TEACHERS TRAINING MANUAL

Project Intellectual Output 4

PROJECT TITLE

innovative educational ROBOtics strategies for PrImary School ExperienceS

PROJECT ID

2019-1-IT02-KA201-063073

LEADING ORGANIZATION

University of the Aegean

PARTICIPATING ORGANIZATIONS

Università Politecnica delle Marche, Italy
University of Latvia, Latvia
University College Dublin, Ireland
MRC St. Paul's Bay Primary, Malta
Istituto Comprensivo "G.Solari", Italy
Osnovna skola Titusa Brezovackog, Croatia

Website: robopisces.eu
Contact: info@robopisces.eu

Co-funded by the Erasmus+ Programme of the European Union

RoboPisces OER are available on the RoboPisces MOOC and can be accessed by following the instructions found [HERE]

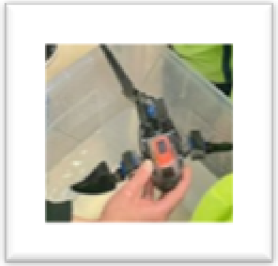
Table of Contents

Overview of Sections

Section 1: Theory and Tools for Educational Robotics, Distributed Control and Marine Robotics

Section 1 includes two Chapters: one with tips and tricks for teachers and one on the fundamentals of robotics, IoT and marine concepts.

Section 2: Design of Excellent Educational Robotics Courses with Open Education Resources



Section 2 includes the training material of the corresponding course and a set of policy recommendations.

ANNEXES

Annex 1: Innovative ways of teaching Educational Robotics STEAM in Primary Schools

Annex 2: Customize the RoboFISH toolkit 3D printers

Annex 3: Glossary of Technical Terms

Section 1
Chapter 1: Tips and Tricks for Teachers

The structure of the module plan:

1 module per topic

A module can include up to 5 lessons

Each lesson has the same structure

1. Warming up	5 min
2. Introduction	10 min
3. Robotics activity 1	20 min
4. Mid-activity check	10-15 min
5. Robotics activity 2	20 min
6. Discussion	10 min
7. Quiz	5-10 min

1. Warming Up

What?

- Interesting activity
- Connects prior knowledge with a new topic
- Catches the attention of students

How?

- The interesting activity should be connected with the topic we intend to teach during the particular lesson
- Students can follow the topic if they have some previous knowledge connected with the topic you are talking about, and it means that there shouldn't be much new information
- There should be only one interesting fact/object as the development of the attention span of primary school students should be supported gradually

2. Introduction

What?

- Basic information about new topic
- Learning objectives to be reached
- Basic terms
- Rules for classroom behaviour

How?

- The basic information about the topic should be very short and clear. If there are new terms, which students do not know yet, then teacher should explain the meaning of the term and explain in detail what is the role of this term and why it is important, but we should be aware about student's cognitive load capacity. If there is no previous knowledge about the topic, teachers have to remember that students need to process this information and it takes particular amount of cognitive load. To support the development of new knowledge students, need to develop schema in their brain. It can be supported with visual or audial information. The additional information shouldn't cause more cognitive load. For example, much additional text, a lot of tiny details, a lot of changing pictures etc. can cause extra cognitive load which prevents student's ability to process new information and develop new knowledge.
- The teacher explains the objectives of the lesson and explains how it is connected with the knowledge students already have. It should be explained where students can use such knowledge to let them understand why they have to learn something new.
- The teacher has to explain classroom rules. How to work with robotics sets, how to work in groups, how to ask questions. Sometimes teachers assume that students must know that, but at the beginning of new lessons (for example, robotics), students are not aware about tiny details, that at the end of lesson they have to put them back in boxes, that the details can't be taken home etc. Later on, when it is a routine then students will know the rules. But there can't be too many rules at one moment because it can cause cognitive load.

3. Robotics activity (Part I)

What?

- There are enough kits
- 1 main activity
- Everyone is focused on tasks
- 3-5 sub-activities
- The task is clearly defined
- Students know where to look for additional information

How?

- The teacher makes sure that the attention of students is gained. In most cases students are interested in robotics but some students may be scared of new information. It is the task of the teacher to ensure that all students are focused.
- The teacher makes sure that everyone is focused on the task and if not, teacher gives extra explanation about new information to let students integrate the new knowledge in the schema of the previous knowledge. Such explanation will ensure that the cognitive load of students is balanced. Otherwise, students will not be able to follow the topic because of extra cognitive load and it can lead to avoidance motivation.
- The teacher makes sure that there are enough kits to organize the work. If there are a number of kits that is lower than the number of students present in the class, then teacher divides students into groups. The division in can be done by random principle but it is advisable that teacher organizes some activity to divide students – for example, students make the line according to the date of birth and then teacher divides them in the groups or there are pictures cut in the pieces (for example 5 pictures are cut), each student gets one random piece and they have to find other pieces of the pictures. Once they have found their picture, the group is formed. It is necessary to ensure that students are not grouping by themselves to avoid the situation when some students are left aside because they are not popular among the classmates.
- When students have to work in groups on the activity, the teacher has to make sure that everyone is involved because sometimes there are active leaders who wish to do everything by themselves not letting others to do anything. It can be solved in a way where teacher divides the roles in the group and the roles have to be changed from time to time.

4. Mid-activity Check

What?

- Teacher checks the status of tasks
- Teacher gives supporting information if needed
- Discussions with students about mistakes

How?

