Project code: 2019-1-IT02-KA201-063073

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KA201: Strategic Partnerships for school education

RoboPisces

"innovative educational ROBOtics strategies for PrImary School ExperienceS"

WP2: Curricula and tool development

D2.4.2: "Report on version v2 of the RoboFISH advanced kit"

Responsible Organization: Università Politecnica delle Marche

Version 2.0, Date: 19/08/2022

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Preface

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History of Changes:

Date	Version	History of change
06/02/2022	0.1	Initial version of the template
10/03/2022	1.0	Updated document with final pictures
19/08/2022	2.0	Updated document with results from the assessments carried out by LU and UNIVPM

1 Introduction

1.1 Scope and objectives of the deliverable

This deliverable is related to WP2 "Curricula and tool development" T2.4.7 "Report on version v2 of the advanced kits" of the Work Plan (Annex I of the Monitoring and Evaluation Plan).

The scope of the deliverable is to report the development of v2 of the advanced toolkit, which is the "student's kit" sent in November 2021 to Rafina (Greece), Rhodes (Greece), IC Solari (Italy), Maria Regina College Saint Paul Bay Primary school (Malta), OŠ Tituša Brezovačkog (Croatia).

Objectives of the deliverable are to describe parts of the toolkits, the use of the toolkit and related scores.

1.2 Structure of the deliverable

Chapter 1: description of the scopes, objectives and structure of the deliverable.

Chapter 2: report of the advanced branches of the FISH curriculum

Chapter 3: description of the RoboFISH advanced toolkit v2

Chapter 4: report of the relevant comments from teachers and students

Chapter 5: report of the planned next steps

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2 The FISH curriculum advanced branch

As described in deliverables D2.3.1 and D2.3.2, UNIVPM identified 3 groups of required technological topics to be faced with the RoboFISH toolkit, divided into basic and advanced: Fundamentals of robotics, IoT and Marine Robotics.

The three **Marine robotics** topics of the Advanced FISH curriculum are:

1. Peculiarities of the environment we are moving into
2. The right actuators for the environment
3. The right sensors for the environment

These topics are the basis for the RoboPisces advanced curriculum, and they are essential to learn how to explore the marine environment and the ocean engineering with the RoboFISH advanced toolkit.

Other topics that exploit the RoboFISH advanced toolkits are:

- The three **IoT t**opics:
  1. The robotic things
  2. Robots and sensors networks
  3. Distributed actuation

- The **3D printing topic** scenario:
  1. 3D printing with the RoboFISH advanced kit

In order to train teachers on the RoboFISH advanced toolkit the topics of the curriculum were introduced to them thanks to the C1 base and extended course. At the elearning platform teachers can find all the information about the toolkit (how it is composed, user guide, demo activities) and also discuss it in the forum section.

In the following subsections we provide the list of activities for the teacher training course available at the online course "THEORY AND TOOLS FOR EDUCATIONAL ROBOTICS, DISTRIBUTED CONTROL AND MARINE ROBOTICS".

2.1 List of the Marine robotics topics and activities for teachers

Marine robotics			
Topic 1 – Environments Peculiarities			
MR010	Topic structure	list of the resources available in topic 1	no need
MR011	Introduction	theoretical introduction to the topic	no need
MR012	Air	theoretical aspects + hands-on activity	basic teacher's kit
MR013	Land	theoretical aspects + hands-on activity	basic teacher's kit
MR014	Water	theoretical aspects	no need
Topic 2 – The right Actuator s for the environment			
MR020	Topic structure	list of the resources available in topic 2	no need
MR021	Introduction	theoretical introduction to the topic	no need
MR022	Moving in the Water	theoretical aspects	no need
MR023	Robots Motion	theoretical aspects	no need
MR024	Activity introduction	hands-on activity	advanced teacher's kit
MR025	Floating activity	hands-on activity	advanced teacher's kit
MR026	Move Forward	hands-on activity	advanced teacher's kit
MR027	Go Right/Left	hands-on activity	advanced teacher's kit
MR028	Go Up/Down	hands-on activity	advanced teacher's kit
Topic 3 – The right sensor for the environment			
MR020	Topic structure	list of the resources available in topic 3	no need
MR021	Introduction	theoretical introduction to the topic	no need
MR022	Gravity	theoretical aspects	no need
MR023	Gravity activity	hands-on activity	advanced teacher's kit

