



The Lighthouse project

Project description & guidelines for teachers

Smooth introduction to Levels 1-4

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PART A: Theory & pedagogy

General approach/considerations

RoboScientists aims at engaging secondary school students in robotic artefact construction through interdisciplinary in nature projects. The set of the projects (that are going to be carried out) offer students opportunities to explore different aspects of the field of Science, Technology, Engineering Arts and Maths. Crafting/ handcrafting is a pivotal point in all the projects. Through the crafting process (highly interwoven in the robotic artefact construction) it is likely that the students will explore a number of engineering and design concepts, confront challenges and consider multiple solutions in order to achieve the results that they want.

About the Lighthouse project

In this line, this project revolves around the concept of Lighthouse. When developing the designing and setting up the project please have in mind the presentations and the discussions that took place during Day 1 of the Training (i.e. Pedagogical Considerations, Examples of Robotic Artefacts constructions). It is recommended to the educators that for a project to be delivered it is important to: employ the makeology approach, work in teams, encourage experimentation, involve crafting and coding, apply the Engineering design process is employed, encourage sharing, employ the STEAM approach, design and develop robotics models and artefacts, use various tool, equipment and materials, involve students as makers.

In the following section, three categories of skills are presented and explained. The first category includes the 21st century and transversal skills, the second category are the general pedagogical skills and finally, the third category describes the learning objectives to be achieved through various subject matters when the Lighthouse project is implemented.

The 1st category: 21st century and transversal skills

The 21st century and transversal skills have been outlined and described in the literature by various researchers (e.g. *Bybee & Fuchs, 2006; Ananiadou & Claro, 2009; Trilling & Fadel, 2009; Mojika, 2010; Rotherham & Willingham, 2010; Griffin & Care, 2015*) and reports from ministries of education, policies and organizations (*UNESCO 2014, 2016*). These are the following: Communication, collaboration, critical thinking, problem solving, knowledge construction, creativity, innovation, self-directed learning, global citizenship and digital literacy. In the section below, definitions, descriptions and characteristics of the main 21st century and transversal skills are given.

Learn how to learn: It is a very important skill to learn how to acquire knowledge and skills on their own and manage to construct their own knowledge and meanings.

Investigation: Investigation can be defined quite simply as a systematic fact finding and reporting process. It is derived from the Latin word *vestigere*, to “track or trace,” and encompasses a patient, step-by step inquiry. Investigation is finding facts; it is akin to research conducted in the academic arena. In addition, it is a multi-disciplined field of study. It encompasses law, the sciences, communications, and a host of other things. Finally it requires an inquisitive mind coupled with an attention to detail.

Exploration: Exploration-based learning is an active learning approach. Students' abilities are dynamically balanced with difficulty level in the system to provide exhilarating and fulfilling learning experiences. The visually and intellectually compelling storylines within the environment challenge each student to leverage their own curiosity and passion to solve complex problems using data and evidence, to form arguments and reach conclusions. This approach is positioned to deliver high levels of engagement and concentration while reducing stress and boredom for all students. Through these experiences, students build their levels of confidence and creativity, resulting in improved performance and sustained motivation to learn.

Reflection: Reflecting helps you to develop your skills and review their effectiveness, rather than just carry on doing things as you have always done them. It is about questioning, in a positive way, what you do and why you do it and then deciding whether there is a better, or more efficient, way of doing it in the future.

Problem Solving: Problem-solving skills help students determine the source of a problem and find an effective solution. Although problem-solving is often identified as its own separate skill, there are other related skills that contribute to this ability.

Critical Thinking: Critical thinking is not a matter of accumulating information. A person with a good memory and who knows a lot of facts is not necessarily good at critical thinking. A critical thinker is able to deduce consequences from what he knows, and he knows how to make use of information to solve problems, and to seek relevant sources of information to inform himself.

Digital literacy: Digital literacy refers to a particular set of competencies that allow you to function and participate fully in a digital world. Students, nowadays, are generally considered to be digital natives - able to use technology effectively and easily. They must be able to resolve conflicts, source material ethically and interact with the wider world in a responsible manner.

Creativity: Creativity simply means being able to come up with something new. Therefore, creative thinking is the ability to consider something – a conflict between employees, a data set, a group project – in a new way. The term is referring to the act of turning new and imaginative ideas into reality involves two processes: thinking, then producing. Finally, creativity is characterized by the ability to perceive the world in new ways, to find hidden patterns, to make connections between seemingly unrelated phenomena, and to generate solutions.

Innovation: Innovation skills refer to the talent of exploiting new ideas for the purpose of gaining social or economic value. Innovation skills are usually a combination of one's ability to think creatively, problem-solving ability, as well as functional and/or technical abilities. Fairly speaking, innovation skills are basically one's ability to apply a blend of knowledge, skills and attributes in a specific context.