- After 15-20 minutes of work teacher has to check the situation with the progress of task and has to be sure that everyone is involved. Sometimes it could happen that students are stuck in the task, and they do not know the way how to solve the situation. Teacher should give some hints where the additional information can be found.
- Sometimes the roles in the group are divided in a way when one or two students are involved in programming, but others should do some creative activities, for example build the parking space, or develop the design for the robotics solution. Although these are activities which are important for the development of the robot, those students will not gain particular knowledge about programming, about sensors, actuators etc. Teacher should ensure that roles are changed from time to time.
- It is suggested that the mistakes are discussed openly to let students learn not only from their mistakes but also from the mistakes of other students. When evaluating the students' work the way how they search for information to solve the mistake can be one of the most important criterions to evaluate their motivation.

5. Robotics activity (Part II)

What?

- There are enough details for the extended task
- 1 main activity
- 3-5 sub-activities
- Everyone is involved in activities
- Students know where to look for the additional information
- The extension of task is given based on previous knowledge
- Students put all the materials in designated place

How?

- After the mid-evaluation of the progress, there can be given extra assignments to let students extend their knowledge or to ensure that the knowledge gained in the previous steps of the activity is used in the different context.
- If there are extra assignments given and extra details are needed teacher ensures that there are enough details available. If there is not enough the same kind of details available, then there can be assigned different tasks for each group.
- The teacher has to be aware about the situation where students do not understand particular concepts and if this information is too much for them, they lose the interest and can develop avoidance motivation or vice versa students have learnt something very well and if no new challenges are given for their cognitive load, then they can get bored. It is up to the teacher to carefully monitor the processes and if necessary additional help is provided or new challenging tasks are given.
- The teacher must follow that at the end of the activity students put all the details in designated places, robotics block, tablets are connected to charger. These rules should be explained at the beginning of the activity and reminded at the end of the activity and teacher keeps an eye on the process.

6. Discussion

What?

- About the new knowledge learned
- About the mistakes and solutions found
- About the difficulties faced

How?

- At the beginning of robotics activities, the teacher should explain the culture of discussions. Later on, when it is a routine procedure, it shouldn’t be reminded unless there are some problems occurring.
- The discussion should be led by the teacher by asking particular questions. Teacher should ensure that each student/each group has the possibility to tell others what happened, what kind of mistakes or problems they faced and how these problems were solved.
- Sometimes it could happen that there are very talkative children who would like to talk every time they have such a possibility. In such a case the teacher allows them to talk but follows the strict timeline to keep them focused.
- In cases there are introverted students, the teacher shouldn’t insist that they speak in the front of the class. Such students can be encouraged but they can’t be forced. Introvert students can learn everything very well, but they are getting stressed if they have to present something. Sometimes it can be fake signals – like they can be seen as lazy, not interested, or even shameless because they will reject the teacher’s invitation to speak.

7. Quiz

What?

- Some simple questions (1-2)
- Some questions about the new knowledge learned
- 1-2 open questions (not mandatory)

How?

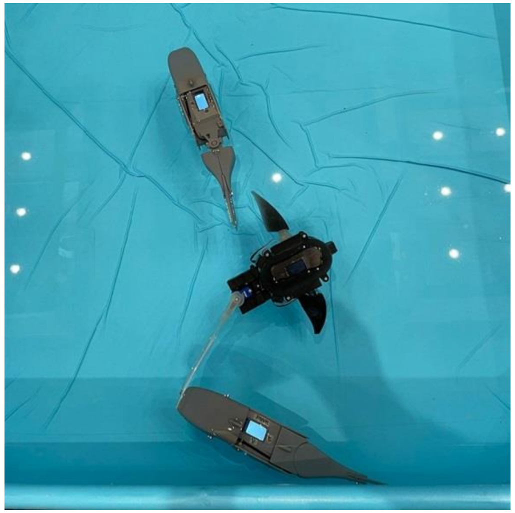
- It is advisable that after each activity students have a short quiz which consists of 5-8 questions.
- 1-2 questions should be very simple to give the opportunity for all students to answer them correctly. It is needed to let them keep motivated because sometimes new knowledge is not very well acquired yet and if there are only questions about the new knowledge students can feel distracted, they can feel stressed and they can feel that haven't learnt anything. Those simple questions will help to avoid such situations.
- There should be 2-4 questions about the new information students learnt during the activity. It will help them recall the information recently learned and used from their memory and it supports that this knowledge will be stored in a long-term memory. Such questions are also serving as the motivator because not all the students have well developed intrinsic motivation.
- At the starting period of new activities there should be smaller number of questions about the new information but later the number of questions can be increased but it is advisable not ask more than 8 questions here.
- There can be 1-2 opened questions where students can freely express their feelings, their thoughts about the activity. Sometimes these spaces will be left blank, but such an option can help students who are too shy, or introverts express their opinion.

If you want to study what else you should think about before starting the RoboPisces Curriculum with your pupils visit the following link:
https://tinyurl.com/Tips4Teacher

Chapter 2: Fundamentals of Robotics, IoT and Marine Concepts

What is Robotics?

By general agreement a robot is a (re)programmable machine that imitates the actions and/or appearance of a natural organism, being it a plant, a human being or an animal.
Robotics is the branch of engineering that studies and develops robots.



Which is the main difference between a robot and a machine?