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MR024	Sensors Displacement	theoretical aspects	no need
MR025	Sensors Displacement Activity	hands-on activity	advanced teacher's kit

2.2 List of lessons for each topic of the IoT and 3D printing advanced topics for teachers

Internet of Things			
Topic 1 – The robotics things			
IOT010	The robotic things	theoretical introduction to the topic	no need
IOT011	The robotic things - Activity	hands-on activity	Basic kit
Topic 2 – Robots and sensors network			
IOT020	Robots and Sensors Network	theoretical introduction to the topic	**no need**
IOT021	Robots and Sensors Network - Activity	hands-on activity	Basic kit
IOT022	Climate Change activity	hands-on activity	RoboFISH toolkit (basic and advanced)
IOT023	Traffic Light activity	hands-on activity	Basic kit
Topic 3 – Distributed actuation			
IOT030	Distributed Actuation	theoretical introduction to the topic	**no need**
IOT031	Distributed Actuation - Activity	hands-on activity	Basic kit
IOT032	Alarm activity	hands-on activity	Basic kit
3D printing			
3D001	3D printing with the RoboFISH advanced kit	Theoretical introduction and hands-on activity	Advanced kit

2.3 List of the contents of each lesson of the advanced topics

Each code that you can see here below is related to the table reported in section 2 "Advanced topics overview". Red text represents an activity. Green text highlights prerequisites. Disclaimer: for the whole path of the advanced topics, it is assumed that participants are already familiar with the fundamental topics (topic 1 – 10), as stated in AT000.

MR011

- Environments: definition for humans and for robots
- Different Environments influenced the structure of the body, the sensory systems, and the actuation systems of living beings, and so they do also with robot's structure, sensors and actuators.
- The peculiarities of the environment must be considered and properly addressed when we are designing our robot.
- A "peculiarity of the environment" is the presence of humans. Robot should not harm humans. Asimov's laws.

MR012

- Prerequisite: topic 6 "Senses and Sensors"
- Air in the history of art.
- Air composition
- Candle example
- Layers of the atmosphere
- Altitude, pressure, humidity and temperature.
- Air activity (thermometer, hygrometer, barometer): scientists at work!

MR013

- Prerequisite: topic 6 "Senses and Sensors"
- Gravity
- Land activity (gravity)
- Land Activity (Soil moisture)

MR014

- Earth is a blue planet (percentages of land and water on Earth)
- Ocean is almost unknown: we cannot explore it because we cannot survive to the lack of breathable air, we cannot move easily, we cannot resist high pressures, low temperatures, we cannot use our senses like we do on land.
- The many resources of the ocean
- 7 principles of Ocean literacy
- The different ways humans have invented to go underwater.
- Depth, pressure (Bottle experiment), temperature, light, sound.

MR021

- Natural life in the ocean vs marine machines in the ocean

- Actuation basics: buoyancy and thrust.

MR022

- Buoyancy and Archimedes principle.
- Measure how much liquid is displaced in a graduated cylinder. Does the object float or sink?
- Try to fill a bottle with sand to make it neutrally buoyant at different depths.
- Thrust must win the resistance of the water to make the object move forward.
- The 4 forces that act upon an object in a fluid: Resistance to the movement, Thrust, Weight, buoyancy.
- The names of the angular movements in the water: Roll, Pitch, Yaw.

MR023

- Biomimetic robots
- Kind of fish movements
- Anatomy of a fish: the fins are the organs that allow the movements of the fish.
- Know your RoboFISH: fin and motors!

