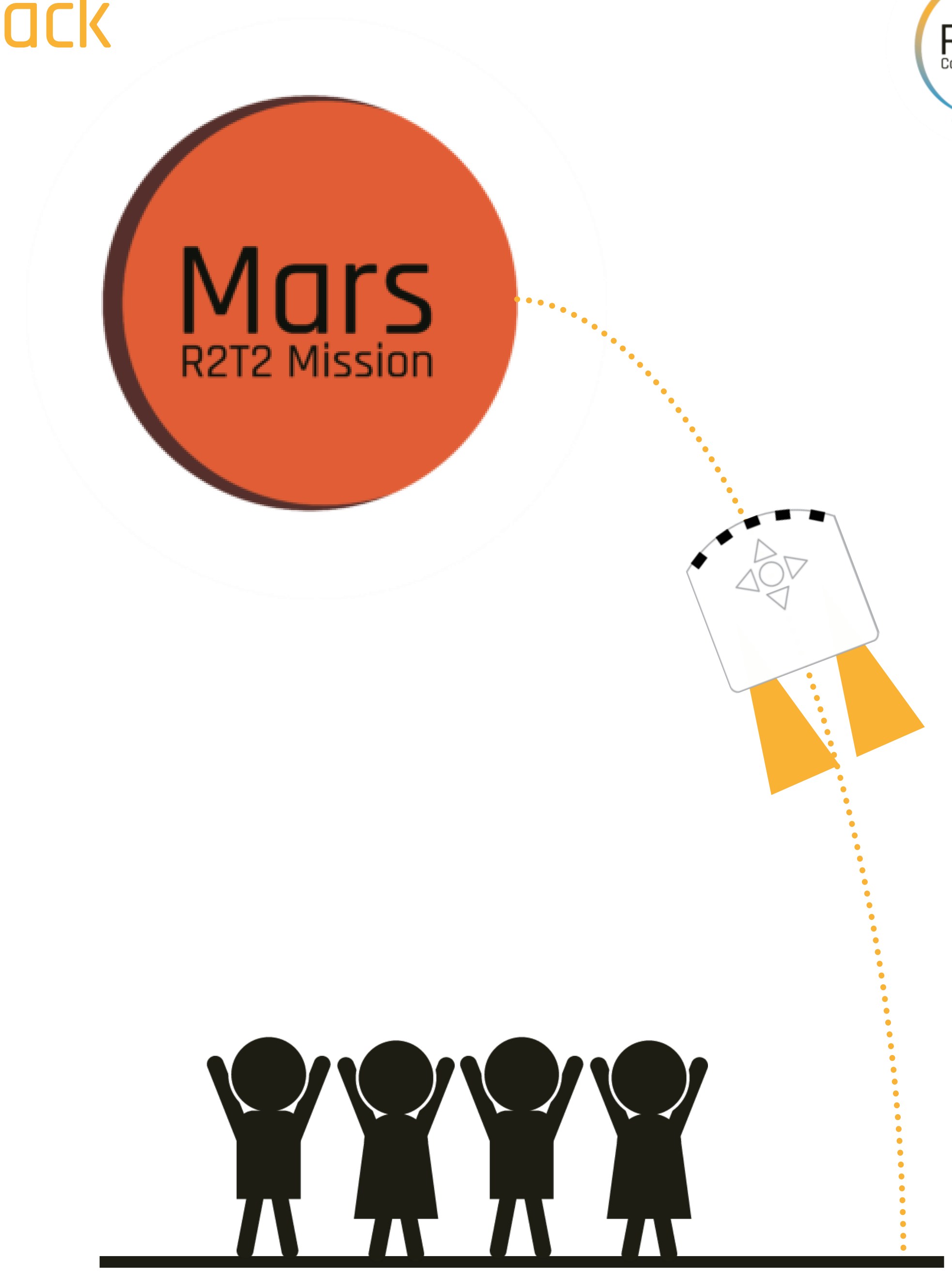
Do your students plan to use VPL or VPL advanced? Both can work! The modules in the programming pack will help you to prepare teams for the programming tasks. These seven modules of practice exercises and detailed explanations can be shared directly with students to work through during the training classes*:

1. How to program with VPL and advanced VPL
2. How to program proximity horizontal sensors
3. How to program ground sensors4. How to program IR sensors to detect grayscale or distance
5. How to program line and wall following
6. How to program a given distance or a given angle
7. How to cut a complex task into simpler ones

On pp.3-9, you'll find some further ideas for you on how to use the seven modules in order to gain a better learning experience for your students during the program.

