Chapter 5

Exemplary projects and examples of learning activities with robotics

5.1 Two projects proposed by French teachers-trainees

Authors: Liliane Aravecchia, Luc Montel

This section presents two exemplary projects produced by our teacher-trainees within the framework of their training within the TERECoP project at IUFM, Marseille: Robotics challenge (trainees: BAUR Matthieu, CLEMENT Gabriel and VINCENZI Guillaume); Automated camera (trainees: Nicolas BOLDRINO and Laetitia CANDIDO)

5.1.1 First example: Robotics challenge

The project is based on the following challenge: A robot has to go from point A to point B either through a labyrinth with colored walls (white when the path turns left and black when it turns right) or following a black line on the floor.

This activity was implemented in a classroom of 28 secondary school pupils, aged 12-13, as part of their technology course treating the topic of "computer-aided piloting".

The target skills aimed at are part of the French Technology curriculum. After the end of this project, pupils were expected to be able to:

- Identify the different parts of the robot ;
- Identify and justify the sensors and actuators used ;
- Represent the various stages of the movement by observing the robot;
- Modify an existing program according to the specifications given ;
- Adapt the system to a new situation.

The project was designed to be completed in 5 stages:

- Engagement stage: Pupils watch a video on robotics, followed by a discussion. The robotics challenge is then presented. (1h)
- I exploration stage: Pupils analyze the route their robot will have to follow from point A to point B and decide on a strategy to program the robot (30')
- Creation stage: Pupils modify the existing robot by implementing the sensors and the program chosen according to their defined strategy (2h 30')

- Evaluation stage: The different projects from each group of pupils are analyzed and compared by the class, and a synthesis is made by the teacher and the pupils (1h)

For the above project each group of pupils was given:

- One basic moving platform (Tribot), but without any sensors (the robot is given partly built due to lack of time to let the pupils do the building)
- A computer with NXT-G software for programming the robot.
- Different Lego sensors and Lego parts to modify their robot.
- One of the arenas the robot has to cross (labyrinth, obstacles or black line).

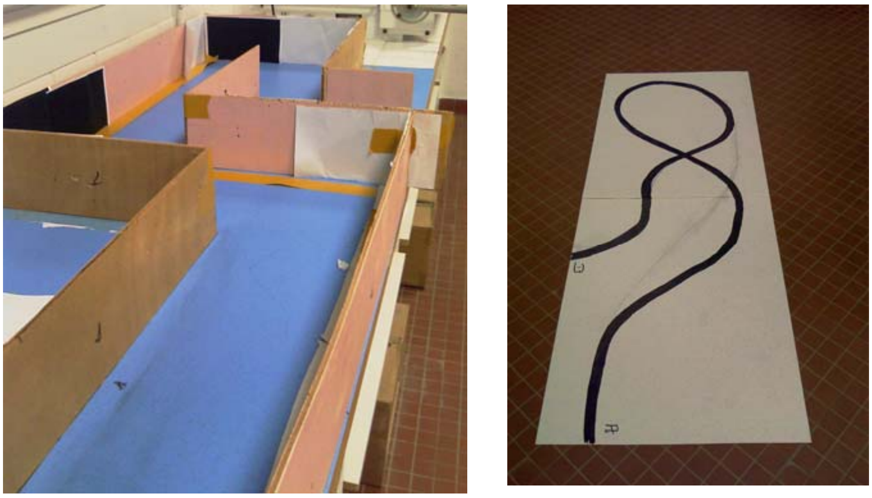


Fig. 5.1.1 *The Labyrinth and the Black Line challenges*

Teacher's guide:

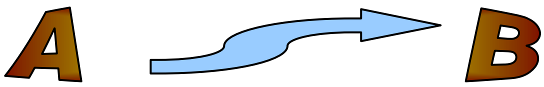
Stage	Activities and Progress	Class Organization	Time
Engagement stage	Introduction	Full class	5'
	Playing the video	Full class	20'
	Discussion on robotics		25'
Exploration stage	Presentation of the robot, the teacher asks "how will it be able to cross the arena?" Each group receives its robot, sensors and arena		10'
	Pupils analyze their arena and define a « way » for the robot to go from A to B They write it down in their own words at the back of the document they were given	Group of 3	20'
Creation stage	The pupils choose the sensors suited to their situation and install them on the robot. The teacher questions the pupils on the reasons of their choice	Group of 3	20'
	Pupils finish the robot and then go to their arena where they discover the necessity of the right program in order to pilot the robot. Then, they go to the computers and use the NXT-G programming software Teacher gives instructions on how to use the software	Group of 3	1h 40'

