The Sunflower project

Project description and guidelines for teachers

Contents

PART A: Pedagogical considerations

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 Sunflower project

In this line, this project revolves around the concept of phototropism: The orientation of plants according to the location of light. 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, involves 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. Investigation is a multi-disciplined field of study. It encompasses law, the sciences, communications, and a host of other things. Investigation 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 model 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. Creativity is the act of turning new and imaginative ideas into reality. 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. Creativity involves two processes: thinking, then producing.

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 modeling our behaviors 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, analyze, 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. Skills problem solving that is being developed is critical, creative, reflective and logical thinking, 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, time management and available resources, computation and risk-taking and dispute resolution.

Social and Interpersonal Skills: The proposed activities as well as the 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. Analyze 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.
- Design and conduct research, determining which variables will change, what will remain stable and what will be measured.
- Selection of appropriate tools, technological equipment and suitable materials for a construction.
- Presentation and interpretation of 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.
- Evaluation of ready-made technology products and suggestions for improvement.
- Presentation of a design and explanation of the use of the finished product.

The 3rd category: The Learning Objectives (Links to Subject Matters – Curriculum)

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 ICT, Art, Physics, Mathematics, Biology, Language and Linguistics:

- **ICT:** programming, connecting physical and digital world through the use and synchronization of multiple sensors
- **Physics:** electrical circuit making, understanding what a motor is and how it works, controlling motion

- **Biology**: the phenomenon of Phototropism
- **Environmental Education:** environmental factors that might cause a plant to move or face a different direction
- **Maths:** variables, analogue reading transformation, rotation degrees
- **Arts**: Van Gogh's sunflowers
- **Language and Linguistics:** analysis of a text related to the sunflower

