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KA201: Strategic Partnerships for school education

RoboPisces

"innovative educational ROBOtics strategies for PrImary School ExperienceS"

WP2: Curricula and tool development

D2.4.1: "Report on version v0.1 of the RoboFISH advanced kits"

Responsible Organization: Università Politecnica delle Marche

Version 2.0 , Date: 01/10/2021

Table of Contents

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Preface

Main Authors for the deliverable:

Name of partner organization	Main authors
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History of Changes:

Date	Version	History of change
01/10/2021	0.1	Initial version of the document
01/10/2021	2.0	Final version

1 Introduction

1.1 Scope and objectives of the deliverable

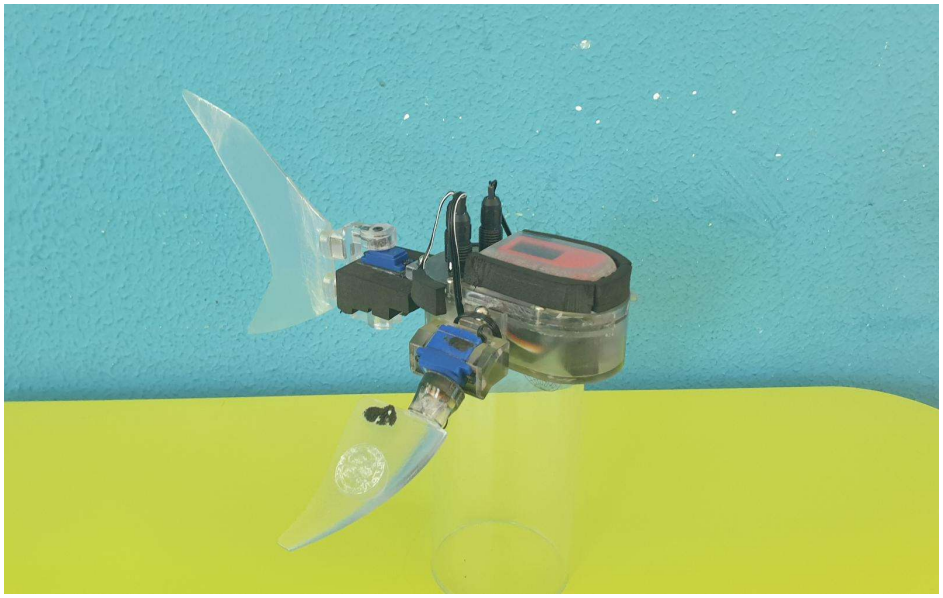
This deliverable is related to WP2 "Curricula and tool development" T2.4.3 "Report on version v0.1 of the advanced kits used during C2" of the Work Plan (Annex I of the Monitoring and Evaluation Plan).

The scope of the deliverable is to report the development of v0.1 of the advanced toolkit, which is the "teacher's kit" sent in June-July 2021 to the teachers.

Objectives of the deliverable are to report the genesis of the toolkit as it is, to describe the toolkit in this phase, to briefly report its functioning, to describe teachers' acceptance of the toolkit, to highlight next steps in the development of the advanced toolkit, which will be the v2 (student's kit).

1.2 Introduction to the advanced toolkit v01

The RoboFISH advanced toolkit is the toolkit that will be useful for carrying out the advanced activities of the FISH curriculum. It can be easily integrated with the basic toolkit, thus enhancing the possibility to tailor the learning path to the learning speed of the classroom.



1.3 Structure of the deliverable

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

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

Chapter 3: description of the RoboFISH advanced toolkit v0.1

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Chapter 4: report of the relevant comments from teachers collected at C2

Chapter 5: report of the planned next steps in the development of IO2

2 The FISH curriculum advanced branch: Marine Robotics topics

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 curriculum, and they will be essential to learn how to explore the marine environment and the ocean engineering with the RoboFISH advanced toolkit.