Cooperation/ Collaboration: Cooperation is a division of labour between-group members. It occurs when a task is divided up into individually manageable subparts, which are subsequently constructed into a final outcome. Although this is conceptually different to collaboration, at a fine-grained level, all collaborative tasks have a degree of cooperation (Lai & Viering, 2012).

Communication: Communication is the art of transmitting information, thoughts and attitudes from one person to a different one's. It is the route of meaningful interaction among human beings. We learn basic communication skills by observing other people and modelling our behaviours based on what we see.

Building knowledge: Knowledge building provides an alternative that more directly addresses the need to educate people for a world in which knowledge creation and innovation are pervasive. Knowledge building may be defined as the production and continual improvement of ideas of value to a community, through means that increase the likelihood that what the community accomplishes will be greater than the sum of individual contributions and part of broader cultural efforts. Knowledge building, thus, goes on throughout a knowledge society and is not limited to education.

The 2nd category: General Pedagogical Skills / Objectives

The second category of skills are the General pedagogical ones. These are the skills to be developed or in other words the general pedagogical objectives of the Curricula of various subject matters. They are mainly outlined within the Curricula of various subject matters and specifically from subject matters such as Mathematics, Science, Technology, Engineering, Social Sciences, Arts and Linguistics.

General skills

Information Management Skills: Students make various calculations and metrics, make estimates and use graphs, tables, charts, and more optical media, to manage the various information and solve the problems which are presented. Also, students communicate with different ideas, criteria, possible solutions and outcomes. This communication takes place through sketches, graphs and representations on paper and computer, making two-dimensional and three-dimensional models and prototypes through symbolic and verbal representations. At the same time, they recognize, organize, analyse, compile and evaluate data information and interpret different views and approaches.

Problem Solving Skills: The Design and Technology Study Program is particularly useful for developing problem solving skills. Problem solving is closely related to the development of critical, reflective and logical thinking mindset, the development of imagination and creativity, problem determination and analysis, the exploration, construction and control of products and constructions, the evaluation of processes and products.

Project Management Skills: Through cross-thematic activities proposed and implemented through teamwork, pupils can develop skills in targeting, managing time and the available resources, computation, risk-taking and dispute resolution.

Social and Interpersonal Skills: The proposed activities as well as the respective framework offer a rich and authentic communication environment between pupils and teachers, working in groups, respect and cooperation, etc.

Skill Category: Design

Middle School

1. Ask appropriate questions and through ideas of stature propose ideas for various constructions and procedures.
2. They discuss ready-made technology products, referring to their form, function and safety.

3. Analyse the factors that affect a problem, through the collection and utilization of various information.
4. Report and develop problem-solving ideas, taking into account security, ergonomics, aesthetics, economy, applying the design process.
5. Carry out research and evaluate sources and information about a particular product or process.
6. Evaluate products and processes based on criteria that have been set.
7. Apply the stages of the design process.
8. Recognize and use symbols in diagrams, circuits and drawings, in applications on paper and on PC.

High School

1. Investigate and evaluate industrial products and processes based on specifications.
2. Implement a manufacturing process according to the product they are going to manufacture.
3. Draw up an action plan and implement the planning process stages.
4. Evaluate products based on specifications and needs that have been put forward and propose modifications.
5. Report and document modifications and variations made during the design and construction phases and explain the necessity of these differentiations.

Skill Category: Communication

Middle School

1. Describe verbatim and / or design the design process for ideas to be implemented.
2. Use lines, shapes, and simple design methods to present their ideas.
3. Recognize and use symbols that recognize within diagrams, circuits and patterns.
4. Communicate using sketches and 3D drawings and spelling projections.
5. Communicate using recognized symbols.

High School

1. Enhance their designs by adding information through detailed three-dimensional drawings and magnifications.
2. They present ideas and ways of construction through three-dimensional drawings and spelling projections.

Skill Category: Construction

Middle School

1. Collect and categorize materials from simple constructions.

2. Prepare simple constructions with various materials, using different skills and manufacturing methods.
3. Cut, bind and shape materials to use in simple constructions.
4. Mark, cut and assemble with precision various materials.
5. Safely use a range of tools and machines to manufacture products made up of more than one kind of materials.

High School

1. Use manufacturing techniques, materials, tools and machinery in a way that appears to be familiar with manufacturing processes, taking into account safety during manufacture and quality assurance of the final product.
2. Propose and apply alternatives to implement their ideas.

Additionally, exploratory skills are promoted through the Curricula (Programs of Study) of Secondary Education. The exploratory skills are summarized below:

- Writing hypotheses that can be checked.
- Designing and conducting research, determining which variables will change, what will remain stable and what will be measured.
- Selecting appropriate tools, technological equipment and suitable materials for a construction.
- Presenting and interpreting the results using a range of representations and dynamic images, simulations and models.
- Communicating results and explaining structures to classmates and other audiences / users, using appropriate vocabulary.
- Evaluating ready-made technology products and suggesting improvements.
- Presenting a design and explaining the use of the finished product.