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

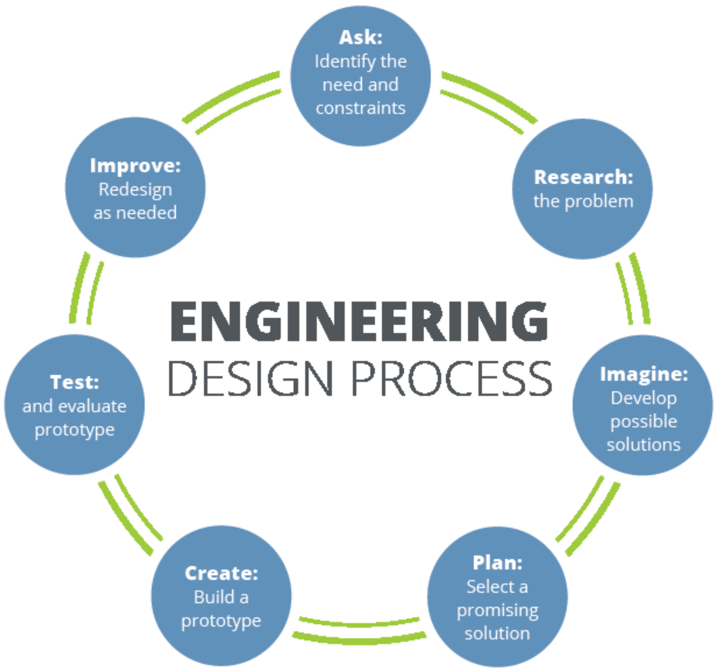


Diagram 2: The Engineering Design Process

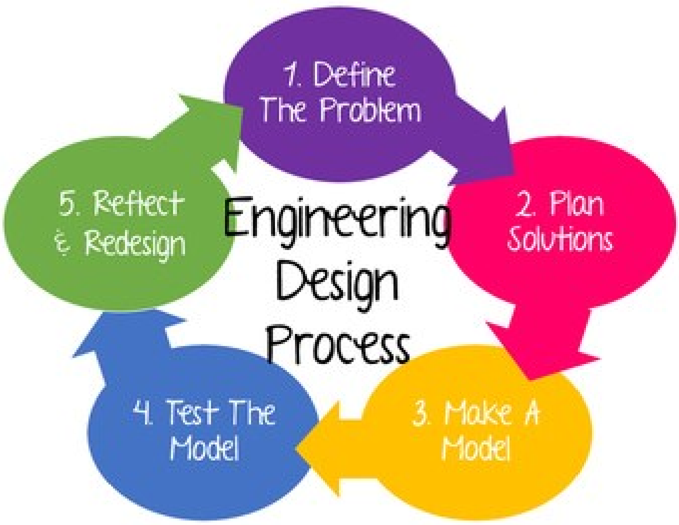
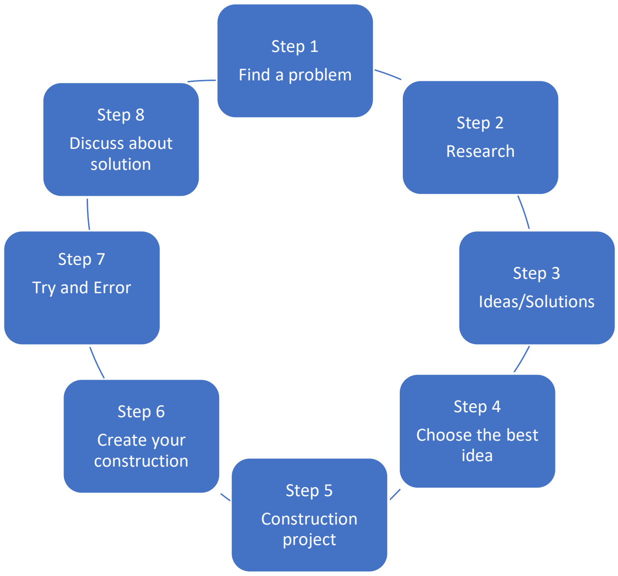


Diagram3: The Design process according the Design and Technology Curriculum (Cyprus Ministry of Education and Culture)

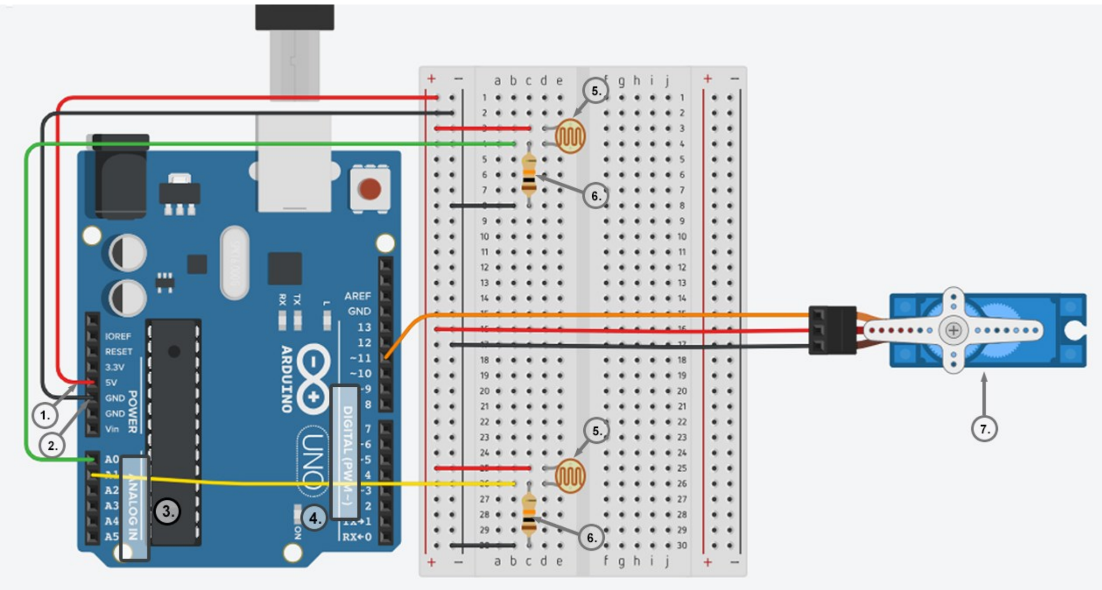


PART B: Practice

Level 1: The sunflower moves towards the direction of light

Creating the circuit

For the circuit of the Sunflower activity, students will need – apart from the breadboard and some jumpers – two photoresistors, two resistors of 10 KΩ and a servo motor. 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
- Connect one of photoresistor's (**5**) legs to power (5V), and the other to one of the analog pins (**3**) (pin A0 in the example), as well as to ground through the 10KΩ resistor (**6**). Repeat the same procedure for the second photoresistor.
- Connect the orange colored pin of the servo motor (**7**) to one of the digital pins (**4**) (digital pin 11 in the example), the red one to power (5V) and the brown one to ground.

