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STEAM2GO PROJECT

**Mobile makerspaces for promoting maker education in schools democratizing
STEAM education and innovation development for all the learners**

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Learning Scenario

Traffic light control system with RPi Pico and Phyton
proposed by IIS Leonardo da Vinci

Difficulty level: medium-high

Reference age: from 16 to 18 years

Cost: currently very low

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Project title	RPi Pico and Phytion Traffic Lights
Partners authors	IIS Leonardo da Vinci <i>Renato Gatti - Loris Ranalli - Giovanni De Rita</i>
Project abstract	The students will try their hand at the realization of a traffic light control, starting with a study of the system found on the Internet and the definition of the block diagram. An in-depth study on the timing diagram will be carried out to subsequently move on to programming a RPi Pico board. RPi Pico will, in the end, be implemented to control the input buttons and LED outputs, using dedicated breadboards and components. The students will also create a model of a crossroad with two traffic lights. Vehicle and pedestrian safety will be an important phase of the project in order to avoid dangerous accidents due to system failures or design errors.
Students' age	From 16 to 18 (3 rd to 5 th grade of High School)
Educational goals	- Understand and implement timing diagrams - Understand an electronic circuit in detail - Create circuits using RPi Pico board and electronic components - Being able to create a floor plan of a system by creating a paper model using everyday materials - Learn the fundamentals of basic programming to implement the proposed model - Analyze and identify the parameters and functions to be controlled in a complex system - Interface, through the RPi Pico GPIO, the I/O signals coming from the external devices - Develop, through the Thonny IDE software, the traffic light control system using Phytion - Test the prototype - Create a technical sheet and a bill of material of the system - Optimize and define the optimal work solution by sharing among the participants
Phases of the project	<i>Exploring</i> - Targeted research on the internet on how a traffic light works - Discuss how to realize the floor plan (a road junction with one/two traffic lights each road) of the traffic light control system by creating a paper model using everyday materials - Research on the internet about various programming

	software
	- Identify the possible uses of the proposed system (e.g. road crossing, garage entrance/exit, etc.)
	<i>Identifying functional specification</i>
	- Use simple material and crafting tools to create the floor plan (a road junction with one/two traffic lights each road) - Identify the timings necessary to make the system work correctly - Identify the main functional blocks of the system
	<i>Creating and testing the prototype</i>
	- Realize the floor plan (a road junction with one/two traffic lights each road) of the system by creating a paper model using everyday materials (it can be made by hand using markers or graphics programs or word processors such as MS Word) - Create the timing diagram necessary for system operation - Create the block diagram of the system - Make the interconnections between external devices and RPi Pico board - Build the program using Thonny IDE and Phyton to get the traffic light to work - Testing the working prototype
	<i>Documenting and reflecting</i>
	- Video and photos of the final product - In plenary: technical discussion regarding the critical issues and possible improvements of the project carried out.
Prerequisites	- Basic mathematical knowledge (solve simple equations, knowing how to understand and apply a formula) - Basic knowledge of combinatorial and sequential logic - Knowledge about the use of basic electronic components (resistors, LEDs, pushbuttons) - Basic use of the PC.
Outputs	- The floor plan (a road junction with one/two traffic lights each road) of the system - Photos of the model made of paper or cardboard - Video showing the correct functioning of the traffic light and relative timings - The timing diagram of traffic lights - Thonny source code
Total number of hours	8 - 16 hours (based on the students average level and the time spent in the preparatory phases)