The 3rd category: The Learning Objectives

The third category includes the Learning Objectives to be achieved within various subject matters, or in other words across various disciplines. The particular project, the Lighthouse, aims to achieve learning objectives from the disciplines/subject matters of Mathematics, Science, Design and Technology, Language and Linguistics, ICT, Arts, Physics, and Technology/History:

- **Mathematics:** angles, degrees, geometry
- **Science:** simple electronics circuits
- **Design and Technology:** transport and communications (How people communicate through a lighthouse.
- **Language and Linguistics:** analysis of a text related to the lighthouse
- **ICT:** programming, connecting physical and digital world through the use of sensors
- **Physics:** electrical circuit making, understanding what do mean by intensity of light, controlling intensity and frequency of blinking, what a blinking pattern is

- **Technology/ History:** issues related to continuity and change of lighthouses over time, technological and scientific developments over long period, Maritime History
- **Arts:** in the case of Van Gogh's Starry Night.

The process

The process to be followed from the students is the Engineering Design Process as presented in the following two diagrams.

Diagram 1: The Engineering Design Process

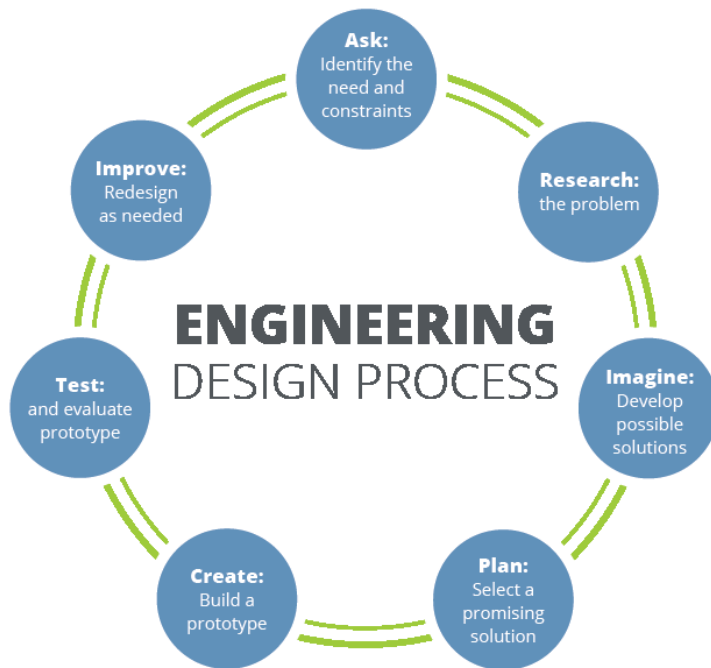


Diagram 2: The Engineering Design Process

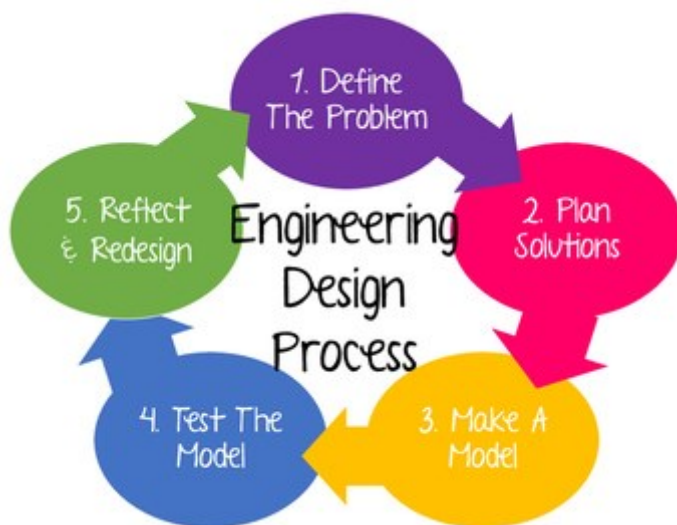


Diagram3: The Design process according the Design and Technology Curriculum (Cyprus Ministry of Education and Culture)