Questions that can be raised/discussed:

- Why two photoresistors are needed?
- Can we safely remove the resistors?
- What is the range of values in which the motor operates?

Block-based programming solution

At this level, the students should be encouraged to breath some life into their construction by composing the relevant script.

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. The green ones are from the Operators Palette and the orange ones are from the Variables Palette.

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. Below you can see the blocks that will be used to compose the final solution.

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.

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

If it reports false, the else-input is executed.

Click on the Variables Palette and then here to make a variable

This block from the Variables* Palette sets the value of a specific variable (in this case: position) to 180 (subject to change).

This block from the Arduino Palette instructs the servo* to move to the value indicated by the variable position.

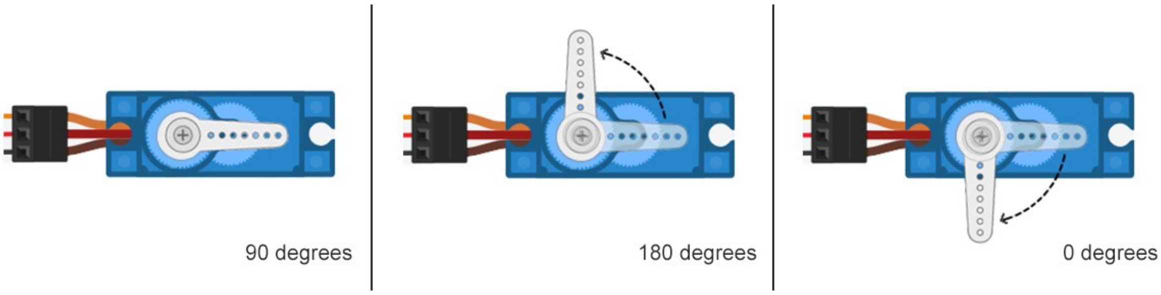
* Variable:

About variable: Variables are symbolic tags that are given to name and store values for later use by the program. These values are related to the content of our project. In simple words, we can imagine a variable as a box that contains a pre-defined value.

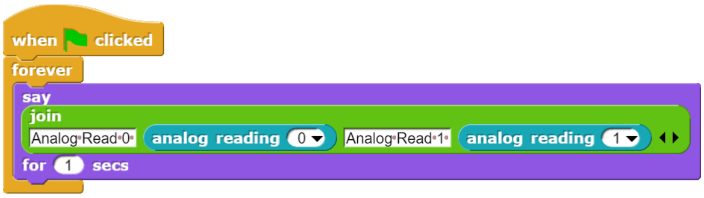
For the sunflower project we want to create a variable which contains values related to the positions that our flower can occupy. Therefore, for the needs of level 1 we will create the "position" variable and we will set two crucial value, namely 0 (0 degrees) and 180 (180 degrees).

* Servo motor:

A servo motor is a type of geared motor that can only rotate 180 degrees. The following diagram presents the way that servo rotates and the crucial positions that it can occupy, namely 0, 90 and 180 degrees.