2.1 List of lessons for each topic of the Marine Robotics advanced topics

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

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

2.2 List of contents

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: fins 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

3 The RoboFISH advanced toolkit (v0.1)

3.1 Requirements for the development of the robot "RoboFISH"

The requirements for the RoboFISH advanced toolkit were derived from the proposal and from the feedback received by UNIVPM in parallel activities with previous prototypes. Requirements which are the starting point for the development of the RoboFISH advanced toolkit v01 are:

1. A robot which is useful to learn marine robotics and the concepts associated with the marine environment.
2. A biomimetic or biomorphic robot. It should resemble the shape and the motion of an actual fish.
3. It should allow 3D printing activities.
4. It should allow IoT activities.
5. It should be easy to handle, transport and store.
6. It should allow some degree of interaction.
7. It should move in the water.
8. It should be programmable.
9. It should be compatible with the FISH curriculum as a whole.

At the time of the proposal, the RoboFISH was at TRL2: it was designed and only some parts of it had already been assembled. Thanks to RoboPisces project, the first RoboFish proof of concept is now realized, and the toolkit will reach TRL 7 (system prototype demonstration in operational environment) at the end of the project.

The actual RoboFISH advanced kit v0.1:

1. Is a robot that can be used at school or in other educational contexts to learn marine robotics and other concepts about the marine environment. To this purpose, the elearning platform shared some examples of useful activities with the Robofish Advanced kiit (see Section 2.2 of this document).
2. It actually resembles a fish (main body, two lateral fins and one caudal fin) and thanks to its structure it actually moves like a fish.
3. Its hull and fins are 3D printed. Other lessons will be uploaded to the elearning environment to teach teachers how to realise 3D printing activities for their RoboFISH. It should be noted that not all the school are in possession of a 3D printer, but partners are interested in buying one in the near future or to use the one they already have to try to print some basic parts of the RoboFISH robot.
4. The computing unit of the RoboFISH advanced kit is the M5StickC. It can be easily integrated with the RoboFISH basic toolkit (v0.1 and v2) and with other cloud services. On the elearning platform teachers can find instructions for carrying out IoT activities also with the RoboFISH activities (https://learn.univpm.it/course/view.php?id=10571).