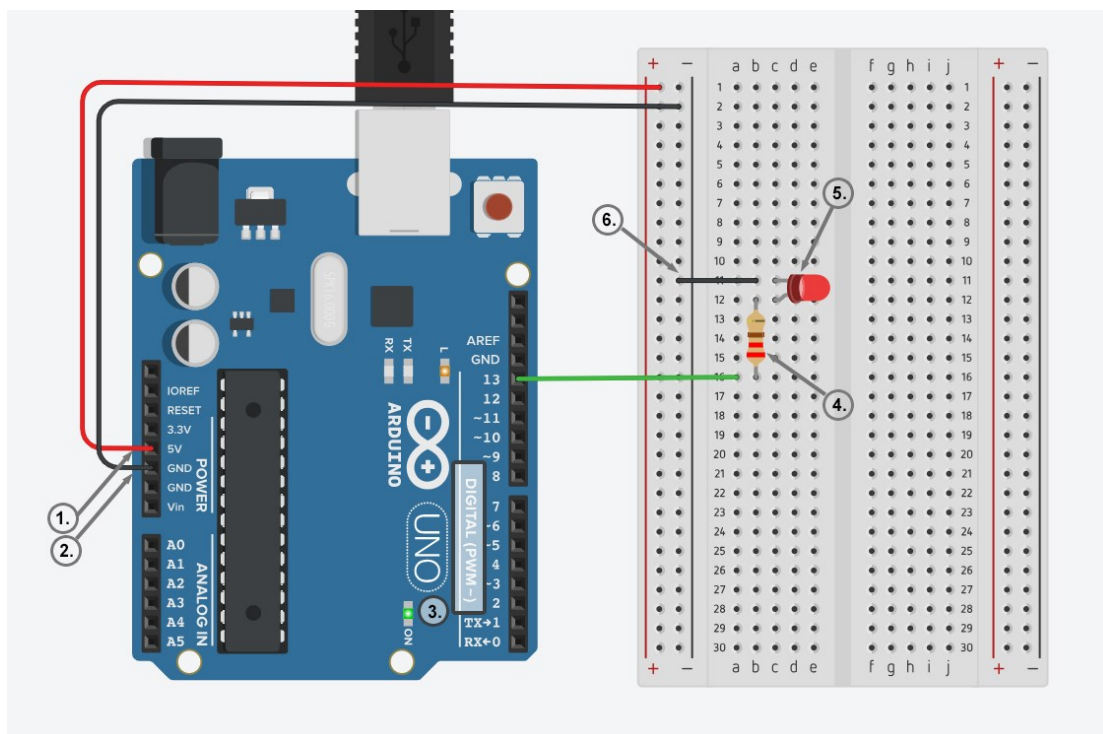


PART B: PRACTICE

Level 1: The lighthouse blinks in repeat

Creating the circuit

For the circuit of this level, students will need – apart from the breadboard and some jumpers - a LED and a 220 ohm resistor. The following diagram indicates how the aforementioned components should be connected to the Arduino.



- Use 5V (1) and Ground/ GND (2) pins to respectively provide 5V power and ground to your breadboard
- Use one of the digital pins (3) (pin 13 in the example) to connect the anode of your LED (5) through the resistor (4)
- Connect the cathode of your LED to ground (6) in order to create a closed circuit

Questions that can be raised/discussed:

- Why a resistor is needed?
- Why are we using digital instead of analog pins?

Level 1- Block-based programming solution

At this level, the students should be encouraged to implement the blinking functionality. The blocks that appear below will be needed: The gold blocks are from the Control palette. The turquoise blocks are from the Arduino palette and achieve the communication with the Arduino board. A script in Snap4Arduino (and in most of the block-based programming environments) is assembled by dragging blocks from a palette into the scripting area in the middle part of the window in Snap4Arduino. Blocks snap together when you drag a block so that its indentation is near the tab of the one above it.



This is a *hat* block that indicates that the script should be carried out when the green flag will be clicked.



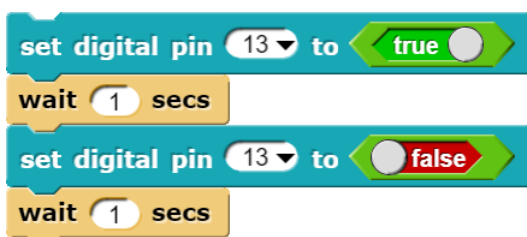
This is a C-block. The slot inside the C shape is a special kind of input slot that accepts a *script* as the input. Any script placed **in there** will be carried out forever in a circle.



This is a control block that pauses the execution of the script for a predefined number of seconds (keeping the current state on): in this case 1 sec.



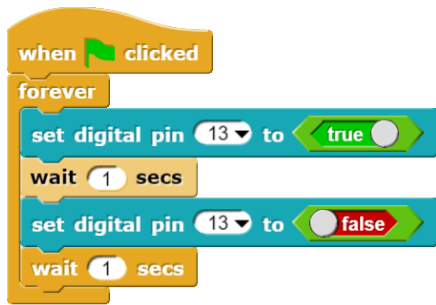
This block sets the selected digital pin (in this case 13) to the logical true value. You can toggle between the true and false values directly in the block. Normally a LED is connected to pin 13.