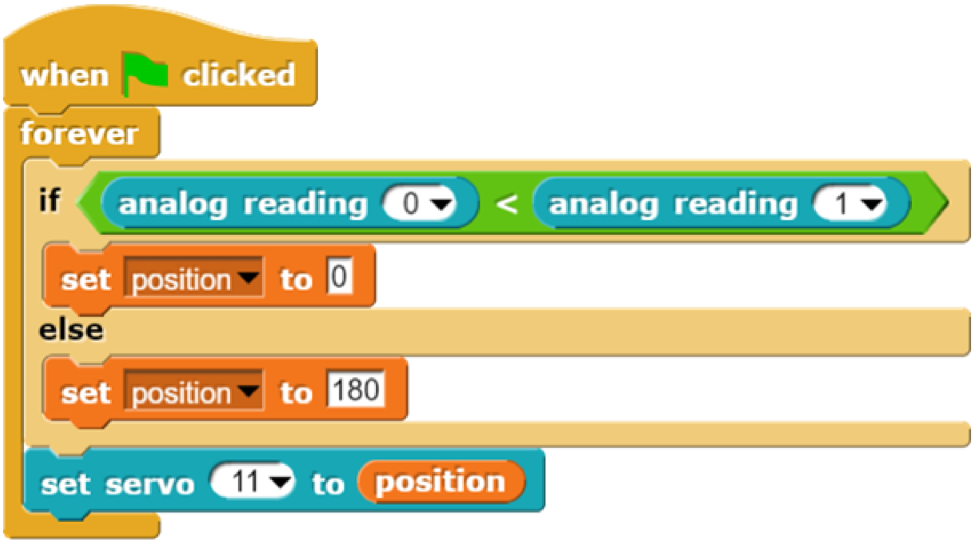
Observe your analog readings:



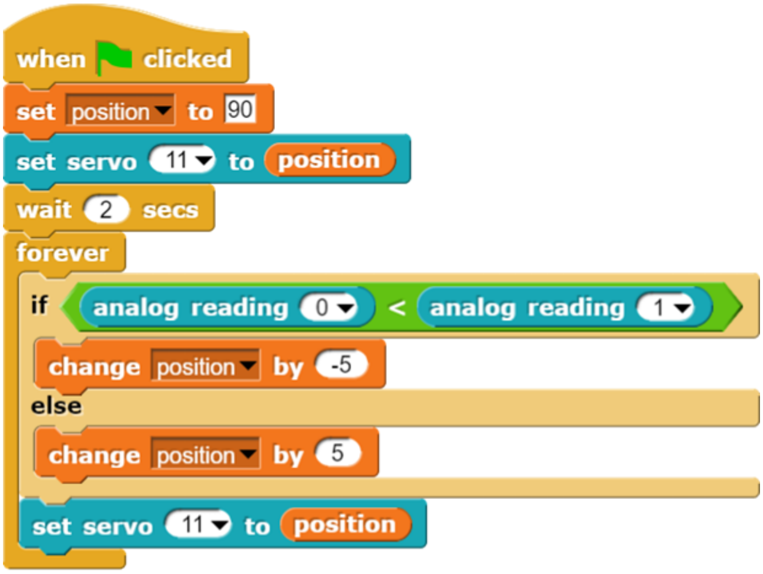
This block reports the values of the analog readings retrieved by the photoresistors and can run in parallel with the script above. It gives you a visual feedback of the brightest source and you can check whether your script works well.

Tip: You can introduce the project by starting with this script and encouraging the students to observe the analog readings retrieved by the photoresistors.

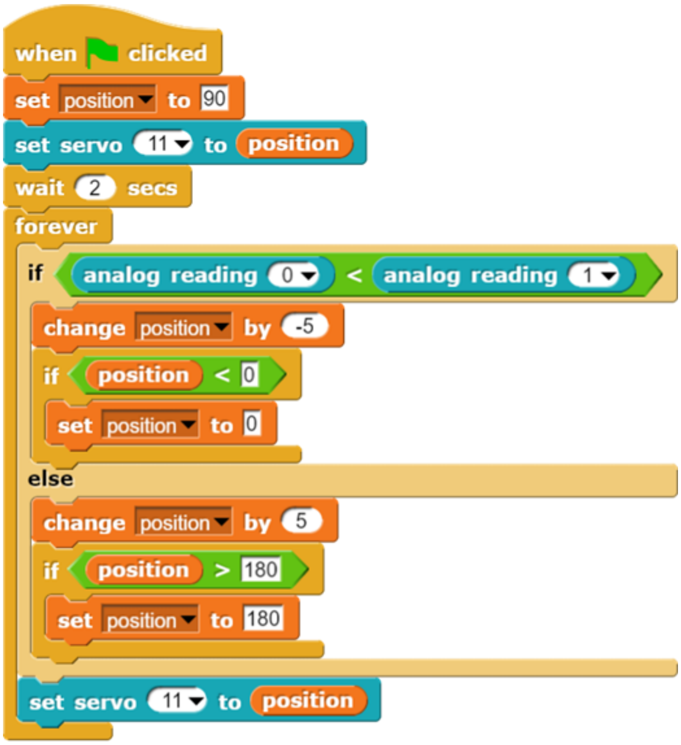
Three simple solutions to experiment with