Please feel free to adapt the content to suit you and your students.

**Students can work in small groups if you do not have one robot per student. The groups may be the same or different from the teams planned for mission day.*



Introduction to the mission

Story

We are in 2032. A meteorite has damaged an important Martian power station and we need to assess the damage and restart the main generator. We have 16 robots on site. Each robot can be controlled by a team of engineers and space experts from Earth. Between Mars and the Earth there is a delay in the video transmission (between 3 minutes when Mars is closest and 21 minutes when Mars is farthest from Earth in its orbit) and direct remote control is impossible. Therefore the Earth experts need to program the robots to solve the task.

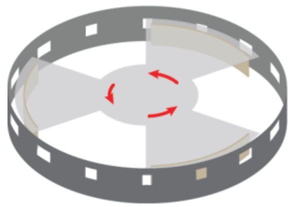
Phases of the mission

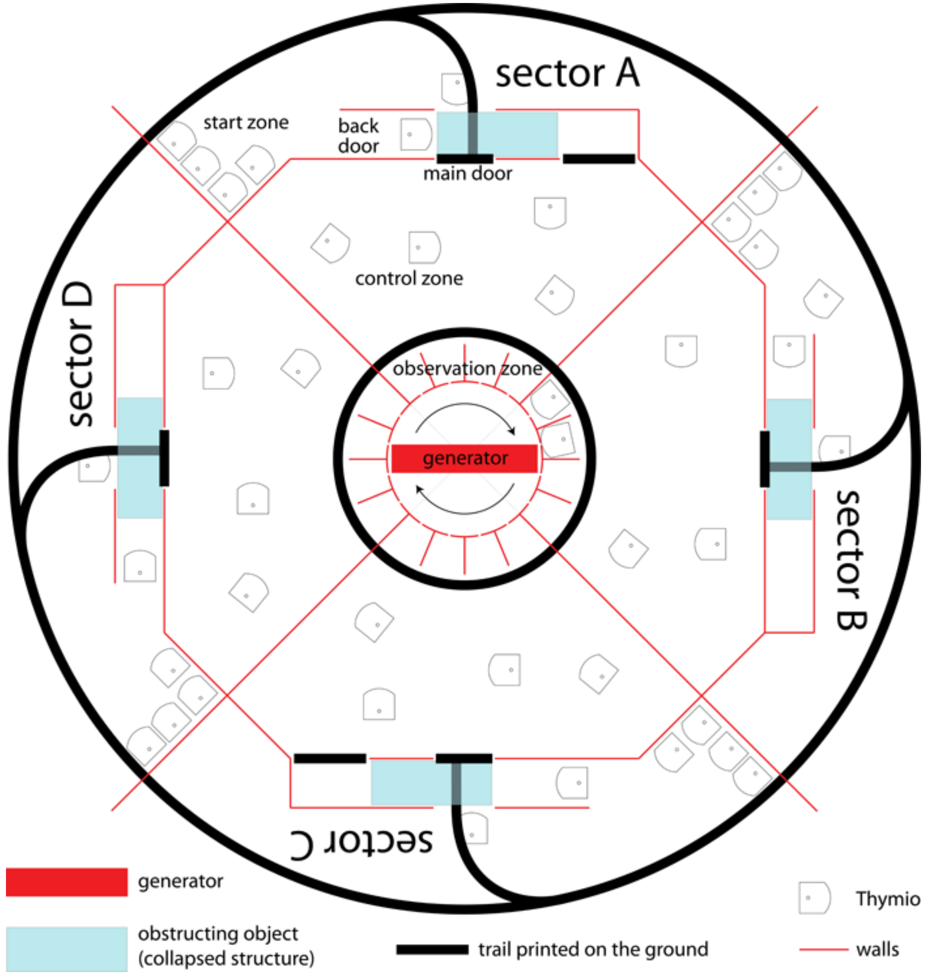
- **Phase 1:** One of the four robots in each sector needs to take the very difficult task of clearing access to the main door by pushing away the obstructing object using the back door. In parallel, the others need to line up in front of the entrance so as to be ready to enter. Once the collapsed structure is removed, the other three robots can enter the station.
- **Phase 2:** The robots need to find the reflective spots and stay on them, indicating that they have found them by showing green. As soon as all 4 robots of the sector are correctly positioned, the access to the "observation zone" of the central generator will be opened. The engine inside of the generator will start to turn a little bit when all slots in the observation zone of the station are opened.
- **Phase 3:** There are 4 slots in the observation zone where the robots can connect to the generator. To check the connection, each Thymio needs to determine when the rotating engine of the generator is passing in front of its slot, show this event by lighting up the top LEDs in the colour of the robot and turn off the LEDs if it sees nothing.