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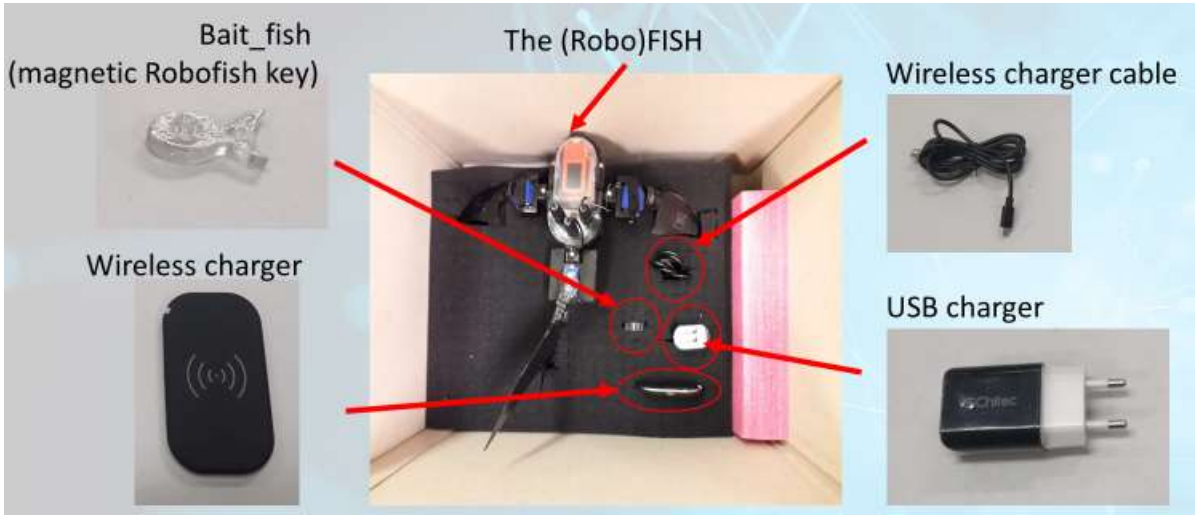
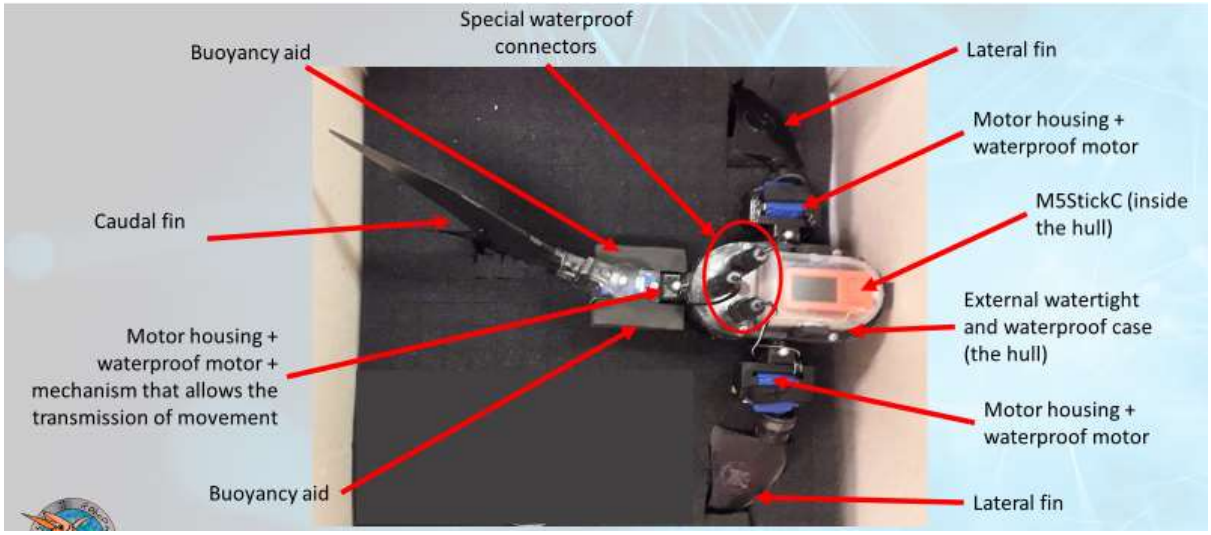
5. The RoboFISH weigh only 0,4 kg and was shipped in a box (dim.: 30 cm x 30 cm x 40 cm; weight: 1,3 kg) which can be used also to store it and all its parts safely and easily.
6. The RoboFISH was adapted to allow user's interaction; it has 2 magnetic **buttons**: 1 to power up or power off the device, and 1 to interact with the Robot. The hull was printed specifically to let the users see the **screen** on the top of the M5StickC and the light from the M5StickC internal **LED**. The M5StickC also has a **microphone** onboard and an **IMU**. Furthermore, the M5StickC can extend the capabilities of the RoboFISH by communicating with other external M5StickCs (for example, an external M5StickC connected to a joystick hat can be used to interact with the RoboFISH, or an external ENV sensor hat combined with the M5StickC can be used with the RoboFISH advanced toolkit).
7. The RoboFISH can move in the water thanks to its fins. The caudal fin thrust the body forward, whereas the two pectoral fins make the robot move upward/backward or right/left or straight forward.
8. Thanks to the M5StickC which is the computing core of the RoboFISH, the robot can be programmed by means of the UIFlow IDE (Blockly or Python) or even the Arduino IDE.
9. In order to ensure the compatibility with the whole FISH curriculum, UNIVPM created a library of commands that can be imported in the UIFlow IDE (which is the same that students in the RoboPisces implementation use). These commands help the user to make the robot move or respond to user's inputs.

3.2 Hardware description

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



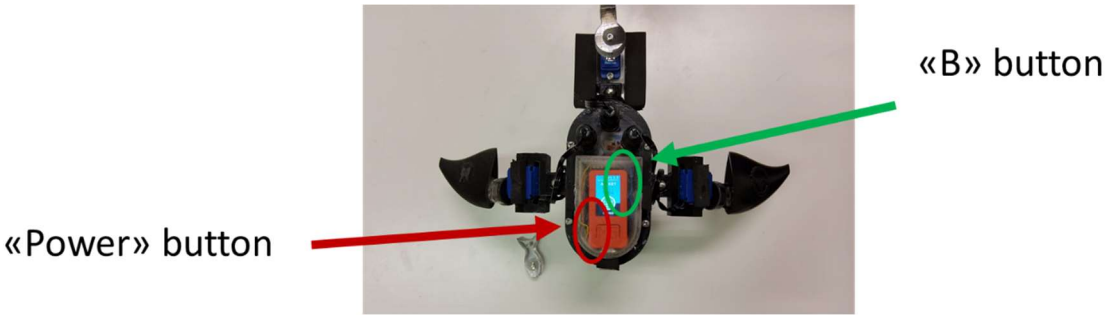
The specific parts of the main robot are the ones highlighted in the picture below:



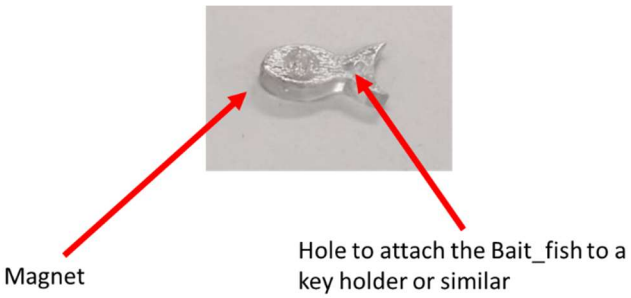
The hull, the caudal fin and the lateral fins were 3D printed as well as some minor parts of the robot. The hull is watertight thanks to its special connectors, internal O rings and special design.

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):

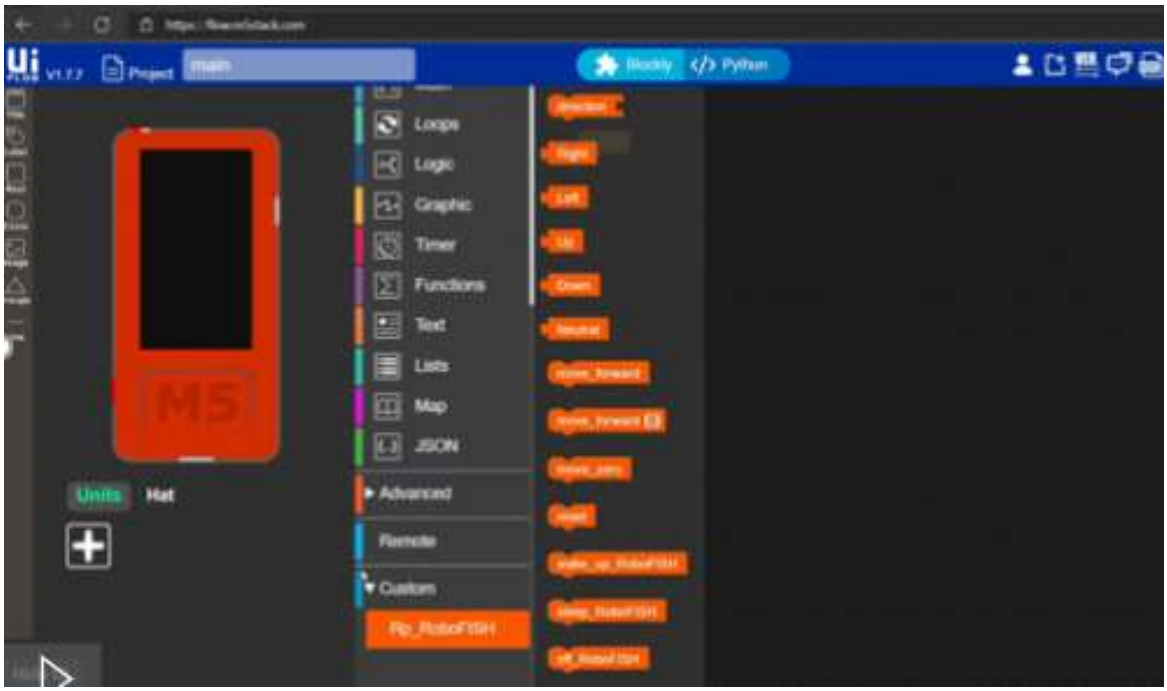


In order to attract users, UNIVPM provided also a magnetic key to interact with the RoboFISH:



3.3 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

4 Feedback on the RoboFISH advanced toolkit

4.1 Delivering the toolkit

The kits were shipped by UNIVPM to all partners using the DHL courier (all but IC Solari which received the kits directly from the coordinator). The RoboFISH advanced toolkits v0.1 were shipped not only to schools but to all partners, so each partner can learn to use it, disseminate the project's result IO2 and thus interest and engage more people to the project's aims.
As a future perspective, to transfer and exploit the output of the RoboPisces project even beyond its final closure, LU will use the RoboFISH advanced kit and also the associated material (technical topics, lesson plans and evaluations) with their student teachers to re-use, mix and create learning and teaching path on educational robotics, marine robotics, and IoT. Also, the NUID UCD plan to use the RoboFISH advanced kit for future developments, both regarding the tech developments and the dissemination of the present result.

Country	No. of kits sent	date	notes
Croatia	1	29/06/2021	to Mrs. Mirjana Torer
Greece – Rafina	1	30/06/2021	to Mrs. Nancy Pyrini
Greece – Rhodes	1	01/07/2021	to Mr. Kostantinos Karampelas
Ireland	1	29/06/2021	to prof. Eleni Mangina
Italy - Loreto	1	August 2021	delivered by UNIVPM
Latvia	1	12/07/2021	to prof. Linda Daniela
Malta	1	30/06/2021	to Mr Mark Azzopardi

4.2 Feedback from teachers at the LTTA C2

During the LTTA C2 the RoboFISH advanced kit v01 and the related teacher training were presented by Laura Screpanti (UNIVPM). Giacomo Fiara (UNIVPM) described the experience that UNIVPM and IC Solari had with the RoboFISH advanced toolkit v0.1 at IC Solari's premises. UNIVPM and IC Solari organized a summer experience for students of IC Solari. Students learnt robotics using the RoboFISH toolkit, both basic and advanced.

The RoboFISH was presented by describing its parts, both hardware and software, and by describing all the resources to explore hands-on activities. Unfortunately, even if the Marine Robotics lessons and the kit were delivered by the beginning of July, most of the teachers attending the LTTA C2 could not complete the training. So, they provided qualitative feedback on the robot saying it is awesome and it will raise students' curiosity, but to have more detailed feedback and to program how to integrate it into the school activities teachers need more time. So, it was arranged that teachers would complete the course by February 2021, in order to start the advanced topics in the classroom by the beginning of the next semester.

In her presentation Livia Alesi (IC Solari) described the summer experience with the robot saying that children were enthusiast about the activities carried out with the toolkit (both basic and advanced toolkit were used). She also reported that the demonstration of the activities with the toolkits also raised the enthusiasm of parents and teachers.

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Furthermore, results from the final liking questionnaire of the activity showed that: all participants stated the activities were fun and engaging and working with the M5StickC was easy. The 88% wanted to have more activities like this. The general rating of the experience was very good. Students also proposed the projects they would like to realise using the toolkit; some answers were: “Save the animal”, “Free the ocean from plastic pollution”, “observing the underwater world”, “swim companion”, “save people from the flood”, “restore and preserve the underwater environment”.

In the end the experience at IC Solari showed a very good acceptance of the RoboFISH. It is likely that the possibility to realise face-to-face activities makes it all easier and feasible. Unfortunately, lockdowns and restrictions hit badly on both teachers and students in the previous school year and will be the same perhaps for the next school year. Anyway, such onsite activities help recover from the time lost. Students need face-to-face activities, students need group-based activities that support the development of the teamwork and the reestablishment of the social aspect.

Other comments were that even if teachers and students carried out activities of the basic curriculum with classrooms in the past school year, some additional work on basic activities can be beneficial to students before starting the advanced curriculum with the advanced toolkit. Moreover, teachers themselves need more time to familiarise with the advanced toolkit and the proposed demos to decide whether to adapt them into age specific activities or to use them as they are.

5 Next Steps

Next steps include:

- Prepare 5 RoboFISH advanced toolkit v2
- By November 2021 send one to each: Greece - Rafina, Greece – Rhodes, Italy - IC Solari, Malta – MRC SPB, Croatia - OS TB.
- Prepare the OER presentation of the toolkit.
- Deliver the OER for the final presentation.

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