Solution 1



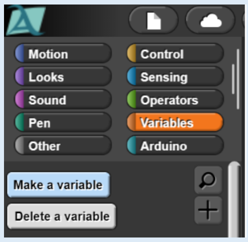
Solution 2



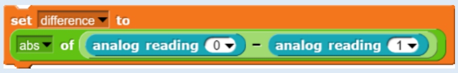
Solution 3

Towards a more optimal solution (optional)

This block comes from the Variables palette and sets the value of the variable ‘step’ to 5. You can create variables “by hand” that aren’t limited to being used within a single block. At the top of the Variables palette, click the “Make a variable” button:



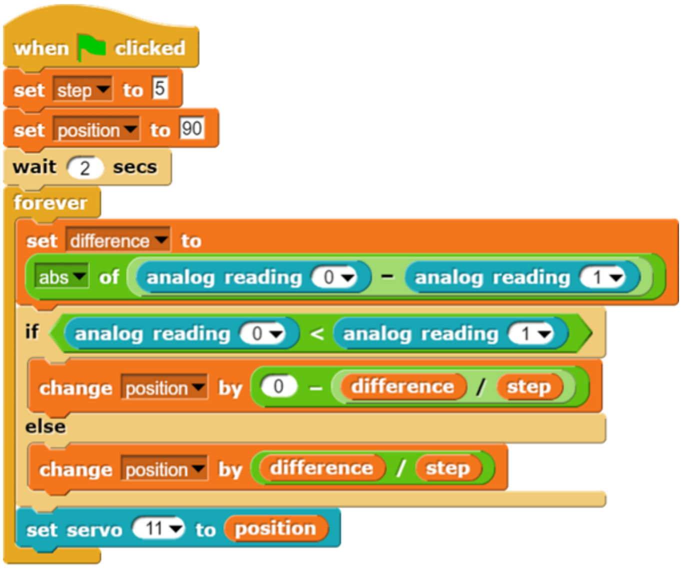
This is an operator that given the absolute value of a predefined operation (in this case the difference between analog readings 0 and 1, which are related to the 2 photoresistors). We can address this value to a new variable titled “difference” by using the “set block”



This block changes the value of the position by a certain value (which can be a digit number or the result of an operation). The value of the position ranges from 0 to 180.

This block from the Arduino Palette instructs the servo to move to the value indicated by the variable position.

Bringing everything together:



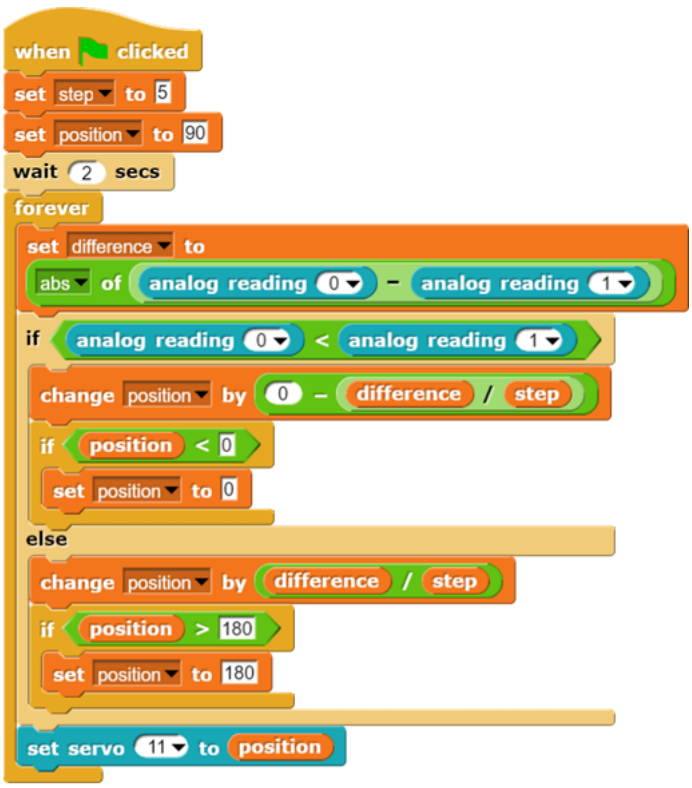
We create 3 variables (step, position, and difference). The step variable is set to 5. In the beginning the position of the sunflower is set to 90. The "difference" variable is set to the absolute value of the difference of the two analog readings provided by the photoresistors. Then we compare these two analog readings in order to instruct the sunflower to move towards the brightest source. The sunflower (attached to the motor) can move from 0 to 180. The operations