Discussion ideas: (time permitting and so may work better if you introduce the mission objectives and phases before the actual mission day itself)

- Look at the start zone. Imagine that we have this robot (choose one of them). How might we enter the station?
- How could we access the back door to the station?
- Imagine that our team is now in Phase 3. What do you think we need to be able to program Thymio to do in order to detect the rotating engine?

Generator's engine





1. How to program with VPL and advanced VPL

Time in class: 25 minutes
Objective: How to program Thymio with VPL

Story for students

The robots on Mars are Thymios! You are a group of engineers who will program them from the Earth. Therefore, you need to get to know this robot well and how to control it! What can Thymio do? How do we program it? Let's start to figure it out!

Tips to run the activity

If this is the first time that you introduce Thymio, the students can observe first which elements Thymio has: 5 proximity sensors on the front, 2 on the back, 2 ground sensors, LEDs, motors, etc.

A detailed explanation of the VPL interface is given in module «1. How to program with VPL and advanced VPL». It contains an example of a program, but you can also create your own. However, if your class is discovering Thymio and VPL for the first time, the easiest way to start is to use the event blocks such as buttons, shock/incline sensor or sound sensor. It is also possible to let students discover the interface themselves. For example, you can mention that the goal for next 10 minutes is to find a way to program Thymio to move straight forward, back, right or left.

Discussion ideas

- When robots are on Mars, is it useful to program buttons of the Thymio? (No, as there is nobody there who can press them.)
- How do we set the speed of the motors?
- What will Thymio do if we give the same speed to both motors but in different directions? (Thymio will spin on the spot)
- Create a program of more than two lines and test it. Does Thymio do actions line by line? How do you think it happens? (Thymio will do an action when the associated event has happened. So, it does not execute actions line by line in sequence.)

Time in class: 20 minutes
Objective: How to program Thymio with VPL advanced

Story for students

Mars has a lot of different mountains, canyons, craters and volcanoes. Some of them are very high, for example, Olympus Mons is about 21 287 m high. So, maybe it is better to avoid climbing on it to not break our robots? Program Thymio in order to avoid climbing on a very steep slope and find the steepest slope that Thymio can climb.

Tips to run the activity

Show how to activate the advanced VPL mode. Explain its new features available in the interface. A detailed explanation of the VPL interface is given in module «1. How to program with VPL and advanced VPL».

When we add a new event block in advanced VPL mode, a green state variable block appears automatically on each line. We advise to avoid its use and its explanation in the beginning (you can just ignore it for now) if your students are not familiar with variables or the state machine concept. States will be explained in another module.

Notice also that the sensor blocks have changed a bit: The two grey lines that have appeared will allow us to adjust the detection range of the sensors. More on this later!

Discussion ideas

- What differences do you notice between the interfaces of VPL and VPL advanced?
- Which blocks do you think would be useful for programming robots on Mars? (Not music, nor any buttons)
- What to do in the night on Mars? How could you "see" the robots? (Turn your Thymio's lights on to recognise your robot. It could also be useful to assign different light colours to different robots if there are many of them working together.)

2. How to program proximity horizontal sensors

Time in class: 45-60 minutes
Objective: Discover the programming of the proximity horizontal sensors

Story for students

In the mission scenario, as in real life, we do not have any people (yet!) on Mars. Will it be useful then to program the Thymio's buttons? We will also not have a signal coming from Mars 24/7. So, we will not be able to control the robots directly. We really need to program the robots so that they can work in the most autonomous way possible. The robots have to be capable to analyse the environment around them and not fall off cliffs or run into big rocks in their way. IR (infrared) sensors could help us to do it!

