Application of the kits – RoboSTEAM O2.A5
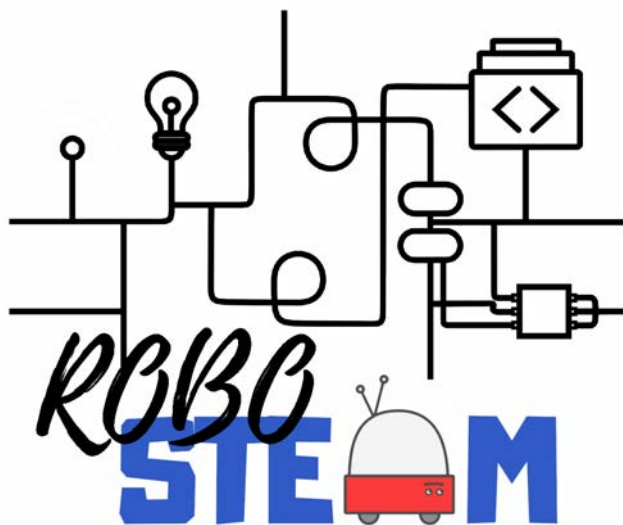
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Version History

Version	Date	Comments
0.1	01/05/2019	Pre-Piloting
0.2	01/06/2019	Pilots Design
1.0	01/07/2019	Pilots Application
1.1	31/03/2020	Final pilot application
1.2	31/03/2021	Pilots with COVID-19 adaption

Table of Contents

1. O2.A5

This document describes the work of the RoboSTEAM project [1-8] Output 2 - Guides for designing Open Hardware PD&R. The output aims to define guides that allow designing learning challenges for the development of STEAM [9] competencies and computational thinking [10-18] by using PD&R [19-21]. An important part of this output is the application of the challenges and kits defined in the previous activity. This is described in the project proposal as follows:

> "This will be done during the pilot activities that is developed in A3 and A4. For the first pilot kits defined specifically for each specific testing contexts are used. The second will use again the same kits and other achieved from other socioeconomic environments".

This document summarizes the pre-piloting stage, the pilot design, the pilot application, the changes due to COVID-19 [22-34] and the final application result.

2. THE PROCESS

The process followed was the selection of the challenges to apply, the adaption to the target contexts and the selection of the assessment instrument to apply before, during and after the experience. In order to ensure the success of this application a pre-pilot was carried out in a summer camp at IPB [3].

2.1. The pre-challenge description

The Robotics Summer Camp at IPB has a duration of 5 days, not being only scientific, because the students have many activities that are not related with the scientific topics of the summer course, being mainly cultural and social. The summer course starts Monday morning with the welcome reception, and then students, after lunch, initiate the course with a mini challenge that is shared by all the 16 students. From Tuesday to Thursday the students will be separated in 4 groups, having each group to address a challenge. However, the development of

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a Challenge involves to many hours for the camp, so the idea solving something more concrete as a Mini-Challenge that can be decomposed in Nano-Challenges.

Figure 1. – Participants in the Summer Camp

Each of the groups have dealt with Nano-Challenge [2]. The summer camp ends on Thursday with a farewell dinner and on Friday it's a travelling day for them to get back to their homes. The students are from secondary schools and have an average age of nearly 15.5 years old, being present students from 14 to 17 years old, from all over the country (Portugal). The physical space that was used in the summer camp was the Laboratory of Control, Automation and Robotics of the school of technology and management of the IPB, that can be seen in Figure 2.

Figure 2. – Laboratory of Control, Automation and Robotics of the school of technology and management of the IPB.

To teach the students, there were three professors coordinating the course, José Gonçalves and José Lima from the IPB and also Miguel Ángel Conde, from the

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University of León, being the ROBOSTEAM Project Manager. There were also 4 monitors (three master students and a fellowship student), that played an important role, mainly in the Nano-Challenges, because each one supervised a different group that had a different Nano-Challenge.

Both the Mini-Challenge and Nano-Challenges were evaluated concerning the degree of success of each challenge, having in mind the context in which the challenges were done. The students will work with hardware only during the Nano-Challenges, having to solve previously a Mini-challenge that they have to answer a research question, but they do not have to implement hardware or program any physical device.