This is a script composed by 4 blocks: 2 blocks from the Arduino control palette and 2 blocks from the Control palette. The script turns on the led in digital pin 13, waits for 1 sec, turns the led off and waits for another 1 sec. In other words, this script blinks a LED connected to digital pin 13 on Arduino board.

Questions to raise in the class:

- *What will happen if we place this script in a forever loop?*
- *What will happen if we change the 1 sec of 3 sec?*



A continuous loop will have the LED flash endlessly; that is, until the user clicks on the red Stop icon at the top on the right in Snap4Arduino.

Questions to raise in the class:

- *Can you make the led flash slower?*
- *Can you make the led flash quicker?*

Level 1- Arduino IDE Code (optional)

Below you can see the programming solution in IDE programming environment. You can encourage your students to experiment with the blinking pattern by changing specific values.

```
//Constants
const int ledpin=13;

//Variables
int value;

//Set up
void setup(){
  pinMode(ledpin, OUTPUT);
  Serial.begin(9600);
}

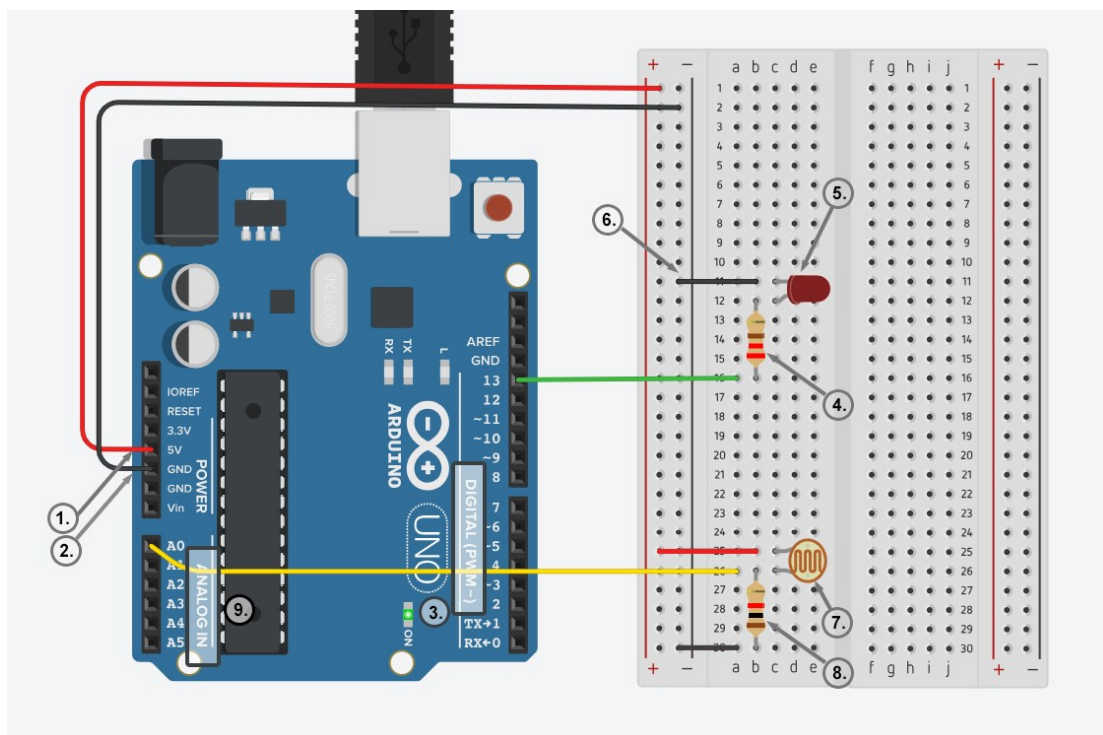
//Main loop
void loop(){
  digitalWrite(ledpin, HIGH); // Led is On
  delay(1000);
  digitalWrite(ledpin, LOW); //Led is Off
  delay(1000);
}
```

Level 2: The lighthouse blinks only at dark

Having practiced the simple and continuous blinking, you can encourage now your students to reflect upon the real functionality of the lighthouses, which is the blinking/flushing at dark. You can encourage your students to search information online about the lighthouses, the life of the lighthouse keepers and so on. You can raise simple questions to motivate their interest in the context of the project i.e. *In a lighthouse without a keeper how the flashing light is turned on when it is getting dark? How it is turned off in daylight?*

Level 2- Electrical circuit making

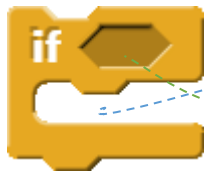
Apart from the components used for Level 1, students will also need a photoresistor and a 10 K Ω resistor. The following diagram indicates how the aforementioned components should be connected to the Arduino.