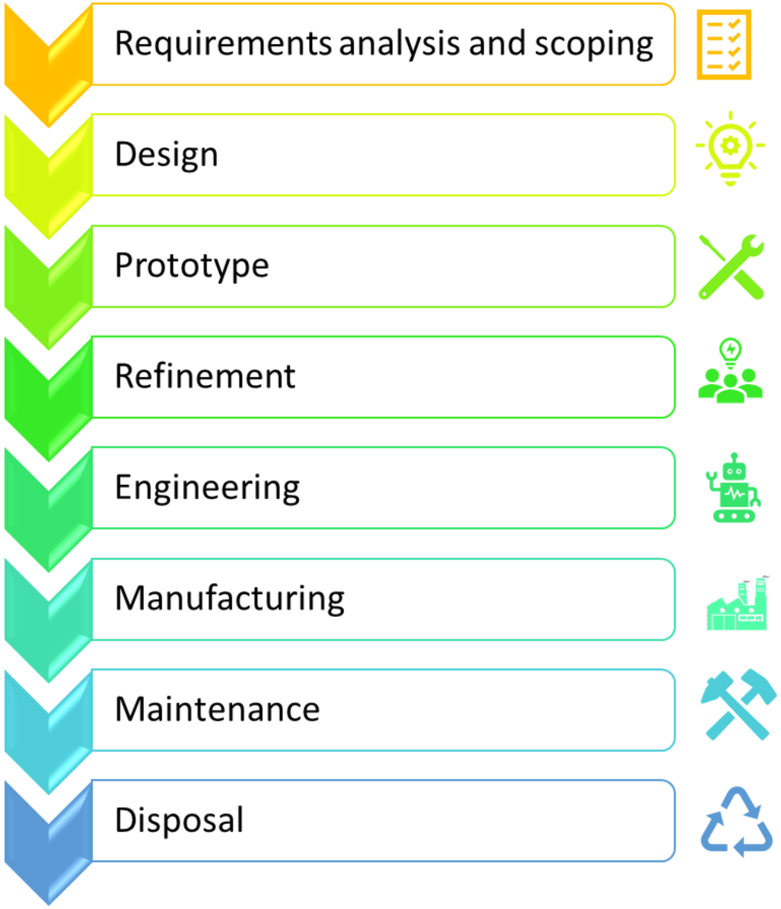
All robots are machines but not all machines are robots. A robot is a self-governing machine, it is capable of making decisions without an external input or trigger. This feature is called autonomy.
Machines need to be operated by humans; they cannot make decisions. An example of machine is the vacuum cleaner we have to operate to make it clean the floor. An example of robot is the autonomous vacuum cleaner that autonomously decide to hoover the floor, which path to follow, how to avoid obstacles and where to insist to remove the dust.

Which disciplines help us understand Robotics?

To build a robot several experts from different disciplines work together. Historically, robots were developed by engineers with different background: mechanical engineers developed the mechanical structure of the robots, Electronic engineers developed the electronic circuits that are needed to power up and to move the robot, Control system engineers developed the strategies to control the robot, to define the path the robot have to follow, computer scientist developed the software of the robot, namely a way for the engineers to tell the robot what to do and how to behave.

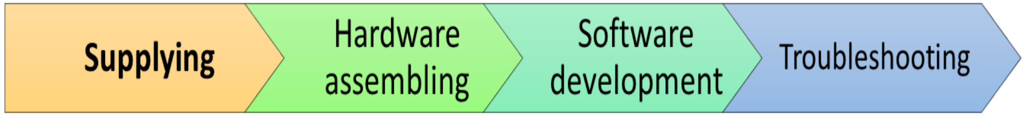
Image 1. ANcybernetics (09/07/2022). Guizzo_Xs and Guizzo together [Photograph]. Rhodes. University of the Aegean

What is the product development cycle?



Which are the jobs in the robotics sector?

Cooperation is the key! If you want to develop a prototype of a robot, you need to design your robot, look for the materials you need to realise it, assemble the hardware, programming the robot's brain to accomplish some tasks and put the prototype to test to see if it works or if it behaves like it should. Eventually, you may find it is not working as expected, so you need to observe and troubleshoot issues. Each phase of this process needs a professional worker.



The warehouse worker is responsible for the management of the robotic kit, both supplying materials at the beginning of the activity and by storing them safely.

The technical assembler will be responsible for assembling materials.

The software designer is responsible for the interactions with the device (tablet or PC) to develop software.

The technical validator is responsible for the troubleshooting and validation of the prototype solution.

Meet the RoboFISH Toolkit!

The RoboPisces project developed a whole robotic toolkit to support the many activities proposed by the RoboPisces curriculum. It comprehends a basic toolkit and an advanced toolkit.