The Minichallenge defined was defined as: Over the years, increasing fossil fuels as a source of energy for vehicles has generated a major impact on the environment. In this sense, a possible solution to solve this problem in controlled environments can be the use of mobile robots. However, mobile robotics requires the development of many tasks working together to solve problems that seem trivial to humans.

The four nano-challenges were:
- **Mobile Robots to digital transportation.**
- **Follow Lines with A Mobile Robot to Facilitate Autonomous Navigation.**
- **Follow Line with Mobile Robot Using Scratch-Based Programming**
- **Maintenance and Calibration of Mobile Robots Based on a Low-Cost Stroboscope Prototype**

More information about these nano-challenges can be found at [3].

2.2. The selected challenges and kits

During Karlsruhe Transnational Meeting the different kits and challenges were evaluated. Taking into account the project proposal each partner should address a challenge with a kit in the first piloting stage, but in the second challenges and kits should be exchanged. Given this situation the partners decide:

1. The granularity of the challenge to be addressed. During the academic course, given the restrictions of each institution learning plan, the better length for this experiment was that of a mini-challenge.

2. Each partner of the piloting institution will address the mini-challenge they proposed in the first staged. That is:

- AEEG – Wildfire and mobile robotics navigation.
- IES Eras - Illuminated sign.
- KIT (Karlz Benz School) – Make it Shine.
- CIC - Logistic management of a warehouse.
- UEF – Entertainment of Senior Citizens and also Well-being of Senior Citiziens.

More information about the challenges is described in the next sections.

For the second piloting phase it is decided to exchange nano-challenges instead of mini challenges. Because they are easily addressable by the teams, taking into account the number of hours employed and the equipment and teachers' availability in each institution. ERAS nano challenges can be exchanged with KIT and AEEG, CIC nano-challenges can be exchanged with Finland and vice versa. AEEG nano-challeges can be exchanged with ERAS.

During the students exchange it is interesting that the travelling students work with the hosting ones in solving the challenges of these last ones with the kits they have.

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2.3. The evaluation instruments

Regarding the evaluation instruments they were also discussed during the Karlsruhe meeting, taking into account those described in O2.A2 and also those found when carrying out the Systematic Mapping.

Regarding the indicators it is necessary to take into account the time employed to complete the challenge, the number of persons involved in each team and the grade (that could later be compared with previous editions of the same subject). Regarding the evaluation instruments, the STEM Semantic Survey will be used in the diagnosis phase. Most of the partners need to ask for permissions and some of them to translate it and upload it to another platform different from Google. Besides, this test will be employed in a pre- and post-test with the students implied in the challenges. In the post-test, also some questions regarding motivation. In addition, a computational thinking instrument to be used after the piloting that includes several CT dimensions. It is decided to use the if/else dimensions (from the conditionals section) and do/until dimension (from the loop section) because they are most related with robotics. Finally, teachers will also use a rubric to assess other competencies development. All these instruments will be available in the platform.

3. PILOT PHASE 1 AND CHANGES MOTIVATED BY COVID-19

3.1. Pilot Phase1

The pilot phase 1 began in September of 2019 for several of the partners, but not for all at the same time. It was defined as commented in the Karlsruhe meeting and started with the diagnosis phase that would include a very important number of students and will last up to the end of the project. For it was used the STEAM Semantics Survey with the results commented in A4 report.