MR024

- What's inside the RoboFISH? (Remember the topic 7 "Muscles and actuators")

MR025

- RoboFISH is watertight (completely water-resistant) and waterproof (resistant to water under certain conditions)
- Creating a support for the RoboFISH
- Compare the RoboFISH capacity to float with other objects and observe!
- Procedure to use the RoboFISH safely.

MR026

- Programming the RoboFISH to move forward

MR027

- Programming the RoboFISH to move left/right

MR028

- Programming the RoboFISH to move up/down

MR031

- Marine environmental conditions strongly influence our senses, and our capability to sense the underwater environment.

MR032

- The 5 sense and the marine environment: can you describe the sight/smell/sound/taste/touch of the sea?

- Two (too often discarded) human senses: proprioception and vestibular system
- The robot's vestibular system: the IMU sensor
- Is there gravity underwater? Can the robot feel it?

MR033

- Prerequisite: topic 1 of the marine robotics branch - Land Environment
- Activity: Getting the information from the IMU
- Activity: Displaying information from the IMU
- Remember the datasheet activity

MR034

- Prerequisites: topic 9 and 10
- You have sensors that can be placed inside the RoboFISH structure, and sensors that you can be displaced outside the roboFISH structure.
- RoboFISH can communicate with humans: storytelling activity, activity on emotions
- RoboFISH can communicate with "intelligent sensors".

MR035

- Prerequisite: topic 10 of the fundamental topics
- Activity: Establish a connection between an M5StickC and the M5StickC Plus
- Activity: Send a message over the connection established

IOT010

- Prerequisite: topic 10 of the fundamental topics
- What is a robotic thing
- What is the internet of robotic things and its basic elements
- The EspNow protocol

IOT011

- Prerequisite: topic 10 of the fundamental topics
- Activity 1: Send a message between two M5StickCs
- Activity 2: remote controlling the BugC

IOT020

- Prerequisite: topic 10 of the fundamental topics
- What is the IoT
- What is a sensor network
- Applications

IOT021

- Prerequisite: topic 10 of the fundamental topics
- Activity 1: 2 senders and 1 receiver, the receiver shows the message and the mac address of the sender

- Activity 2: 2 senders and 1 receiver, the receiver performs something on the screen when the message arrives
- Activity 3: 2 senders and 1 receiver, the receiver plays a different tone for each sender

IOT022

- Prerequisite: topic 10 of the fundamental topics
- Activity: Climate change

IOT023

- Prerequisite: topic 10 of the fundamental topics
- Activity: Traffic Light

IOT030

- Prerequisite: topic 10 of the fundamental topics
- What is a system
- Natural system vs artificial system
- Control of a dynamical system: open loop vs closed loop

IOT031

- Prerequisite: topic 10 of the fundamental topics
- Activity: 1 sender and 2 receivers; depending on which button of the sender is pressed, a message will appear on the screen of one receiver or on the screen of the other receiver.

IOT032

- Prerequisite: topic 10 of the fundamental topics
- Activity: Alarm!

3D001

- Prerequisite: none
- Activity: customize your RoboFISH

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3 Description of the toolkit

Since the requirements used to develop v01 were all satisfied, since teachers reported no issues to fix or changes to make to the prototipe, since the experience at IC Solari showed a good acceptance of the robot by students, no changes were made to the structure or functioning of the RoboFISH advanced toolkit.