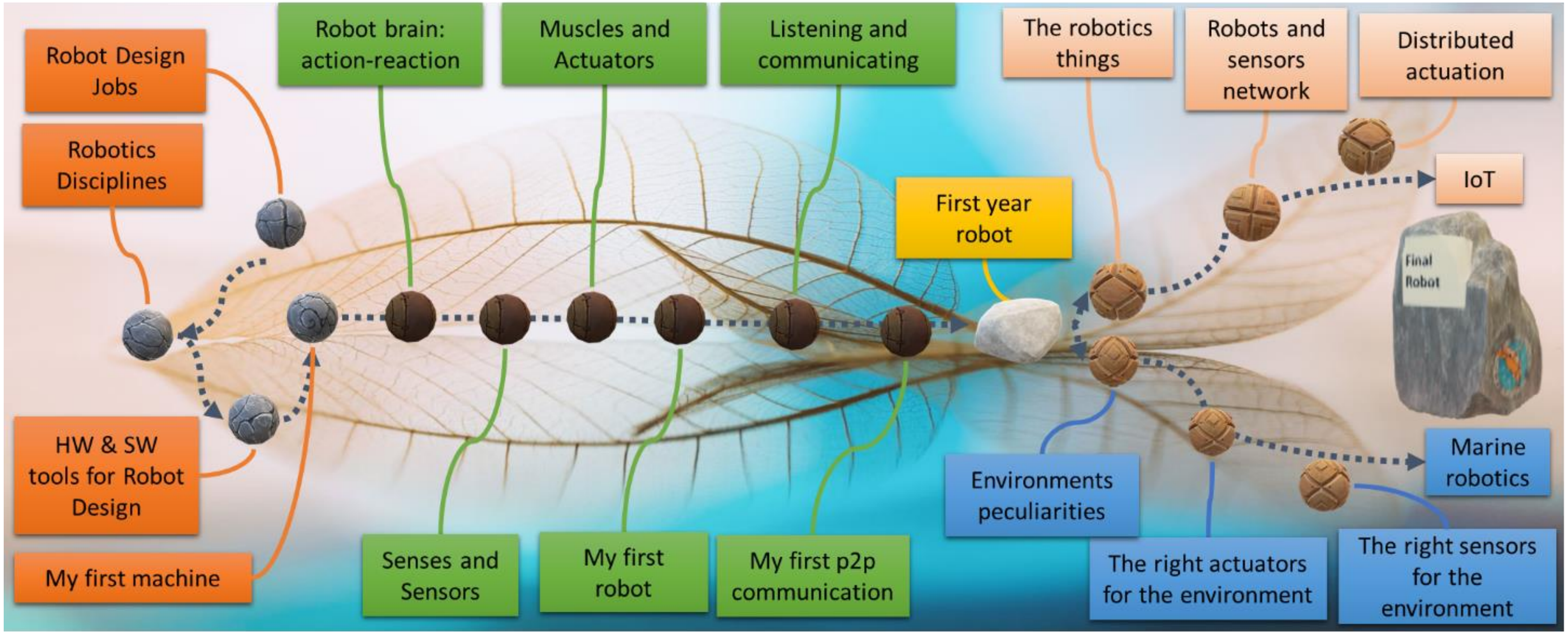


Figure 1. UNIVPM. (2019). The RoboFish Curriculum

What is a sensor?

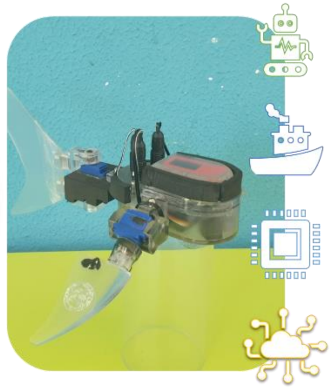
A sensor is a device which detects or measures a physical property of the environment, like for example the temperature, the colours, or the proximity to an object. The RoboPisces toolkit has many sensors that students can use to explore the environment, to empower the robot or to reflect about ourselves through the discovery of the robot's senses.

What is an actuator?

An actuator is a component of a machine that is responsible for its operations, for its movements and for controlling a mechanism or system. For example, motors are actuators. Can you think about more examples?

How can robots communicate?

Humans developed many ways to communicate with each other. This richness in mirrored also in the way robots interacts with each other. The RoboPisces curriculum exploit the communication capabilities of the RoboPisces toolkit to teach the way two robots communicate over a network.



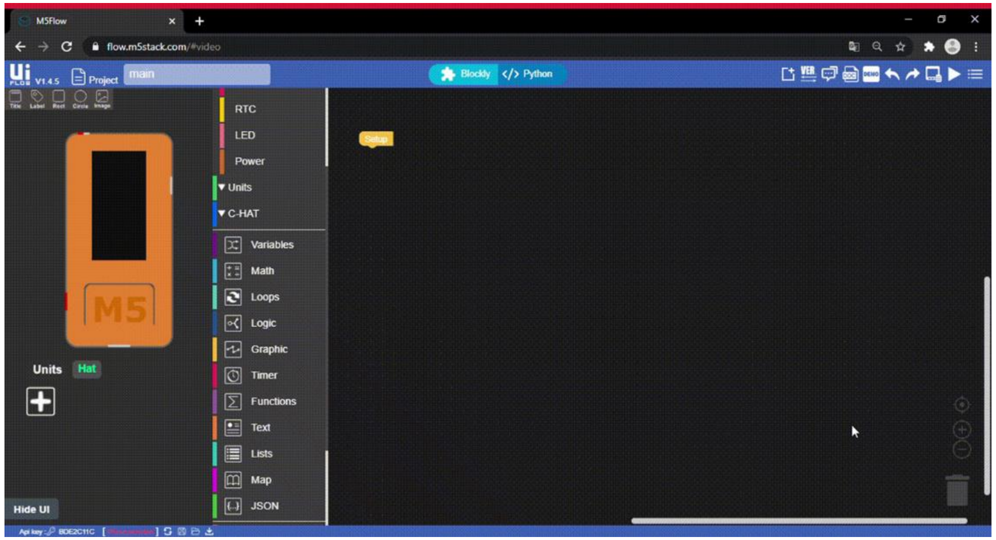


Figure 2. UNIVPM. (2022). The Advanced RoboFish Toolkit

What is IoT?