The minichallenges and nano-challenges applied in detail were the following:

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AEEG

Title	Wildfires Prevention – a global issue.
Description	
Wildfires concern all of us. It is a worldwide issue. According to Environmental Defence Fund (EDF), the number of annual large fires in the American West has doubled. In Europe, numbers and facts must be similar. We want to avoid the causes of wildfires and understand at what extent is Climate change responsible for wildfires in Iberian Peninsula. Propose approaches to reduce the impact of Global Warming (GW) on wildfires and suggest Prevention strategies.	
Goal/s	
i) Improve Environment; ii) define the proper research question(s) for the problem mentioned above; iii) look for successful strategies in order to prevent fires in Iberian territory and reduce GW impact; iv) build a possible approach; v) be a team player. Find out a collaborative solution/strategy that involves students, parents, teachers and experts in this field.	
Evaluation	
During this challenge we can assess: i) Time employed to solve the challenge (students will fill in a grid); ii) degree of success producing a solution (students will fill in a self and hetero evaluation report); iii) number of people involved in the challenge (information sheet including age, role/status and Education level); iv) perception about STEAM (students will be asked to talk about their experience throughout the whole process of this challenge – they can make a video, around two minutes); v) assessment of STEM skills and CT skills before and after the challenge (online questionnaires).	

The challenge was divided in a mini-challenge described in table 2.

Title	Use mobile robots to detect and avoid the cause(s) of wildfires and reduce the impact of global warming on this issue.
Research question or problem addressed by this minichallenge	
Can mobile robots prevent fire(s)? (Acts of arson, lack of cleanliness, global warming – drought and severe heat- etc)	
Description	
Human activities such as lighting campfires, discarding lit cigarettes, acts of arson, bushfires etc are mainly responsible for starting a fire. However, hotter weather makes forests drier and more prone to burn. Rising temperatures, a key indicator of climate change, evaporate more moisture from the ground, drying out the soil and making vegetation more flammable. Think about how to employ mobile robots to reduce the impact of global warming on environment and avoid other causes of wildfires.	
Goal/s	
i) Study mobile robots; ii) develop computational thinking; iii) study possible ways to apply mobile robots to improve environment;	

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iv)	develop soft skills;
v)	implement collaborative solution/strategy that involves students, parents, teachers and experts in this field;
vi)	design and explore the scenarios where mobile robots can be applied;
vii)	develop creativity.

Evaluation	
i)	Time employed to solve the challenge (students will fill in a grid);
ii)	degree of success producing a solution (students will fill in a self and hetero evaluation report);
iii)	number of people involved in the challenge (information sheet including age, role/status and Education level);
iv)	perception about STEAM (students will be asked to talk about their experience throughout the whole process of this challenge – they can make a video, around two minutes);
v)	assessment of STEM skills and CT skills before and after the challenge (online questionnaires).

Which is divided in the following nano-challenges (Tables 3-5)

Table 3. – First nano-challenge addressed

Title	Follow lines with a mobile robot to patrol the forest
Specific Issue to deal with	
Use or built a robot that was able to follow a line	
Description	
Human activities in the countryside namely forests have a great impact on the environment. A possible solution to address this issue can be the use of mobile robots. We want to find out how to use a robot to follow a line in order to patrol the forest.	
Goal/s	
i) study navigation issues in mobile robots; ii) study possible ways to make a mobile robot follow a line; iii) explore scenarios where mobile robots can be applied; iv) implement collaborative solution/strategy that involves students, parents, teachers and experts in this field; v) develop soft skills; vi) develop CT skills; vii) enhance creativity.	
Kits to use	
mBot, a STEAM educational robot for beginners.	
Evaluation	

i)	Time employed to solve the challenge (students will fill in a grid);
ii)	degree of success producing a solution (students will fill in a self and hetero evaluation report);
iii)	number of people involved in the challenge (information sheet including age, role/status and Education level);
iv)	perception about STEAM (students will be asked to talk about their experience throughout the whole process of this challenge – they can make a video, around two minutes);
v)	assessment of STEM skills and CT skills before and after the challenge (online questionnaires).

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Table 4. – Second nano-challenge addressed

Title	Avoid obstacles with a mobile robot to facilitate autonomous navigation
Specific Issue to deal with	
Use or built a robot that was able to avoid obstacles	
Description	
Human activities in the countryside namely forests have a great impact on the environment. A possible solution to address this issue can be the use of mobile robots. We want to find out how to use a robot to follow a line that can avoid obstacles.	
Goal/s	
i) study navigation issues in mobile robots. study possible ways to make a mobile robot follow a line; explore scenarios where mobile robots can be applied; implement collaborative solution/strategy that involves students, parents, teachers and experts in this field; develop soft skills; develop CT skills; enhance creativity.	
Kits to use	
mBot, a STEAM educational robot for beginners.	
Evaluation	
Time employed to solve the challenge (students will fill in a grid); degree of success producing a solution (students will fill in a self and hetero evaluation report); number of people involved in the challenge (information sheet including age, role/status and Education level); perception about STEAM (students will be asked to talk about their experience throughout the whole process of this challenge – they can make a video, around two minutes); assessment of STEM skills and CT skills before and after the challenge (online questionnaires).	