- Use 5V (1) and Ground/ GND (2) pins to respectively provide 5V power and ground to your breadboard
- Use one of the digital pins (3) (pin 13 in the example) to connect the anode of your LED (5) through the resistor (4).
- Connect the cathode of your LED to ground (6) in order to create a closed circuit.
- Connect one of photoresistor's (7) legs to power (5V), and the other to one of the analog pins (9) (pin A0 in the example), as well as to ground through the 10K Ω resistor (8).

Level 2- Block-based programming solution

Once again, the script is assembled by dragging blocks from a palette into the scripting area in the middle part of the window in Snap4Arduino. Blocks snap together when you drag a block so that its indentation is near the tab of the one above it. At this level, the students should be encouraged to implement the blinking functionality only at dark. A new C-block from the Control Palette will be needed: the if-block.

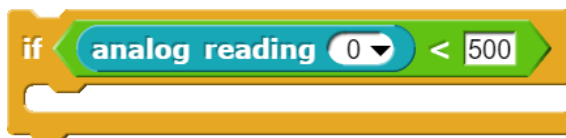


The C-shaped if block runs its input script if (and only if) the expression in its hexagonal input reports true.

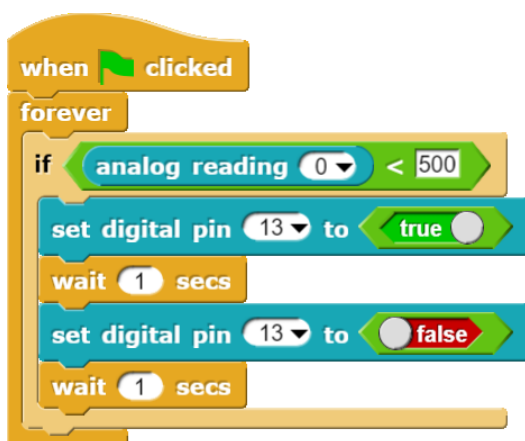
To fix the hexagonal input, we need to use blocks from the operators Palette and create predicates/conditions (based on our needs) that report a Boolean value¹.



This block can be used to create a condition/predicate that evaluates to true or false. Don't get confused; a hexagonal block is a predicate/condition, but the value it reports is a Boolean.



The C-shaped if block runs its input script if (and only if) the analog readings from A0 are lower than 500. In other words, any input script will be executed only at dark.



A continuous loop will have the LED flash endlessly only at dark (only if the photoresistor gives values below 500). The script will be activated when the green flag will be clicked.

Questions to raise in the class:

- *Can you make the led flash slower?*
- *Can you make the led flash quicker?*
- *How can you specify the threshold value for the analogue reading?*

¹ Boolean" value: it has a capital B because it's named after a person, George Boole, who developed the mathematical theory of Boolean values

Level 2- Arduino IDE Code (optional)

```
//Constants
const int photoresistor = A0;
const int ledpin=13;
const int light_level=500; //Environment Light Saturation Level

//Variables
int value;

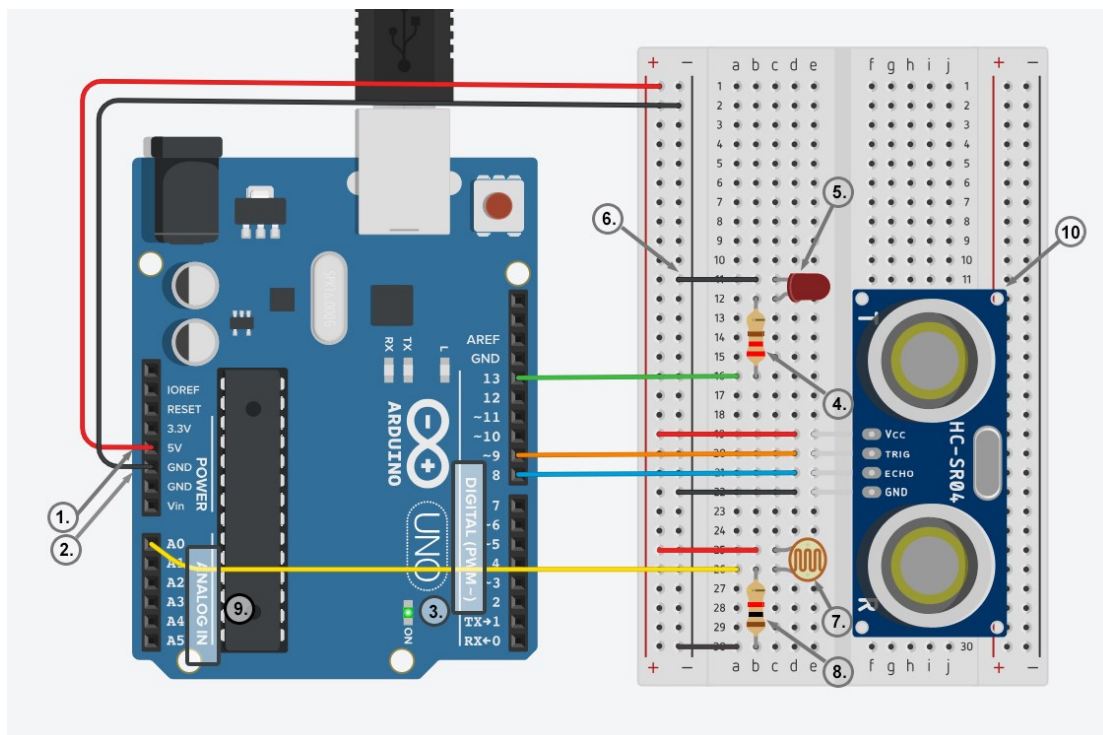
//Set up
void setup(){
  pinMode(ledpin, OUTPUT);
  pinMode(photoresistor, INPUT);
  Serial.begin(9600);
}

//Main loop
void loop(){
  value = analogRead(photoresistor);
  if (value <light_level) {
    digitalWrite(ledpin, HIGH); // Led is On
    delay(1000);
    digitalWrite(ledpin, LOW); //Led is Off
    delay(1000);
  }
  else{
    digitalWrite(ledpin, LOW); // Led is Off
  }
  Serial.print("Value: ");
  Serial.println(value);
  delay(1000); //Serial Monitor Print per 1sec...
}
```