The Internet of Things (IoT) is a term that describes the network of physical objects, the "things" or "robotic things", that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. Thanks to the communication capabilities of the RoboPisces toolkit students can explore the basic concepts of the IoT and also learn how to use technology to realize real scientific experiments to heal the planet or to use them to express technological artworks.

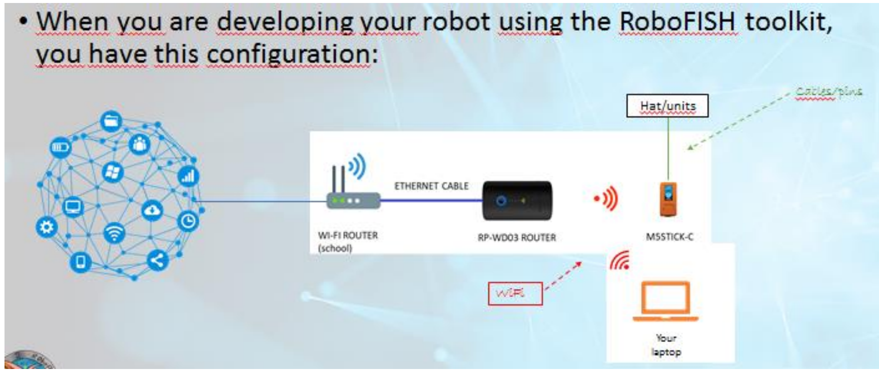


Figure 3. UNIVPM. (2022). Configuration of the RoboFish Toolkit

What is Marine Robotics?

About 71% of the Earth's surface is covered in water. The oceans represent about the 96% percent of all the Earth's water and is a fundamental part of our ecosystem. Despite its size and impact on the lives of every organism on Earth, the ocean remains a mostly unknown. More than 80% of the ocean has never been mapped, explored, or even seen by humans. Marine Robotics helps humans to explore, map, and see the ocean. Among the core concepts of marine robotics there are: buoyancy, thrust, and the Archimedes' principle. Studying marine robotics you can build interesting activities about the differences between the Earth's environments, the different way animals use to move or to sense the environment, about environmental sustainability and much more.

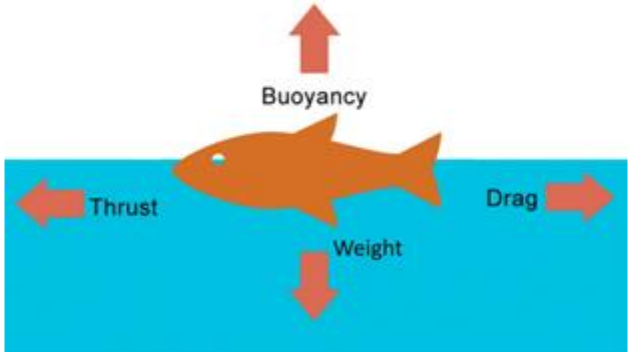


Figure 4. UNIVPM. (2022). Sensing the underwater environment

Section 2

Chapter 1: Open Educational Resources

The concept of open education encapsulates a simple but powerful idea that the world's knowledge is a public good and that the open web provides an extraordinary opportunity for everyone to share, use, and reuse knowledge. In short, the "open" in Open Educational Resources means they must be free and provide the permissions to reuse, revise, remix and redistribute. However, we need to examine the concept in more detail.

Definition by UNESCO (2021):

> *"Open Educational Resources (OER) are teaching, learning and research materials in any medium – digital or otherwise – that reside in the public domain or have been released under an open license that permits no-cost access, use, adaptation and redistribution by others with no or limited restrictions.*
> *OER form part of 'Open Solutions', alongside Free and Open-Source software (FOSS), Open Access (OA), Open Data (OD) and crowdsourcing platforms."*

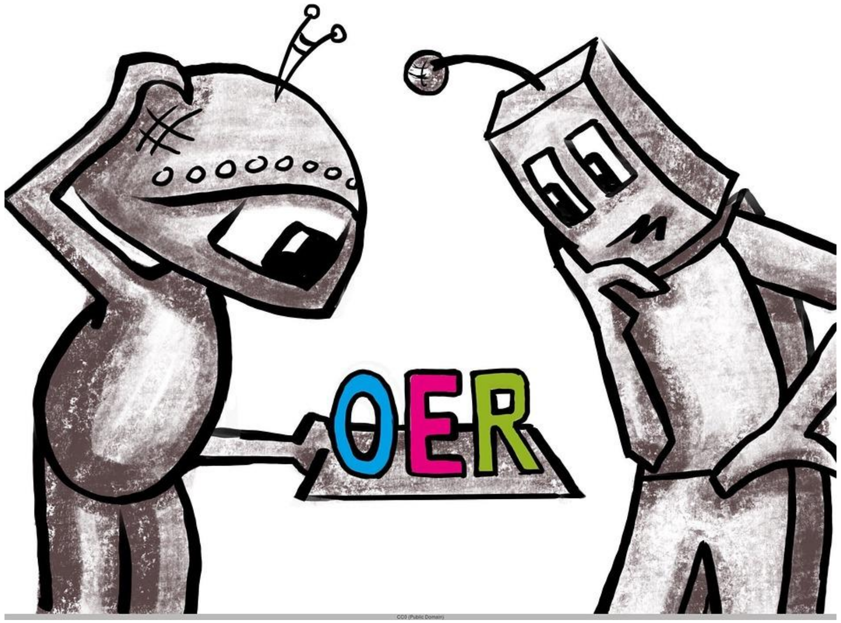


Figure 5: Creator: MaxPixel's contributors. Credit: https://www.maxpixel.net/photo-3263267. Copyright: Copyright by MaxPixel