Number of sessions	4/8 sessions (maximum duration: 2 hours) • Analysis of the system and its operating procedures • Introduction to RPi Pico and Thonny IDE • Working on the first traffic light program • Working on electrical circuit making • Working on the second traffic light program • Working on testing the programs on the test circuit with a single All-in-One breadboard • Working on draw and crafting the physical layout of the crossroad • Working on draw and crafting the physical layout of the crossroad • Working on connecting the complete system • Working on testing the complete system.
The most relevant involved disciplines	- Mathematics - Technology - Electronics - Information Technology - Realization of artifacts related to a technical-scientific project
Hardware needed	Each group needs - 3 x breadboards 170 points (https://amzn.eu/d/bcFYyKs) - 1 x RPi Pico - 1 x SPDT/DPDT switch - 1x pushbutton - Jumper wires kit - Wiring cables kit (M/M and M/F) - 2 (or 4) x preassembled led traffic lights single kit: (https://www.amazon.it/ZHITING-Display-semaforo-Mini-semaforo-elettronici/dp/B0859ZPM47)
Software needed	Each group needs - Excel - Word - Thonny IDE
Crafting material needed	Each group needs - Some sheets of A4 or A3 size white paper or paperboard 1 x Cutter 1 x Scissor 1 x Glue 1 x Double-sided tape 1 x Pencil 1 x Pencil sharpener - Some fine permanent markers of various colors - Stationery equipment like pencils, pens, paper sheets
Inclusive perspective	The project can be modified to meet the needs of students with

	special needs, based on the individual student requests, in order of decreasing difficulty: 1) You can simplify the project in the graphic part, greatly simplifying the layout of the road intersection and assemble the system with only two bread boards, the RPi Pico board and two traffic lights 2) You can simplify the project by completely removing the graphic part and create the system without the graphic part and its realization, using only the two bread boards, the RPi Pico board and two traffic lights 3) In all the above cases, the student can be helped, if necessary, in drafting the timing diagram
Supporting materials for the teachers	<i>The guideline for teachers:</i> https://drive.google.com/file/d/1Y-s-n0gYzeD0Hl7peSqEH2xXz3svCAcu/view?usp=sharing <i>All the programs:</i> https://drive.google.com/drive/folders/1nokWO4zK-r_5Vrcy90BtlD7Yp7LpBP7t?usp=share_link <i>All the figures:</i> https://drive.google.com/drive/folders/1fM-iQzjFthXgETRZ8ON1d2Al_LefqNlz?usp=share_link <i>All the videos:</i> https://drive.google.com/drive/folders/1q2Su3BQKd212-gokSq0zkK3-hiatmJ9y?usp=share_link <i>Thonny Software (IDE):</i> https://thonny.org/ <i>Getting started with RPi Pico:</i> https://projects.raspberrypi.org/en/projects/getting-started-with-the-pico <i>RPi Pico documentation:</i> https://www.raspberrypi.com/documentation/microcontrollers/raspberry-pi-pico.html <i>worksheet for students:</i> https://drive.google.com/file/d/18l_9w-mr3vwWbGJD7AncJVO51bzO8UeA/view?usp=sharing
Alternative solutions and additional implementations	Alternative programming solutions (from simple to more advanced) are described in the teachers' guidelines.
Session # 1	- Analysis of the system and its operating procedures. - Introduction to RPi Pico, Thonny IDE and Phyton - Reply to the worksheet section 1
Cooperating model	The students work in groups of 3-4
Classroom setting	Classroom are equipped with

	- the STEAM2GO mobile makerspace - 1 projector or interactive whiteboard or interactive monitor For each group: - 1 table for each group (a worksheet is available in each table) - 1 chair for each student - working stations with Laptops or PCs
Time	Duration of session: 2 hours
Activities	1) The teacher creates the groups of students 2) The teacher briefly demonstrates the STEAM2GO mobile maker space and helps the groups explore the available material and tools available (10 minutes) 3) Students analyze the system and research the various possible operational and functional modes (20 min.) 4) In-depth study of traffic light timings, with particular attention to safety (20 min.) 5) Introduction to RPi Pico hardware and connectors (15 min.) 6) Introduction to Thonny IDE and programming (45 min.) 7) Reply to the worksheet section 1 (10 min.)
Outputs	- Creation of system time diagrams: - o without overlapping red lights - o with the overlay of red lights - Production of the first simple programs as ice breaking activities - Reply to the worksheet section 1
Extra-session	The teacher facilitates discretely the learning process and supports where needed.
Teacher's input	- Security is the most important factor: how do you think it can be increased? - Why is a switch used to put the device in the "maintenance" condition instead of a push button? - What signals/alarms do you consider appropriate for the technicians who will have to carry out maintenance?
Notes	The teacher must carefully follow all groups of students in order to facilitate the achievement of the final results.
Session # 2	- Working on the first traffic light program - Working on electrical circuit making - Reply to the worksheet section 2
Cooperating model	The students work in teams, the same of the previous session.
Classroom setting	Classroom are equipped with - the STEAM2GO mobile makerspace - 1 projector or interactive whiteboard or interactive monitor