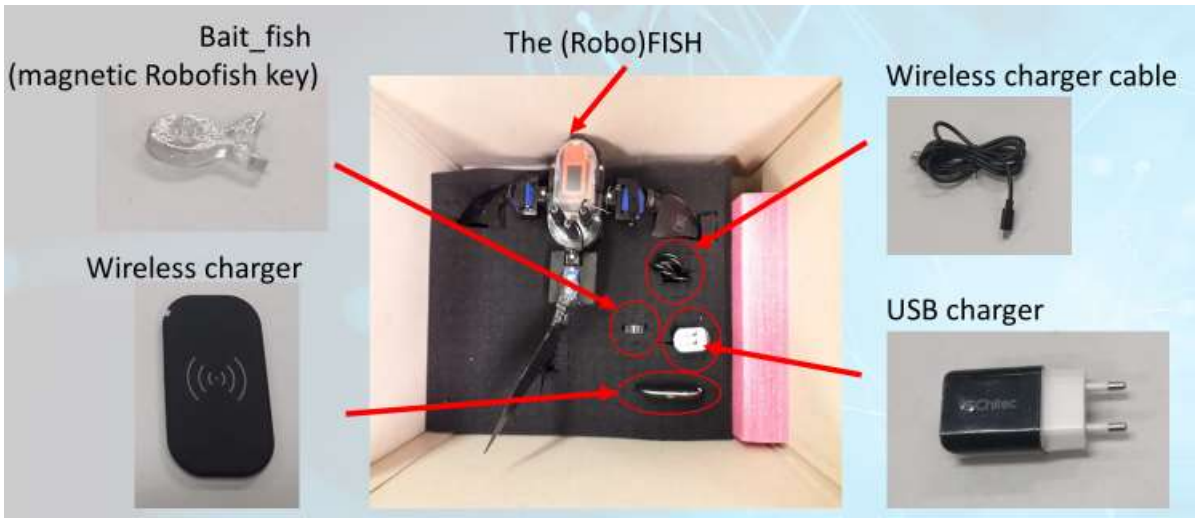
The toolkit v2 differs from the the RoboFISH advanced toolkit v01 only by internal details:

- Added A (magnetic) button
- Improved the design of the 3D printed hull and caudal fin
- Improved the charging capability of the fish robot

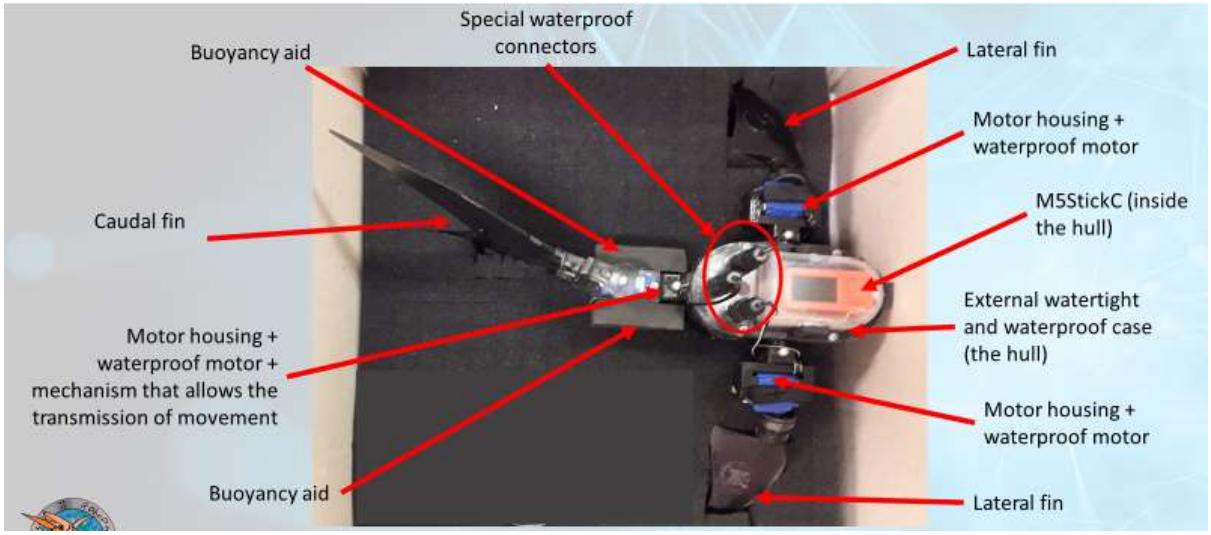
The new user's guide was uploaded to the elearning platform and made it available to all teachers involved in the training along with the training, example of activities and demo software.