Evaluation stage	After clearing up , questions are asked by the teacher to see if the knowledge was understood Each group observes the working of the other groups' robots, try to deduce their logic of pro-gramming and justify the sensors used. A synthesis is made before a written evaluation in class	In groups	55'

Pupil's worksheet:

You have at your disposal a robot capable of evolving in its environment…

The robot has to go from A to B…



The robot moves along a straight line, collides with the first wall in front of it … and stays stuck

Why??

Some hints….

1. Analyze the arena the robot has to cross: What are its characteristics? What parts of the arena can help to guide the robot?
2. Propose a logical way to go from A to B
   - Write down your proposal here :
   - What are your conclusions?

Experiences and feedback

The main difficulty encountered, when this course was implemented in a classroom, was passing from the description in natural language working with the robot to the programming in formal language.

Engagement stage

In the first stage, the viewing of the video and the presentation of the challenge was aimed at catching the pupils' interest in the project and at bringing to light any lack of knowledge, any need to learn. This stage was successful; it induced a lot of interest and curiosity in the pupils. The concept of a challenge allowed to stimulate the children by an effect of competition. This means is effective, but has to be used with care in order not to value systematically the "winners" at the cost of the "losers".

Exploration stage

This stage consisted in the analysis of the course the robot had to follow and revealed the first difficulties. Most of the pupils, having observed quickly the circuit, tried to find a 'sequential' way of crossing the arena. For example, for the "labyrinth", most of the pupils said: "it is necessary to turn right, then left, then left, then right …" It is then advisable to question them in order to boost their reasoning: "but if I now want to go from B towards A, does it work?" Or still "observe, please, the elements of the course which can help you ".

The reflection thus resulted in a "logic", which allows crossing the arena in both directions, of the type: "if we meet a black wall, we make a quarter of a turn to the right, if we meet a white wall, a quarter of a turn to the left". This is true in particular of the arenas labyrinth and obstacle. The groups working with the "black line" had more difficulty because the logic to be built in this case is more complicated

Creation stage

During the designing phase, the first observation which we can make is that the Lego Mindstorms NXT support federated at once the interest of the pupils. Indeed, after the observation of the arena to be crossed, the implementation of one or several necessary sensors was realized without problem by the vast majority of the pupils. They often used the guide of assembly supplied in the box in a mechanical way. The main difficulty was to choose the adapted sensor or, more exactly, to understand the role of every sensor. Some guiding from the teacher helped them.

The contribution of a document allowing the pupils to choose the sensor independently (by describing the role and function of each of them) could turn out to be useful (fewer interventions on behalf of the teacher). We notice that robots are assembled in a very ill-assorted way, while all the groups used the same guide of assembly. We can thus conclude that the association of the material element with its representation is not without raising problems and calls for apprenticeship over the duration.

Furthermore, certain groups chose different sensors for the same use: for example, the detection of an obstacle can be made by a touch sensor or by an ultrasonic sensor. This is interesting and can be exploited during the synthesis by bringing to light the advantages and the disadvantages of each solution.

Once the sensors were installed, the first groups did not identify at once the necessity for programming the robot. They thus went on the arena, placed the robot down, switched it on and realized that it remained totally immovable. We asked them at this moment the question “why would it move if nobody gives it the order?” The role of the programming was then justified.

During the programming itself, the principle of 'blocks' was easily understood. On the other hand, loops and conditional actions raised more problems. It was thus important to establish a link between the logic in the form of a sentence and the software representation. To do it, the pupil has to formulate in writing the actions in a sequential way, by means of a compulsory syntax, facilitating the transition in the programming language under the shape " action if, until, as long as etc. ". For example "I move until I meet a wall, if it is white I turn to the right etc". This stage in natural language is a necessary step before programming in the language of the robot.

The difficulty for the teachers was here avoiding giving too many solutions to the pupils, while helping them not to remain blocked because of the programming language, which is not the object of learning here. In the case of this activity the logic behind programming is a skill that the pupil has to acquire, not the language itself.

5.1.2 Second example: Automated camera

The problem: A firm sells an automated production line that fills packages and packs flasks of different types. In order to present its machine to future clients, the firm wants to make a video of the course followed by a flask along the production line. In order to follow the progress of the flask, a robot with an onboard camera will be used.