Table 5. – Third nano-challenge addressed

Title	Follow lines with a mobile robot to allow waste transport
Specific Issue to deal with	
Use or build a robot which can transport waste by following a line	
Description	
Human activities in the countryside namely forests have a great impact on environment. A possible solution to address this issue can be the use of mobile robots. We want to find out how to use a robot to follow a line in order to pick up waste and carry it into a bin.	
Goal/s	
study navigation issues in mobile robots; study possible ways to make a mobile robot follow a line; explore scenarios where mobile robots can be applied; implement collaborative solution/strategy that involves students, parents, teachers and experts in this field; develop soft skills; develop CT skills; enhance creativity.	
Kits to use	
mBot, a STEAM educational robot for beginners.	
Evaluation	
vi) Time employed to solve the challenge (students will fill in a grid); vii) degree of success producing a solution (students will fill in a self and hetero evaluation report);	

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viii)	number of people involved in the challenge (information sheet including age, role/status and Education level);
ix)	perception about STEAM (students will be asked to talk about their experience throughout the whole process of this challenge – they can make a video, around two minutes);
x)	assessment of STEM skills and CT skills before and after the challenge (online questionnaires).

The kit employed to carry out the challenge was the mBot robot that is described in table 6.

Table 6. – Kit Empoyed by AEEG during pilo1 challenge

Title	mBot Robot
Reference	https://www.makeblock.com/steam-kits/mbot
Description	
Students can develop Nano Challenges using this platform, that can consist in following a line, obstacle avoidance, sensing the environment while navigating and material transportation.	
Proposal	
The device used is the mBot robot, from Makeblock Co. Ltd., an entry-level STEAM educational robot kit for beginners that makes teaching and learning robot programming simple.	
Components (Repeat these rows as many times as components you have)	
About the specifications of mBot, the main control board is microcontroller ATmega328 and comes with a light sensor, button, IR receiver, ultrasonic sensor, line follower sensor, there are the possibilities to program other modules like the buzzer, 2x RGB LED, IR transmitter and two motors. Can be powered with a 3.7V lithium battery or 6V (4x 1.5V) batteries]. To program the robot the students used mBlock 5 PC version, a software-based on Scratch 3.0 designed to support STEAM education. By supporting block-based and text-based programming, mBlock 5 allows users to freely program the robot to solve the challenge.	
Sample of use	
Thereby, the students involved during the challenges can learn about some of the robot machinery and electronic parts, get ideas about how works the fundamentals of block-programming, and develop their logical thinking and design skills. The mBot already comes with 3 preset control modes: 1 - Obstacle avoidance mode, 2 - Line follow mode 3 - Manual control mode.	
User Manual	
https://www.makeblock.com/steam-kits/mbot-2#Manuals	
Other information	
Acquired at https://www.botnroll.com with a cost of 91.50 euros.	

IES Eras

Table 7.- Minichallenge addressed during Pilot1

Title	Illuminated sign
Description	

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The school festival will be held in the auditorium. Students' relatives and friends will be welcome to the event. We want to signal how to get to the auditorium from the main entrance. To do this you will have to design the light signaling.

Design a program to get 8 different colored LEDs to turn on and turn off in a simple sequence. Insert them in a board to get the route correctly marked.

It is required to use a simulator program before making the model.