3.1 Hardware description

In the picture below all the parts of the RoboFISH advanced toolkit are listed:



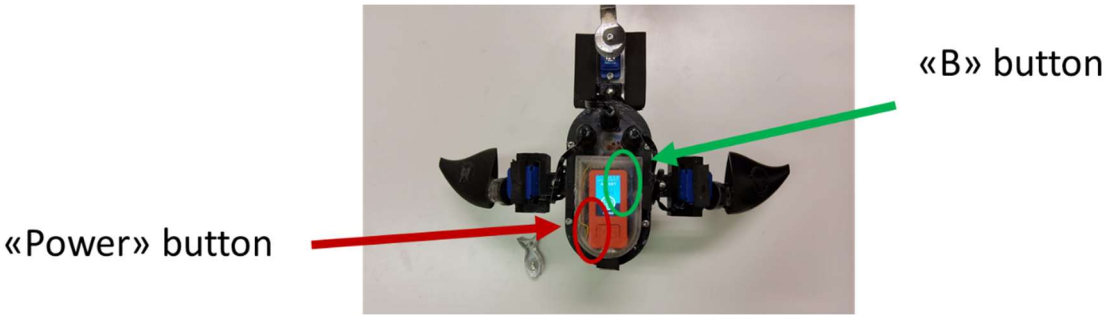
The specific parts of the main robot are the ones highlighted in the picture below:



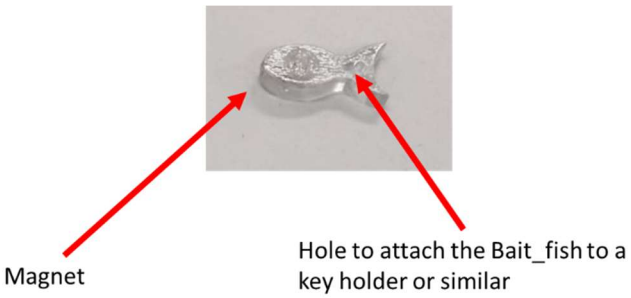
The hull, the caudal fin and the lateral fins were 3D printed as well as some minor parts of the robot. The hull is watertight thanks to its special connectors, internal O rings and special design.

The RoboFISH is neutrally buoyant thanks to the buoyancy aids inserted near the caudal fin mechanism. The buoyancy mechanism integrated by design the buoyancy aids, because they will be an optional activity to carry out in the classroom in order to explore with hands-on activities the buoyancy concept (MR025).

The RoboFISH integrates two magnetic buttons: one to power up the device and power off the device (power button), the other to interact with the software (B button):