This project was designed for a group of 12 pupils of age 16, in their first year of technical secondary school in the field of “Maintenance of Industrial Plants”.The learning objectives of this activity are linked to kinematics. The aim is to enable the pupils to define basic notions, such as trajectories (indifferent, rectilinear and circular) and movements (linear and rotation).

Progress of the teaching sequence: the project was planned over 4 hours, during one day (2 hours in the morning and 2 in the afternoon).

- Engagement stage: The teacher presents the problem to be solved to the pupils (they have seen the production line in function before), as well as the Lego NXT kit and programming software. The next hour is used by the pupils on building the robot with the help of an assembly guideline.
- Exploration and Creation stage: The pupils have to retrace the course of the production line “ERMAFLEX” with their robot.
- Evaluation stage: The different results from each group of pupils are analyzed and shared by the class and a synthesis is made by the teacher and the pupils.

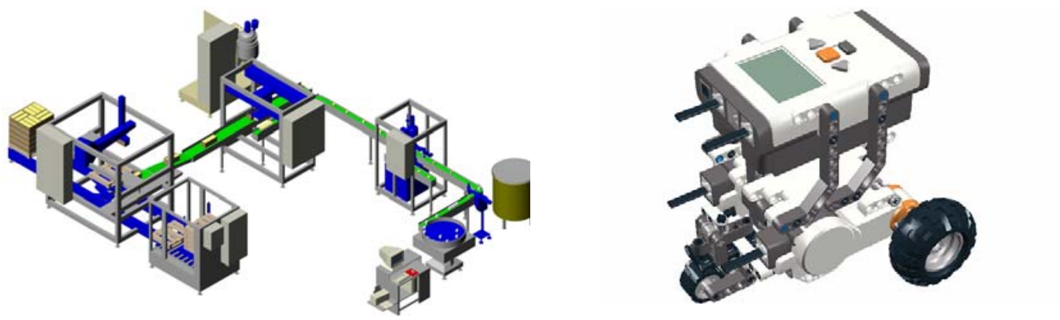


Fig. 5.1.2 *The production line and the robot*

Teacher’s guide:

Stage	Activities and Progress	Class Organization	Time
Engagement stage	Introduction	Full class	5'
	Presentation of the robot and the programming software	Full class	25'
	Teacher divides the class into groups, allocates a robot to each group and gives instructions	Group of 3	15'
Creation stage	Each group constructs its robot		55'
Exploration and creation stage	The pupils analyze the different programming blocks and try them on their robot, they then decide on a program solving the problem of following the path of a bottle on the assembly line	Group of 3	90'
Evaluation stage	Each group observes the work of the other groups’ robots, try to deduce their logic of programming and justify the sensors used. A synthesis is made before a written evaluation in class	Full class	20’
	Each group stores away its equipment, the teacher verifies that nothing is missing	Group of 3	5'

In this example the main goal is to enable the pupils to define the concepts of basic trajectories (rectilinear and circular) with the discovery of linear movements and rotation. In order to really work on the definition of trajectories and movements, it seemed important that the pupils should use blocks already preprogrammed by the teacher with simple movements such as: uniform rectilinear movement, uniform circular movement (left and right), accelerated rectilinear movement, decelerated rectilinear movement

So, by using these preprogrammed blocks to program Lego Mindstorms, the pupils can set up a fast experiment with the aim of recreating the route followed along the production line. The pupils will determine first the function of these various blocks and then, in order to solve the problem, they will create a program. In that way they will not waste time understanding how to program completely the robot and they will concentrate only on the realization of the route by a simple association of these blocks.

Pupil's worksheet:

Short description of the production line: The production line is used in industry, to manufacture, condition, pack and palletize several products in various containers. It makes it possible to fill bottles or flasks while following the process from the distribution of empty bottles to the palletization of packed filled bottles.