Erasmus+ Open Access Requirement for educational materials

Erasmus+ promotes the open access of project outputs to support learning, teaching, training, and youth work. In particular, Erasmus+ beneficiaries are committed to make any educational resources and tools which are produced in the context of projects supported by the Programme – documents, media, software or other materials freely available for the public under an open license. The materials should be easily accessible and retrievable without cost or limitations, and the open license must allow the public to use, reuse, adapt and share the resource. Such materials are known as 'Open Educational Resources' (OER). To achieve this aim, the resources should be uploaded in an editable digital form, on a suitable and openly accessible platform. While Erasmus+ encourages beneficiaries to apply the most open licenses,7 beneficiaries may choose licenses that impose some limitations, e.g., restrict commercial use by others, or commit others to apply the same license on derivative works, if this is appropriate to the nature of the project and to the type of material, and if it still allows the public to use, reuse, adapt and share the resource. The open access requirement is obligatory and is without prejudice to the intellectual property rights of the grant beneficiaries. (European Commission, 2021, p. 14).

To cut the long story short

All RoboPisces educational materials are under

Creative Common License,

Attribution-NonCommercial-ShareAlike 4.0 International (CC BY-NC-SA 4.0)

Figure 5: Creative Commons>Licenses, Retrieved from https://creativecommons.org/licenses/by-nc-sa/4.0/

which means that any interested individual of organisation is free to:

Share — copy and redistribute the material in any medium or format

Adapt — remix, transform, and build upon the material

The licensor cannot revoke these freedoms as long as you follow the license terms.

Under the following terms:

Attribution — You must give appropriate credit, provide a link to the license, and indicate if changes were made. You may do so in any reasonable manner, but not in any way that suggests the licensor endorses you or your use.

NonCommercial — You may not use the material for commercial purposes.

ShareAlike — If you remix, transform, or build upon the material, you must distribute your contributions under the same license as the original.

No additional restrictions — You may not apply legal terms or technological measures that legally restrict others from doing anything the license permits.

Notices: You do not have to comply with the license for elements of the material in the public domain or where your use is permitted by an applicable exception or limitation.

No warranties are given. The license may not give you all of the permissions necessary for your intended use. For example, other rights such as publicity, privacy, or moral rights may limit how you use the material.

If you want to delve deeper into how to design excellent educational robotics courses with Open Educational Resources, we suggest you study the full Section 2 which can be found at:
https://tinyurl.com/RP-OERs

The Chapter on the 'SMART approach'—the necessary pedagogical knowledge to support Technology Enhanced Learning—developed by the University of Latvia is also included in Section 2.
If you are interested in the Policy Recommendations developed by the partners you can find them at:
https://tinyurl.com/RoboPiscesPolicyRec

Croatia

Osnovna skola Titusa Brezovackog

Pupil Voice Quotes

The students participated very positively and motivated in the project; they were happy to gain robotics knowledge. They were particularly looking forward to working with RoboFish. The programming was mostly well received by the students, and some of them showed a strong interest in it. They competed on who could be better and faster at giving answers. Most students said they enjoyed the programme and activities. They would also like to program and work with robots even more.

"It would be great if my mom also had a robot that would tell her if her plants needed water."

"It's great when you make a fish move in the water!"

"The little walking robot reminds me of an insect and it is funny."

"We worked well together. Everyone gave their ideas. We always accepted them. Sometimes in our work we realized that we had to take a different path."

"We really liked the activities. It was interesting to learn about the distribution of occupations related to robots, assemble a prototype vehicle, solve a quiz, and present."

"We loved programming."

"I liked that we all worked together and. that we collaborated with friends."

"I like Robofish and M5 Stick programming."

"... each time we had certain topics and talked about them ... we learned to distinguish a machine from a robot."

"I especially liked the project day, all the experiments and the fish."

Croatia

Osnovna skola Titusa Brezovackog

Teacher Voice Quotes

"The students showed interest, will and interest in the work even though the conditions were not ideal, and some parts of the project were hard for them."

"At first, I was worried that I would teach the students something I didn't know very well, but with the help of the given materials and the support of my colleagues, I managed to master everything."

"I'm glad I had the opportunity to program the robot fish especially for the reason that I tried programming for the first time."

"We explored the conditions in the water using robot fish, the students worked in a team, and we all enjoyed the joint projects together because they now had the opportunity to do the measurements in a way that was more interesting to them with the help of technology."

"Environmental topics are what I want to do with my students, and the project has made it possible for me in a new and interesting way."

"Several students excelled in programming. Although they may not be interested in the broader context of using fish robots, they were excellent technical support and demonstrated technical problem-solving skills, which was very important for the team's work."

"I had to consult the teachers of physics, chemistry and biology of our school to bring some of the concepts closer to the students. So, together with the students, I did the experiments that my colleagues suggested to me. It proved to be a successful experience for both the students and me as a teacher."

GREECE

UNIVERSITY OF THE AEGEAN

Pupil Voice Quotes

Students expressed a strong desire to learn about STEAM activities and ROBOPISCES. This enthusiasm was evident throughout the project and did not diminish, despite the universal problems that held back face-to-face teaching during the first year.