Tips to run the activity

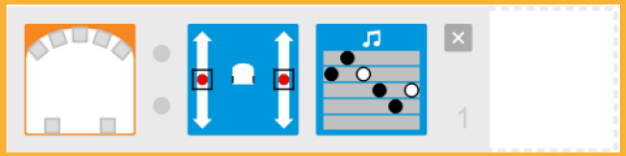
Discover with students what happens when the Thymio's IR sensor detects something. To see it, we propose either to activate the pink pre-programmed mode, or to connect the robots to computers and open VPL. A detailed explanation is given in module «2. How to program horizontal proximity sensors».

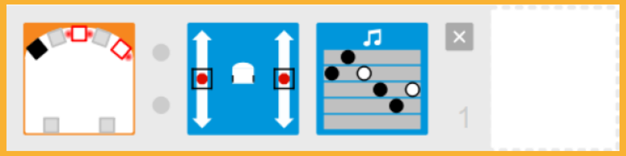
To extend the exercise:
Prepare one table or put two tables together to form an arena. Put walls on the arena's edge with white paper, for example. You can also place some larger objects on the tables that the robots should avoid.

Task: When all programmed Thymios are in the arena, they have to move forward, but not bump into each other or the walls.

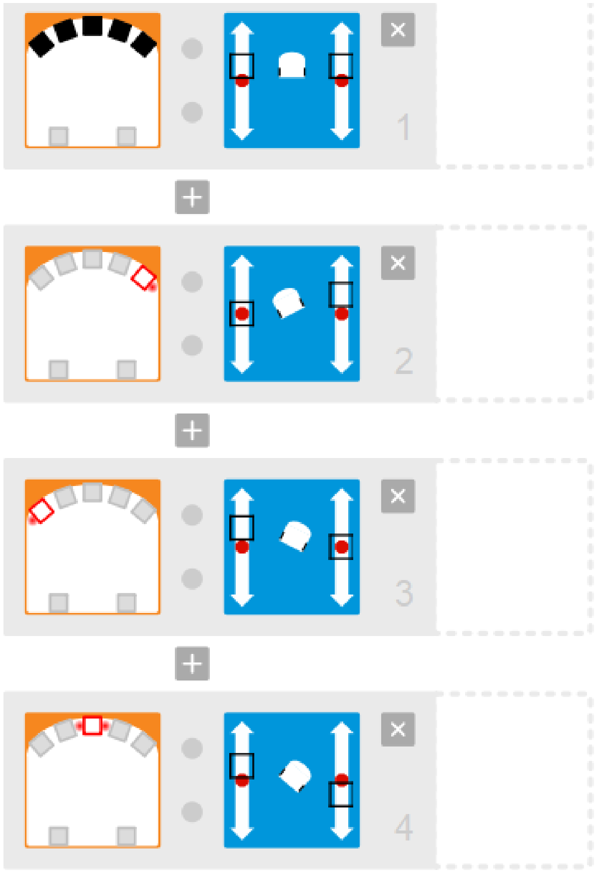
Discussion ideas

- Have your students try the following events programs. What do they do? (A detailed explanation is given in module «2. How to program horizontal proximity sensors» on p.4)





Solution for the task



3. How to program ground sensors

Time in class: 45-60 minutes
Objective: Discover the programming of the ground sensors

Story for students

Engineers have to consider all sorts of possible situations when they program an autonomous behaviour for robots. What if the robots reach the edge of a cliff? of a mountain? or of a crater? How to save them from falling off? In the case of our mission, we have to observe the events that are happening on Mars remotely from Earth and here Thymio's ground sensors can help us.

Tips to run the activity

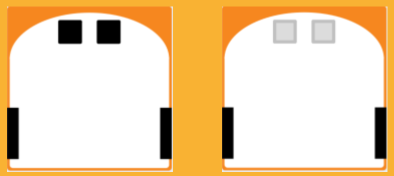
Discover with students what happens when the Thymio's ground sensors detect something that is not black, something dark-coloured/black or nothing. To see it, we propose either to activate the pink pre-programmed mode, or to connect the robots to computers and open VPL. A detailed explanation is given in module «3. How to program ground sensors». You will also find there some experiments and challenges.