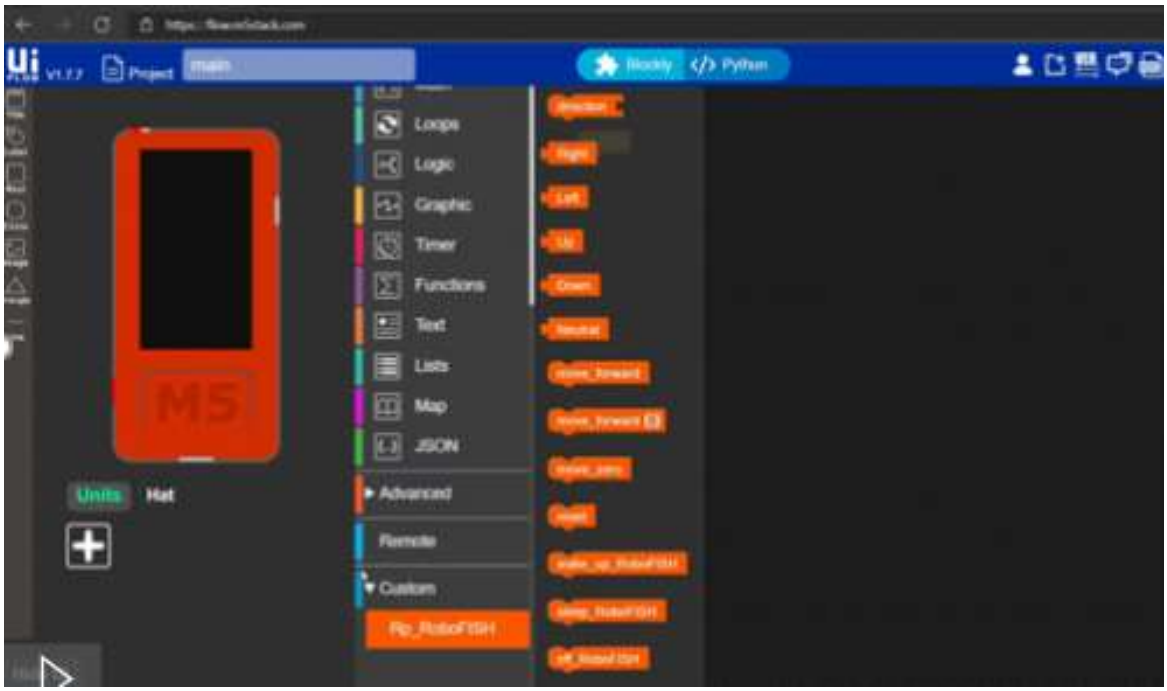


In order to attract users, UNIVPM provided also a magnetic key to interact with the RoboFISH:



3.2 Software

To program the RoboFISH advanced toolkit, users only need to connect to the UIFlow IDE (https://flow.m5stack.com) and import the custom library "Rp_RoboFISH" available at https://learn.univpm.it/course/view.php?id=10571 (MR025). The instructions on how to import the library are available at the same website in the same lesson (MR025), or in the "User's guide" available on the same platform and illustrated at the LTTA C2 by UNIVPM.



Instructions on how to learn to use the package can be found in the lessons:

- MR024 - Introduction to the Activity,
- MR025 – Floating,
- MR026 - Moving Forward,
- MR027 - Moving Left or Right,
- MR028 - Moving Up or Down,
- MR033 - Gravity: activity,
- MR035 - Sensors Displacement: activity

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4 Feedback about the RoboFISH advanced toolkit

4.1 Teachers' feedback on the RoboFISH

Some of the most enjoyable aspect of working with the RoboFISH were:

- movements in the water
- Linking the knowledge gained from the Basic Topics with the marine environment
- relating technology with the natural environment
- Working with the Fish-Robot

Some of the most challenging aspects were:

- Technical terms that teachers will have to explain to children and technical elements of robot
- Coding

About the 90% of teachers answered correctly to the 80% of the questions in the C1 knowledge evaluation and agree to the sentence "After these online courses, I know how to organize the learning process in robotics lessons". About the 55% agrees with the sentence "I understand how to solve problems, if such will be during implementing the Project "RoboPisces".

After activities in the classroom, some teachers reported:

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

Teachers also rated the RoboFISH advanced toolkit on the basis of their experience at school and the 58% of respondents gave good rating (good and easy-to-use). Also, from the answers to the open-ended question, we can mostly conclude that the 2nd kit was easier to deal with, instructions were clear, and the activities were very interesting. Compared to the basic kit, the rating is higher.

With respect to the skills developed with the toolkit the following figure shows the situation before and after the activities of the project. Most interestingly, the share of students reaching tha particular ability enlarged after the use of the toolkit combined with the proposed lesson plans and gamified tools for the assessment.