The children were eager to receive the Advanced Kit in the first year and because of the pandemic and the fact that we stuck to the theoretical part during the distance learning, they couldn't stop asking when they would receive the fish!

"It is very easy to program with Blocks."

"Our fish is bated! We'll call it "The Lame-Mario"

"The best moment of the whole program was when I saw our fish in the water!"

"Our teacher was very insistent on the connection between robotics and physics and that made it a bit difficult for me, but in the end it was all good!."

"The best part was the Kahoots and I came out first in the class and I was so happy!"

"We loved programming."

"I had never been involved in robotics and I thought it was difficult and I wouldn't succeed... Finally, with the help of my team, I did it and programmed Marion to swim ahead and then sleep."

"I can't wait to find out what the children in other countries have achieved!"

ITALY

ISTITUTO COMPRENSIVO "G.SOLARI"

Insights from the school-based implementation in Italy

Project Engagement

Initially, teachers were trained to familiarise themselves with every detail of the project (mission, procedures, objectives, etc.). Then the students were actively involved in the project. Throughout the first year, the class worked during school hours for 1 hour per week. During this period, however, some problems related to the Covid pandemic arose (no devices were available, students were at home ...). Therefore, in May and June we decided to organize after-school classes to work in small groups of 10-15 students. In the second year, new classes started working on the project. In this case, students had one lesson a week and some extra lessons in the afternoon to work in small groups. In the secondary school, students also worked in the afternoon in small groups.

Course and Delivery Model

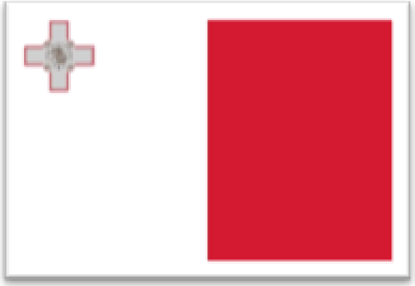
During the first year, all the topics in the fish curriculum were addressed, although we did not strictly follow the suggested order, as students found some topics easier than others. The children worked with the M5stick and used activators.

Most of the pupils who participated in the project in year one were in their final year of primary school, so we decided to revisit the first 10 topics with new pupils at the beginning of year two before moving on to more advanced topics. The whole curriculum was designed by teachers involved in the programme.

Driving and Restraining Forces

The enthusiasm of the students suggests that the project had a very good impact on the ICT curriculum.

They expressed their interest also on the internationality of the project and used more English than before to project started, in particular to program and to know things about the school and University involved in the RoboPisces. The project is an excellent way to innovate Robotics learning in Primary school. The whole fish curriculum can be used as a coding club for Primary and secondary schools.



MALTA

MRC St. Paul's Bay Primary

Insights from the school-based implementation in Malta

Impact

On Students

Students were motivated, gained more general knowledge and practical skills.

On School Community

The school community was curious about this project and was eager to know more about it.

On School Leaders and Teachers

School Leaders and Teachers at first saw this as a very difficult project but when they saw the reaction of students they got interested and motivated.

On other stakeholders

Parents, community and also the general public in Malta go interested in the project and sent very good feedback about it.

Learner attitude to ER, value of the pilot to them

Students saw this project as 'wow'. Many of them went home and did further research about what we were discussing. Others created prototypes of robots they would want to create.

Qualitative feedback from teachers/ school leaders on the value of the pilot as a means to raise awareness of ED

The project is very time consuming but the result on teachers and students was a good one.

Reflection

Driving forces for the accomplishment of the project objectives

Project coordinator, teachers and the students' motivation and excitement were the main driving forces to finalise this project.

Restraining forces and challenges

Covid-19 restrictions

Bureaucracy from outside school

3D Printing at School with RoboPisces

What's 3D printing?

We are accustomed to 2D printing. We read books on printed papers; we look at pictures printed on special paper. That's printing something in a bidimensional support.

What if we want to print an object? With 2D printing we can only print its projection on paper, but with 3D printing we can add a third dimension and make it more similar to the real specimen.

What do I need to 3d print?

We need a 3D printer and a software (or an app) that allow us to draw 3D objects, like for example TinkerCAD.

Can I customize my RoboFISH?

Yes, you can! You can draw the fins or the environment around your RoboFISH. By means of TinkerCAD or any 3D drawing software, you will be able to customize your activity in the classroom with the RoboFISH toolkit!