To extend the exercise:
Prepare one table or put two tables together to form an arena. You can also place some larger objects on the tables that the robots should avoid.

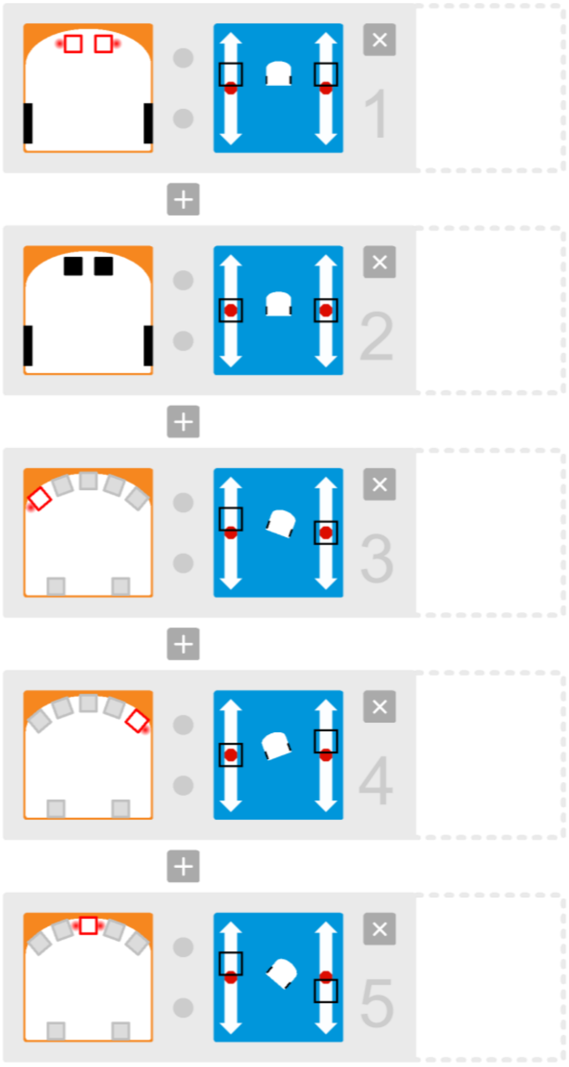
Task: When all programmed Thymios are in the arena, they have to move forward, but not bump into each other or fall down off the tables.

Discussion ideas

- Try to find all pre-programmed modes where Thymio stops at the edge of the table. Does it do the same on differently coloured surfaces, for example, black, red, yellow, green? (You can make differently coloured surfaces using pieces of coloured paper taped down on a table.)
- What happens when Thymio reaches the edge of the table in the light blue mode? (It should fall down.)
- Explain the difference between these two events (check the explanation on p.4 of module «3. How to program ground sensors»):



Solution for the task



4. How to program IR sensors to detect grayscale or distance (Optional)

Time in class: 45-60 minutes
Objective: Discover work of IR sensors (Optional)

Story for students

There are so many different minerals on Mars! Let's explore them! You have some samples of Martian surfaces (represented by different ground colours) and you need to recognise them using Thymio's ground sensors. There is also some sort of cave on Mars and we would like to measure how deep it is.

Tips to run the activity

Discover with students how Thymio detects different surfaces (grey shades) with its ground sensors and different distances with its horizontal sensors. A detailed explanation is given in module «4. How to program IR sensors to detect grayscale or distance». You will find exercises there to help you explore this topic further.

You can divide your class into two groups: those who will experiment with the ground sensors and those who will work with the horizontal sensors. Afterwards, they can explain what they have observed to each other and then rotate activities.

Discussion ideas

- Collect many different materials with different types of surfaces, for example, mirror surfaces, black, white, reflective tape, different colours. Ask the students to test how close Thymio has to get to each surface before it can detect them.
- Why are these different surfaces detectable at different distances? (The explanation is given on p.5 of module «4. How to program IR sensors to detect grayscale or distance»).

5. How to program line and wall following

Time in class: 45-60 minutes
Objective: Discover to program line and wall following

Story for students

During the Mars colonisation, a lot of tunnels and roads in mountains were built to reduce the time needed to go from one point to another and to help robots move around as autonomously as possible. How can we program robots to autonomously go through tunnels and follow these roads? It is up to you to discover it now!