Goal/s

GENERAL OBJECTIVES

- Know the basics of computational thinking and acquire the skills to use it when solving simple problems.
- Understand and practice basic programming concepts acquiring the ability to create simple programs using them.
- Address diversity in the classroom: use methodologies and resources that have been specifically selected for STEAM teaching with students with different cultural, academic and competence levels.
- Identify and use relevant everyday real-life contexts and scientist reasoning to promote the essential values of our society.
- Foster inclusive education and intercultural learning through the use of STEAM contexts

SPECIFIC OBJECTIVES

- Know how a LED diode works.
- Calculate the current limiting resistors you should place in a circuit with LED diodes.
- Send different values to an Arduino digital pin.
- Work with loops to send different values with different delays

Evaluation

An active methodology, based on learning making, will be used. Special emphasis is placed on the social and connected nature of learning when designing the activities, by encouraging communication among participants.

Teachers will act as facilitators, monitoring the activities and providing the necessary support for a successful experience. Teachers will be also in charge of proposing the challenges that students will rise to and provide them with web sources where to obtain the necessary information to carry out these challenges.

In addition, every participant will be able to help and collaborate with other participants to solve difficulties and challenges that could arise.

Every participating group of students will generate a solution to solve the challenge.

The realization of the activity plan will contribute to the development and improvement of digital competence, particularly in the Digital contents generation and Solving problems areas.

This mini-challenge is addressed in several nano-challenges showed in Tables 8, 9, 10, 11.

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Table 8. – Eras de Renueva Nanochallenge 1 Pilot 1

Title	Make an LED turn on and off
What is an LED?	
What type of component is an LED? How is it connected? What resistor is required?	
Description	
- Research into the necessary components for the circuit to work correctly. - Calculate the resistor needed to prevent LED from blowing. - Create a program to turn on an LED. - Simulate the circuit using, for example, Tinkercad and send different values to an Arduino digital pin. - Connect the components to the breadboard. - Power on the Arduino board by connecting it to a computer using an USB cable. - Check that the real circuit works.	
Goal/s	
1. Know how to connect an LED to turn it on and off	
Kits to use	
Simulator program, Arduino Uno or similar Arduino board, a breadboard (preferably with a positive and negative rail), an LED, a resistor, jumper wires, USB cable, a computer, IDE Arduino	
Evaluation	
The students should connect correctly all the components and calculate the value for the resistor	

Table 9. – Eras de Renueva Nanochallenge 2 Pilot 1

Title	Make an LED turn on and off with a switch or push
What is a switch? And a push?	
What is a switch used for? What is a push used for?	
Description	
- Research into different types of switches - Decide which is more suitable for the project - Create a program to turn on an LED with a switch/push. - Simulate the circuit using, for example, Tinkercad - Connect the components to the breadboard. - Power on the Arduino board by connecting it to a computer using an USB cable. - Check that the real circuit works.	
Goal/s	
Know how to control an LED using a switch/push	
Kits to use	
Simulator program, Arduino Uno or similar Arduino board, a breadboard (preferably with a positive and negative rail), an LED, a resistor, a switch/push, jumper wires, USB cable, a computer, IDE Arduino	
Evaluation	

The students should connect correctly all the components

Table 10. – Eras de Renueva Nanochallenge 2 Pilot 1

Title	Make at least 8 LED turn on and off using a switch
How can the LEDs be connected?	
Is it possible to light up only some of them? Is it possible to light up all of them at the same time?	
Description	
- Research into different ways of connecting the LEDs. - Try different sequences to find the best for the project. - Create a program to turn on the LEDs using a switch/push. - Simulate the different sequences using, for example, Tinkercad. - Connect the components to the breadboard. - Power on the Arduino Uno or similar Arduino board by connecting it to a computer using an USB cable. - Check that the real circuit works properly.	
Goal/s	
Know how to connect several LEDs to turn them on and off according to a designed sequence	
Kits to use	
Simulator program, Arduino Uno or similar Arduino board, a breadboard (preferably with a positive and negative rail), LEDs, resistors, jumper wires, USB cable, a computer, IDE Arduino	
Evaluation	
The students should design a light sequence and connect correctly all the components to get the design sequence	

Table 11. – Eras de Renueva Nanochallenge 2 Pilot 1

Title	Design the illuminated sign and the light sequence
Model shape? Size? Required materials?	
What type of component is an LED? How is it connected? What resistor is required?	
Description	
- Research into the suitable dimensions for the illuminated sign to be seen. - Design several ideas and decide the one which better meets the project specifications - Select the materials for making the model - Make the model and fix the circuit inside - Check the proposal works.	
Goal/s	
Know how to design and make a model	
Kits to use	
Simple tools for making the model	
Evaluation	
The students should think up several ideas, select the more suitable for the project, plan the materials, tools and the construction process, make the model, evaluate it and present the result	

Regarding the kits employed they are described in Table 12.