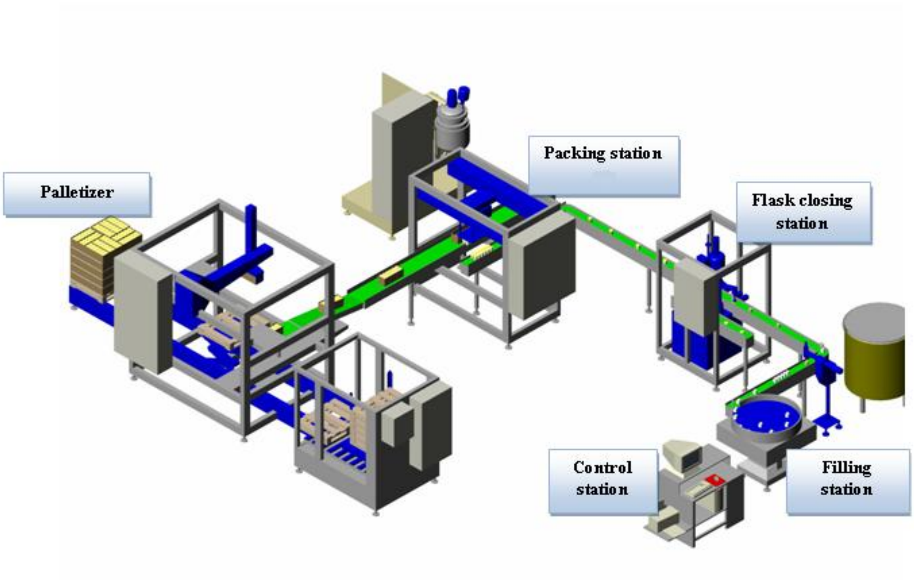


***Fig. 5.1.3** The structure of the production line*

Problem: With the aim of presenting the principle of operation of the production line, the company would like to carry out a video of the course, followed by a bottle on this production line. To follow the path followed by the bottle, a Lego Mindstorms programmable robot with an embarked camera will be placed at your disposal. This robot will allow, thanks to the realization of a program recalling the route followed by the bottle, to film, with the embarked camera, the course of the

ERMAFLEX production line. Before testing the program on the real production line, we will recreate this course in a reduced scale.

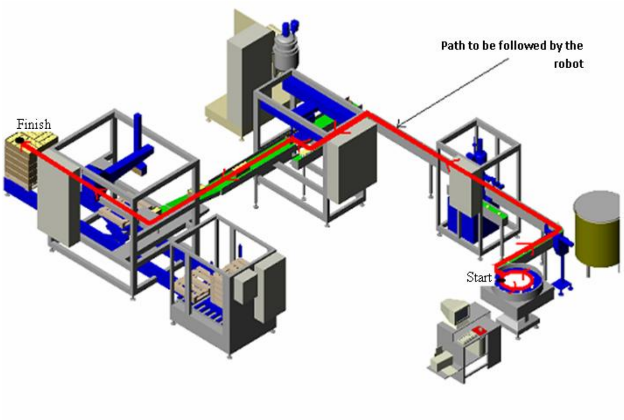


Fig. 5.1.4 *Path to be followed by the robot*

Programming task: To carry out the experimentation, you have:

- 1 Lego robot
- “MINDSTORMS EduNXT” programming software
- 1 USB cable allowing connection of the robot with the computer for programming

Programming instructions:

1. Launch the software.
2. Click on the icon “start a new program”.
3. Click on the Palette icon personalized.
4. In the icon “My blocks”, select a macro by clicking.
5. Position the macro in the programming window of the software.
6. Repeat stage 4 and 5 as many times as necessary, according to the macros that you want to test or to the program that you want to realize.
7. Once the program is finished, connect the robot with the computer via cable USB.
8. Start the robot by pressing on the orange button.
9. Click on the Download icon in order to load the program in the robot.
10. Await the end of the compilation and disconnect the robot.

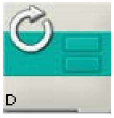
11. Place the robot on the ground and press the orange button of the robot to launch the program.

Experimentation:

✍ Instructions: Explain for each image of the blocks below the behaviour carried out by the Lego robot.

Answer: uniformly accelerated movement
....

Answer: constant speed movement
....



.... *Answer: turn right*

Answer: turn left
....

.... *Answer: half turn right*

.... *Answer: half turn left*

Experience feedback: This project was implemented by two student-teachers in one classroom and was compared with a more typical lesson treating the same subjects. The results of the comparison of the two different teaching methods (with or without the help of educational robotics) was presented by the student-teachers in their professional reports, as part of their evaluation as teachers trainees. In this example, the students had great difficulties in designing a course using a constructivist approach because it had to fit in a curriculum that was built on an approach based on skills, and prevented them to focus on the construction of knowledge in the chosen situation.