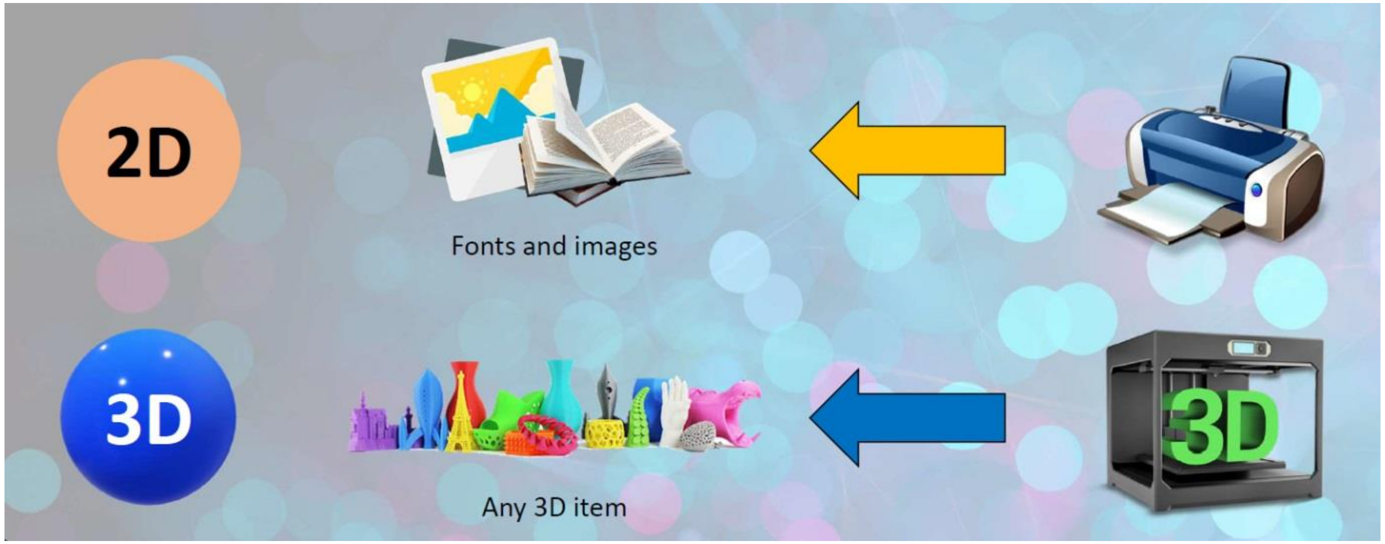


Figure 1. UNIVPM. (2019). The RoboFish Curriculum

Glossary

Term	Definition
Active Sensor	A sensor which instigates an action and then waits for a response – such as transmitting a signal and measuring the response when it comes back.
Actual Position	The position or location of the tool control point. Note that this will not be exactly the same as the demand position, due to a multitude of unsensed errors, such as link deflection, transmission irregularity, tolerances in link lengths, etc.
Actuator	Outputs for the robot brain. They are used in order to make a mechanical movement. A robot's brain sends instructions to actuators.
Algorithm	A set of actions which, if followed, achieve a particular task. These are typically expressed in language a human can 'understand' and may be converted into specific commands that a machine such as a computer can obey.
Annotation	Label with information about different parts. *E.g., The design process needs annotations.*
Artificial Intelligence	Intelligence associated with a machine.
Artificial Intelligence Robot	A robot that learns by observing people.
Artificial Life	The simulation of the behaviour and other characteristics of life typically by computers, robots or biochemical processes – named by Chris Langton.
Assembly Robot	A robot used typically in a production line manufacturing (e.g., cars).
Autonomous Robot	A robot which works on its own, as opposed to being controlled by a human.
Configuration	The arrangement of links created by a particular set of joint positions on the robot. Note that there may be several configurations resulting in the same endpoint position.
Contact Sensor	A device that detects the presence of an object or measures the amount of applied force or torque applied on the object through physical contact with it. Contact sensing can be used to determine location, identity, and orientation of work pieces.
Control Device	Any piece of control hardware providing a means for human intervention in the control of a robot or robot system, such as an emergency-stop button, a start button, or a selector switch.
Control Mode	The means by which instructions are communicated to the robot.
Controller	A device which forms part of a control system – often taking the error between the desired state and the actual state and generating data used to affect an actuator.
Design	A plan or drawing produced to show the look and function
Dynamics	The study of motion, the forces that cause the motion and the forces due to motion. The dynamics of a robot arm are very complicated as they result from the kinematical behaviour of all masses within the arm's structure. The robot arm kinematics are complicated in themselves.

Error	The difference between the actual response of a robot and a command issued.
Feedback	The return of information from a manipulator or sensor to the processor of the robot to provide self-correcting control of the manipulator.
Industrial Robot	A multi-functional manipulator which can be programmed to do various tasks. A robot used for manufacturing.
Input Device	One of many different devices which allow a human to interact with a machine like a computer or robot – including keyboard, mouse, touchpad.
Integrated Development Environment (Uiflow IDE)	It helps developers like to write instructions for the robot.
Intelligence	The ability to acquire and apply skills and knowledge.
Intelligent Robot	A robot whose actions are at least in part determined by the robot.
Led (Light Emitting Diode)	A device that converts electric energy into light.
Law of Robotics	The laws defined by Isaac Asimov in his stories of robots – to define their behaviour.
Localization	In robotics it is about determining where a robot is.
Logic	A branch of mathematics concerned with signals that can be only true or false, and which form the basis of modern computers.
Machine	A device powered by electricity doing things for mankind that is totally controlled by human and cannot work by its' own.
Machine Learning	The construction and study of algorithms that can learn from data and make predictions using data.
Manipulator	A robotic mechanism typically comprising a series of fixed elements joined together at joints.
Motor	A power mechanism used to produce motion – either in a straight line or by rotating.
Passive Sensor	A sensor which just 'listens' for information (in contrast with an active sensor).
Prototype	A working model used to test a design concept.
Robot	A device powered by electricity doing things for mankind that can work autonomously, by its' own.
Sensor	Sensors take information from the environment. They are inputs for the robot's brain. A robots' brain receives information from sensors.
Signal	In Electronics it is a current/voltage/electromagnetic field used to convey information.
Steam	Science, Technology, Engineering, Arts, Mathematics. An interdisciplinary subject.
System	A set of 'things' which work together.
Touch Sensor	A sensor which measures some aspect of the physical contact with an object.
Velocity	The speed at which an object is travelling and the direction in which it is travelling.
Vision Sensor	A device which gives a visual representation of something – typically from a camera.