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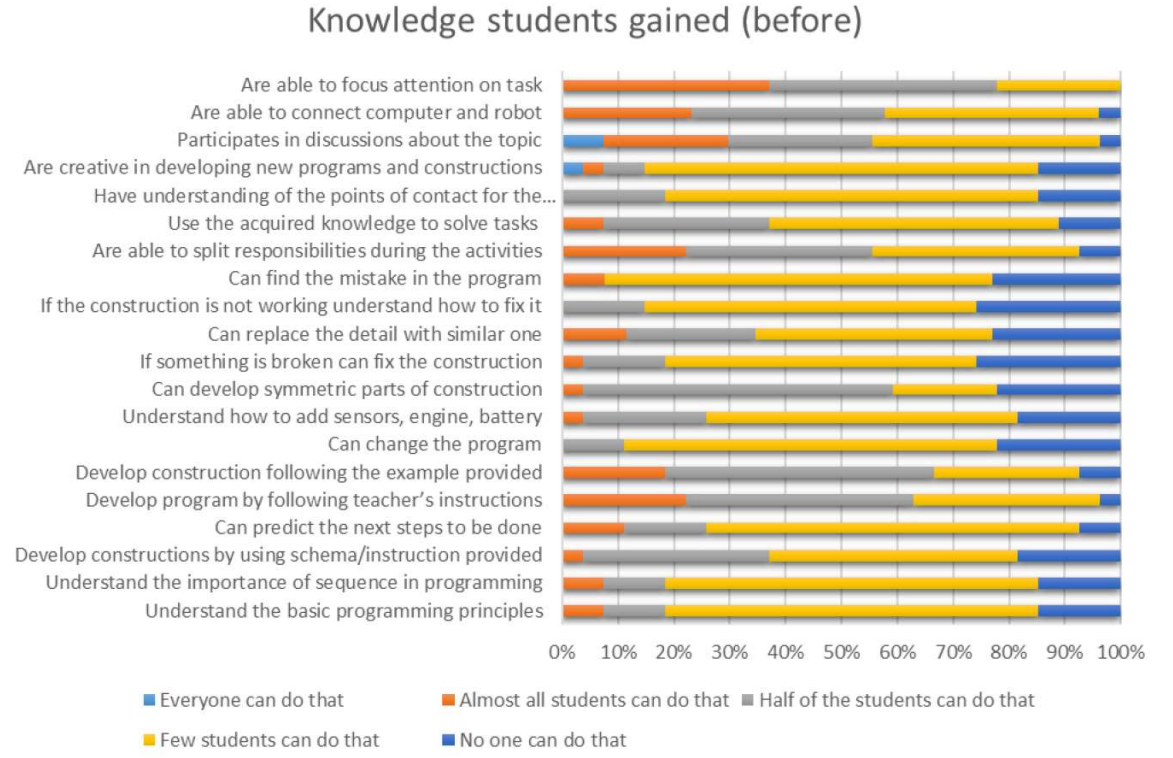
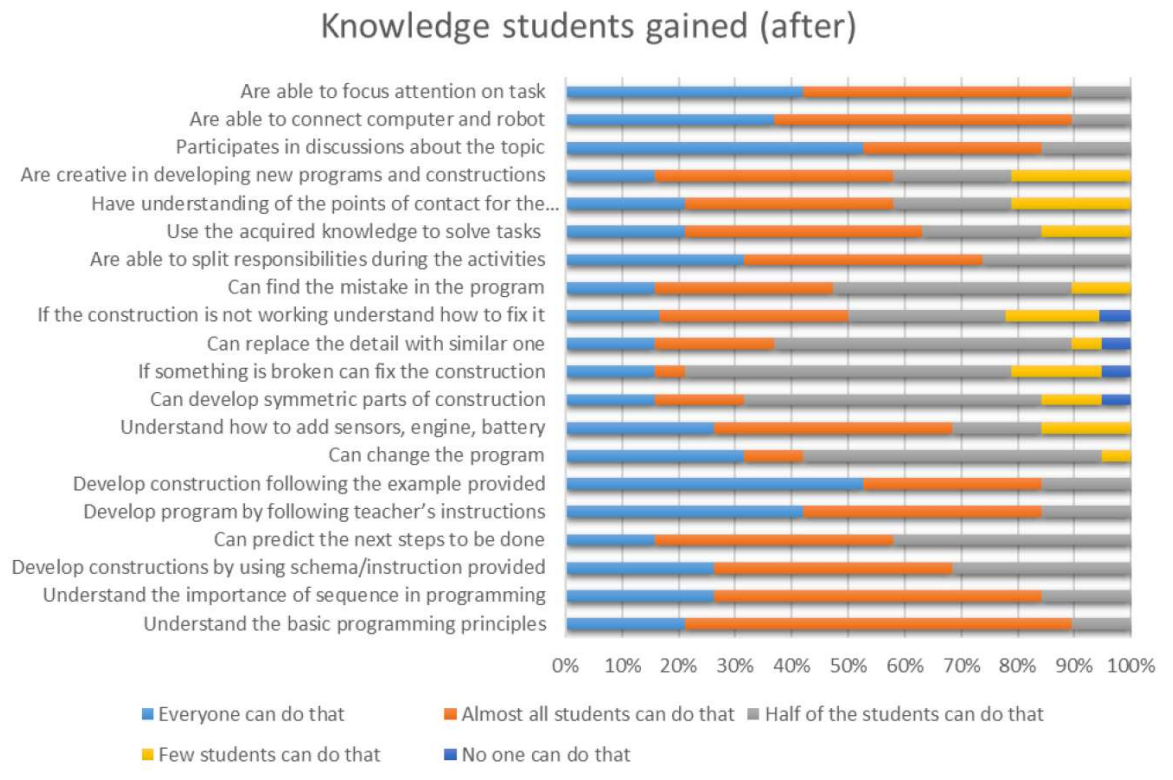