position+ (difference/step)

position- (difference/step)

ensure that the position that we will get is between 0 and 180. Once we have identified the value of the position, we instruct the servo to move correspondingly. The loop gets activated again and the servo moves to a new position based on the two new analog readings. And so on…

Introducing additional improvements:



We can also ensure that the position that we will get is between 0 and 180. Once we have identified the value of the position, we check if this value is bigger than 180 or smaller than 0 and we correct the value of position with 180 or 0, respectively.

Questions/ Additional experimentations

- *Imagine that analog reading 1 is 800 and the analog reading 0 is 400. What will be the position of the servo after the first loop?*
- *If we place first the resistor and then the photoresistor (we switch the current position) what kind of changes we should introduce in condition in the if-then-else script so that the script to give the desired result?*
- *Set different values to the variable "step". Which value works better?*

Arduino IDE Code with minimum and maximum position protection (optional)

```
#include <Servo.h>

int position;

int step = 0;

int difference = 0;

Servo servo_11;

void setup()
{
  pinMode(A0, INPUT);
  pinMode(A1, INPUT);
  servo_11.attach(11);

}

void loop()
{
  step = 5;
  position = 90;
  difference = abs((analogRead(A0) - analogRead(A1)));
  if (analogRead(A0) < analogRead(A1)) {
    position = (position + difference / step);
    if (position>180) { position=180;}
  } else {
    position = (position - difference / step);
    if (position<0) { position=0;}
  }
  servo_11.write(position);
  delay(10); // Delay a little bit to improve simulation performance
}
```

References

Ananiadou, K. & Claro, M. (2009), "21st Century Skills and Competences for New Millennium Learners in OECD Countries", *OECD Education Working Papers*, No. 41, OECD Publishing, Paris. DOI: http://dx.doi.org/10.1787/218525261154

Bybee, R. W., & Fuchs, B. (2006). Preparing the 21st century workforce: A new reform in science and technology education. J. Res. Sci. Teach., 43: 349–352. doi: 10.1002/tea.20147

Griffin, P., & Care, E. (Eds) (2105). Assessment and Teaching of 21st Century Skills, Methods and Approach. Dordrecht: Springer. DOI: 10.1007/978-94-017-9395-7

Mojica, K.D. (2010). *Ordered effects of technology education units on higher-order critical thinking skills of middle school students* (Doctoral dissertation). Retrieved from: ProQuest Dissertation and Theses database.

Rotherham, J. A., & Willingham, D. T. (2010). "21st-Century" Skills: Not New, but a Worthy Challenge. *American Educator*, 34 (1), p. 17-20.

Trilling, B., & Fadel, C. (2009). 21st Century Skills: Learning for Life in Our Times. San Francisco, CA: Jossey-Bass.

UNESCO. (2014). **'Teaching and Learning: Achieving quality for all'. Education for All Global Monitoring Report**, UNESCO, Paris (2014)

UNESCO (2016). A Global measure of digital and ICT literacy skills. Background paper prepared for the 2016 Global education monitoring report, Education for people and planet: creating sustainable futures for all, UNESCO, Paris (2016).

ROBOSCIENTISTS PROJECT

Motivating secondary school students towards STEM careers through robotic artefact making

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Declaration

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