Tips to run the activity

You can follow the detailed explanation of these tasks in module «5. How to program line and wall following». You will find there three challenges to help the students get some practice:
Challenge 1 – Line following with obstacle (Recommended to try)
Challenge 2 – Line following with fork in the road (Optional)
Challenge 3 – Wall following (Optional)

You can divide your class into two groups: those who will work on line following and those who will work on wall following. Afterwards, they can explain their proposed solutions to each other and then rotate activities.

These tasks can be more difficult for some students. So, we would like to emphasize that **wall following is an optional activity! If you see that line following is also difficult for them, do not worry! Remember that one of the goals of the mission is also to learn how to break down a complex task into smaller, simpler steps that can be done with a team effort.** One possible solution is proposed on this page under "Discussion ideas".

Discussion ideas

- Create a similar situation for a robot. Question for students: Thymio is next to a wall and has to reach the black spot. How to do it? What ideas do you have? (It is not necessary to program.)

Possible solutions:

1. Follow the wall and stop when Thymio detects a black point
2. Move forward a little bit. After, to turn to the right a little bit and move forward till the black spot
3. A lot of other solutions are possible!

6. How to program a given distance or a given angle

Time in class: 45 minutes
Objective: Discover how to program Thymio to move forward a given distance or to turn a given angle

Story for students

Sometimes there are dust storms on Mars! If a rover is caught outside of the station during a storm, it may not be so easy for it to get back. For example, if its IR sensors are covered by a layer of dust, it may not be able to detect obstacles and roads. How can Thymio get back to the station in this situation? How can we help the robot find its way without using IR sensors? One possible solution is to wait for a video signal from Mars that would enable us to guide Thymio using simple steps, for example, move forward, turn around. How to program Thymio to move forward a given distance or to turn a given angle in this case?

Tips to run the activity

Discover with students how to move the robot forward a given distance or to turn it a given angle either without a timer or using Thymio's timer functionality. A detailed explanation is given in module «6. How to program a given distance or a given angle». You will find exercises there to help you explore this topic further.

You can divide your class into two groups: those who will discover how to program Thymio to move forward a given distance and those who will program it to turn a given angle. Afterward, they can explain what they have observed to each other and then rotate activities.

Two possible solutions are proposed in the module: either you can program these tasks using a one-line program and stopping this program manually by clicking on the "Stop" button in the VPL interface, or you can use a timer. Using the timer can be more difficult for some students. So, we would like to emphasize that **stopping the program using the timer is an optional activity! If you see that using the timer is difficult for them, then they could use the VPL "Stop" option, even though it is not preferable.**

To extend the exercise: Place all of the robots on a line and put an object somewhere in the classroom that the students can see. Ask them to control the robots by doing small steps like "move forward", "move back", "turn right", "turn left". Each of these steps can be represented as a separate program.

Discussion ideas

- Which setting in the program do you need to adjust in order to achieve the correct distance or angle? (time and speed of motors)
- Suppose that you have programmed Thymio to move a given distance so that it will stop at the edge of a table with a smooth surface. What sort of speed would you choose in this case? (not a high speed, as Thymio can slide at the end and still fall dawn off the table)

7. How to cut a complex task into simpler ones

R2T2 Collaboration

Time in class: 45 minutes
Objective: Train how to break-down a complex task into simpler ones

Story for students

After a meteorite strikes Mars, a big rock is blocking the road and Thymio cannot follow it as usual. Find a way to get Thymio to the other side of the rock.

Tips to run the activity

An exercise and its detailed explanation are given in module «7. How to cut a complex task into simpler ones».

In this last step of preparation for the mission, you can draw the attention of your teams to thinking about how to break down a complex task into simpler steps, why and when it could be useful to do this.

You can divide your class into different teams and give all of them the same task. See if they can find several solutions! Notice how team members work and give them some tips to help improve their collaboration skills. After all of the teams have found a (few) solution(s), let them share their ideas with each other! Afterwards, each team can choose a solution that they would like to program.

Do not hesitate to create a more complex or easier task.

Celebrate all that your students have learned in this final preparation step.

Discussion ideas

- What was it like for you to work together?
- Why did you choose a particular idea as your final solution? What advantages and disadvantages does it have?
- Did this exercise allow you to see that many ideas and solutions can exist, especially for a complex problem?