Knowledge students gained (before)
Are able to focus attention on task
Are able to connect computer and robot
Participates in discussions about the topic
Are creative in developing new programs and constructions
Have understanding of the points of contact for the...
Use the acquired knowledge to solve tasks
Are able to split responsibilities during the activities
Can find the mistake in the program
If the construction is not working understand how to fix it
Can replace the detail with similar one
If something is broken can fix the construction
Can develop symmetric parts of construction
Understand how to add sensors, engine, battery
Can change the program
Develop construction following the example provided
Develop program by following teacher's instructions
Can predict the next steps to be done
Develop constructions by using schema/instruction provided
Understand the importance of sequence in programming
Understand the basic programming principles
0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Everyone can do that
Almost all students can do that
Half of the students can do that
Few students can do that
No one can do that


Knowledge students gained (after)
Are able to focus attention on task
Are able to connect computer and robot
Participates in discussions about the topic
Are creative in developing new programs and constructions
Have understanding of the points of contact for the...
Use the acquired knowledge to solve tasks
Are able to split responsibilities during the activities
Can find the mistake in the program
If the construction is not working understand how to fix it
Can replace the detail with similar one
If something is broken can fix the construction
Can develop symmetric parts of construction
Understand how to add sensors, engine, battery
Can change the program
Develop construction following the example provided
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0% 10% 20% 30% 40% 50% 60% 70% 80% 90% 100%
Everyone can do that
Almost all students can do that
Half of the students can do that
Few students can do that
No one can do that

4.2 Students feedback on the RoboFISH

After working with the robots primary school students reported:

- It is very easy to program with Blocks
- It's great when you make a fish move in the water!
- I like Robofish and M5 Stick programming

Interestingly, UNIVPM engaged university students in the development of the RoboPisces project. Students were guided into the world of underwater robotics and educational robotics by experienced researchers. Two of them grew fond of the activities of the project and started working on their own fish robot to enter the edtech work. These students are currently working to carry out their idea and founded a start-up company called ANcybernetics.

5 Next Steps

The RoboFISH toolkit development reached TRL7 as envisaged by the proposal. It will be available at partners' facilities and its digital presentation will be available at the project website.

The course C1 extended offering the training about the toolkit will be available at the RoboPisces MOOC, so to engage more people with the project's results and objectives.

Useful links:

- IO2 digital presentation: https://www.robopisces.eu/io2/
- IO2 basic toolkit: https://www.robopisces.eu/robofish-basic-toolkit/
- IO2 advanced toolkit: https://www.robopisces.eu/robofish-advanced-toolkit/
- RoboPisces MOOC: https://www.robopisces.eu/robopisces-mooc/

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