Level 3: Make the led blink at different rates only at dark and according to the distance of the sailing ships

Level 3- Electrical circuit making

Apart from the components used for Level 1 and 2, students will also need an Ultrasonic sensor (HC-SR04). The following diagram indicates how the aforementioned components should be connected to the Arduino.

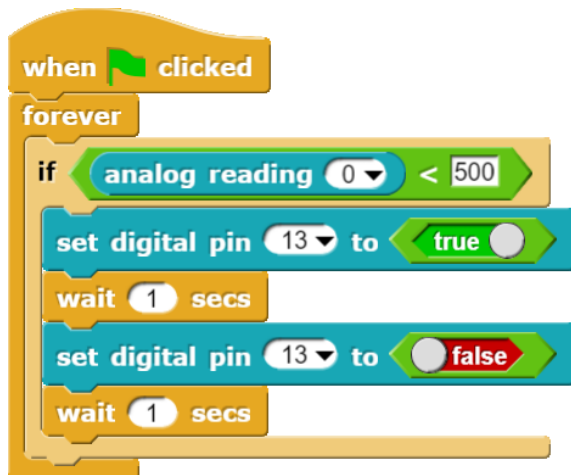
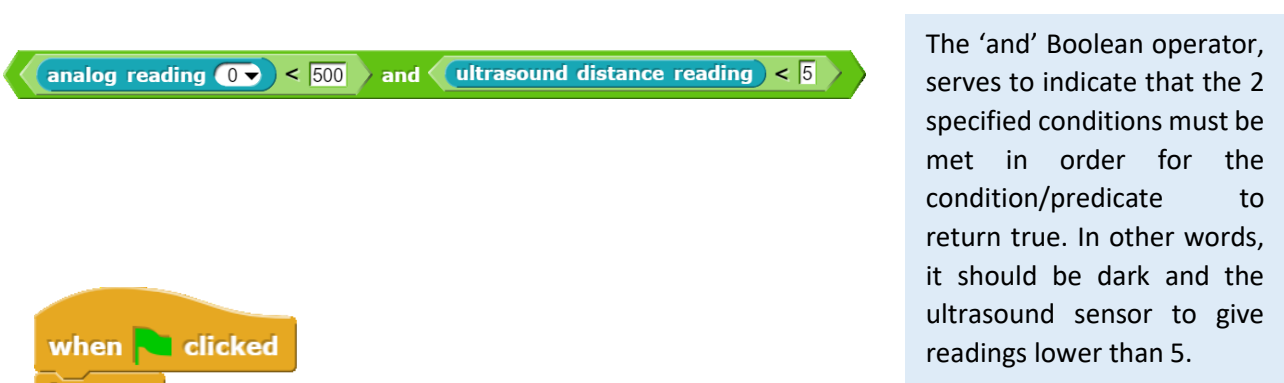
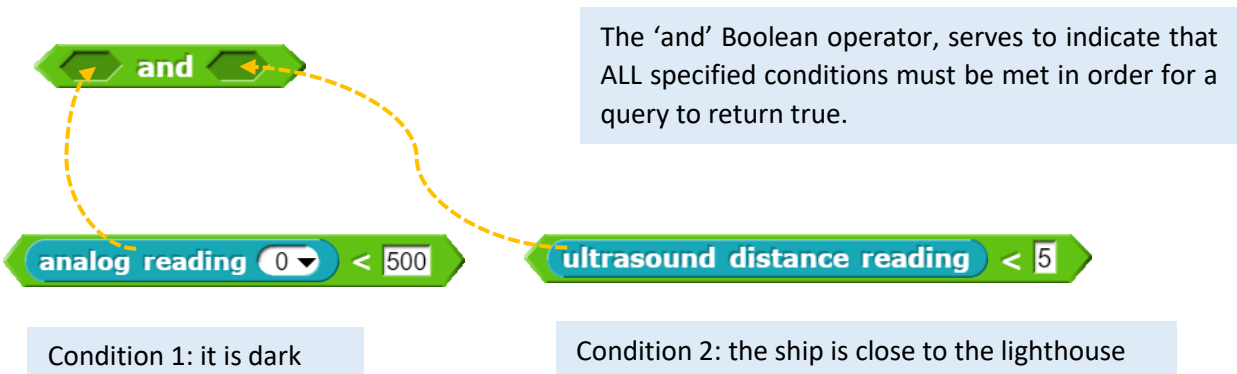