	For each group: - 1 table for each group (a worksheet is available in each table) - 1 chair for each student - working stations with Laptops or PCs
Time	Duration of session: 2 hours
Activities	1) The students realize the first traffic light program (50 min.) 2) The students prepare the first simple test circuit with a single All-in-One bread board and connect it to the RPi Pico board (60 min.) 3) Reply to the worksheet section 2 (10 min.)
Outputs	- Production of the first traffic light program - Production of the first simple test circuit with a single All-in-One bread board connected to the RPi Pico board and to external components - Reply to the worksheet section 2
Extra-session	None
Teacher's input	The teacher can raise questions to ensure that the students have understood how the circuit and the program operate.
Notes	The teacher acts as facilitator and co-maker.
Session # 3	Working on the second traffic light program Working on testing the programs on the test circuit with a single All-in-One breadboard Working on draw and crafting the physical layout of the crossroad Reply to the worksheet section 3
Cooperating model	The students work in teams, the same of the previous sessions
Classroom setting	Classroom are equipped with - the STEAM2GO mobile makerspace - 1 projector or interactive whiteboard or interactive monitor For each group: - 1 table for each group (a worksheet is available in each table) - 1 chair for each student - working stations with Laptops or PCs
Time	2 hours
Activities	1) The students realize the second traffic light program (30 min.) 2) The students test and debug the programs they have created (20 min.) 3) Students begin designing the graphic layout of the physical crossroad (60 min.) 4) Reply to the worksheet section 3 (10 min.)

Outputs	- Production of the second traffic light program - Production of a report of the testing and debugging phase on the system - Start of production of the physical layout of the crossroad - Reply to the worksheet section 3
Extra-session	None
Teacher's input	- The teacher can raise questions to ensure that the students have understood how the circuit and the program operate. - The teacher can ask what were the problems encountered in this phase and promote the discussion
Notes	The teacher acts as facilitator and co-maker.
Session # 4	Working on draw and crafting the physical layout of the crossroad Working on connecting the complete system Working on testing the complete system. Reply to the worksheet section 4
Cooperating model	The students work in teams, the same of the previous sessions
Classroom setting	Classroom are equipped with - the STEAM2GO mobile makerspace - 1 projector or interactive whiteboard or interactive monitor For each group: - 1 table for each group (a worksheet is available in each table) - 1 chair for each student - working stations with Laptops or PCs - Some sheets of A4 or A3 size white paper or paperboard - 1 sheet of expanded polystyrene - 1 sheet of alveolar polypropylene - 1 x Cutter - 1 x Scissor - 1 x Glue - 1 x Double-sided tape - 1 x Pencil - 1 x Pencil sharpener - 1 x Some fine permanent markers of various colors - 1 x stationery equipment like pencils, pens, paper sheets
Time	2 hours
Activities	1) The students realize the physical layout of the crossroad (80 min.) 2) The students realize all the interconnection between the RPi Pico board and the other breadboard mounted on the physical layout (20 min.)

	3) The students realize a short report of the final testing and debugging phase on the “complete” system (10 min.) 4) Reply to the worksheet section 4 (10 min.)
Outputs	Production of the layout drawing of the crossroad Physical production of the crossroad on which all the components are assembled Production of short report of the final testing and debugging phase on the “complete” system Reply to the worksheet section 4
Extra-session	None
Teacher’s input	- The teacher can raise questions to ensure that the students have understood how the circuit and the program operate. - The teacher can ask what were the problems encountered in this phase and promote the discussion
Notes	The teacher acts as facilitator and co-maker.