- Use 5V (1) and Ground/ GND (2) pins to respectively provide 5V power and ground to your breadboard
- Use one of the digital pins (3) (pin 13 in the example) to connect the anode of your LED (5) through the resistor (4).
- Connect the cathode of your LED to ground (6) in order to create a closed circuit.
- Connect one of photoresistor's (7) legs to power (5V), and the other to one of the analog pins (9) (pin A0 in the example), as well as to ground through the 10K Ω resistor (8).
- Ultrasonic sensor (10) has four legs. Connect Vcc leg to 5V power, GND leg to ground, while Trigger and Echo legs to digital pins 9 and 8 respectively.

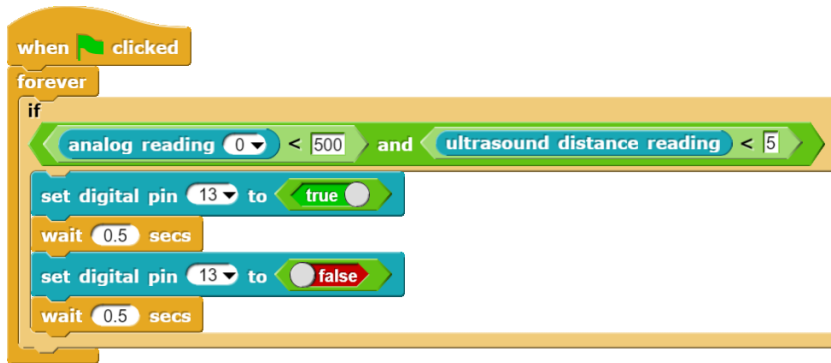
Level 3- Block-based programming solution

Once again, the script is assembled by dragging blocks from a palette into the scripting area in the middle part of the window in Snap4Arduino. Blocks snap together when you drag a block so that its indentation is near the tab of the one above it. At this level, the students should be encouraged to implement the blinking functionality only at dark but also to check a new condition: when a ship approaches the led flashes quicker. In other words, we need two scripts to run in parallel: one that ensures that the blinking takes place only dark and one that ensures that when it is dark and a ship approaches the blinking rate will be faster. Thereby, we insert two scripts in the script area that both activate when the green flag is clicked.

We will need a new block from the Operators Palette that will allow us to check whether the two conditions are met. This is the Boolean operator AND.



A continuous loop will have the LED flash endlessly only at dark (only if the photoresistor gives values below 500). (see also level 2). This script will run in parallel with the one below.



```
when clicked
  forever
    if
      analog reading 0 < 500 and ultrasound distance reading < 5
        set digital pin 13 to true
        wait 0.5 secs
        set digital pin 13 to false
        wait 0.5 secs
```

The image shows a Scratch script starting with a 'when clicked' event block. This is followed by a 'forever' loop block. Inside the loop is an 'if' block with two conditions: 'analog reading 0 < 500' and 'ultrasound distance reading < 5'. If both conditions are met, the script sets digital pin 13 to 'true', waits for 0.5 seconds, sets digital pin 13 to 'false', and waits for another 0.5 seconds before repeating the loop.

A continuous loop will have the LED flash endlessly at a faster rate than before only at dark and only when a ship is approaching the lighthouse. This script will run in parallel with the one above.

Level 4

To be completed

Technical tips

For more technical details and information about the selected technologies and tools please see O1 (TECHNICAL TUTORIAL: <http://www.roboscientists.eu/outputs/output-1/>).

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ROBOSCIENTISTS PROJECT

Motivating secondary school students towards STEM careers through robotic artefact making

Erasmus+ KA2 2018-1PL01-KA201-051129

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Declaration

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

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