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Table 12. – -Eras de Renueva kits applied

Title	Illuminated sign kit
Reference	**Arduino:** ELEGOO UNO Project Basic Starter Kit with Tutorial and UNO R3 Board Compatible with Arduino IDE for Beginner

Description
Components needed for turning on the LEDs of the illuminated sign, according to the sequence designed by the students

Proposal
Cheap and basic kit for beginners. Applicable Age: 12+ To use Elegoo starter kits requires basic electronic knowledge. If the user has no experience, it would be better to have someone lead and teach them while studying

Components
1pcs ELEGOO R3 Controller Board 1pcs USB Cable 1pcs Breadboard pcs 65 Jumper Wire 1pcs IC 74HC595 1pcs Active Buzzer 1pcs Tilt Switch 2pcs Photo resistor 5pcs Yellow LED 5pcs Blue LED 5pcs Green LED 5pcs Red LED 1pcs RGB LED 5pcs Button(small) 10pcs Resistor (10R) 10pcs Resistor (100R) 30pcs Resistor (220R) 10pcs Resistor (330R) 10pcs Resistor (1K) 10pcs Resistor (2K) 10pcs Resistor (5K1) 10pcs Resistor (10K) 10pcs Resistor (100K) 10pcs Resistor (1M) 5pcs Female-to-male DuPont Wire

Sample of use
https://www.mblock.cc/example/blink/ https://www.youtube.com/watch?v=e1FVSpkw6q4

User Manual
Link the user manual for the kit if there is a web with it

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Other information
Other information related to the kit, more documentation, where to acquire it, cost, etc.

KIT (Karlz Benz School)

Table 13. – Minichallenge used by KIT in the Carl Benz School

Title	*Write in this field a title for the mini-challenge* **Overall challenge "Make it shine"** **M1: What's that? – Explore electronic components**
Research question or problem addressed by this mini-challenge	
The **overall challenge** "make it shine" aims to enable pupils to develop circuits, construct and program smart textile objects. The duration of the overall challenge is 5 blocks á 3,5 hours/week. It consists of **5 mini challenges,** which are connected and to be done in order. They are single activities but supposed to be applied in context of the overall goal to make an LED shine. The pupils explore all the steps necessary, such as: 1. "What's that? Explore the electronic components of the Arduino LilyPad technology!" (such as interactive mother board, sensors, actuators and connectors and the pins) 2. "Cable spaghetti? – develop a circuit!" (Using crocodile clips, conductive yarn) 3. "Do you speak computer?" (What is an Algorithm? Understand if-then relations without using a computer, but laying technique with paper elements) 4. Make it shine! Programme your circuit and let the LED shine with Amici 5. "Pimp it up! Test your program! Does the LED shine? Test and correct, improve it.	
Description	
Write in this field the description for the mini-challenge 1. "What's that? Explore electronics": Pupils are asked to identify electronic components, pins and opportunities, connections (Arduino mother board, light sensor, temperature sensor, conductive yarn and conductive textile). This will be done using physical components and work sheets, so that pupils have to identify the sensors and match to the names given on the sheets.	
Goal/s	
Describe in this field the goals of the mini-challenge The challenge overall aim is to enable pupils to develop circuits, construct and program smart textile objects. The goal of mini challenge 1 is, that pupils get familiar with the electronic components and pins, so that they know functions and opportunities of sensors, actors and connectors in a activity oriented way.	
Evaluation	
Describe what you want to evaluate during the pilot and how to measure the grade of success, the instruments used, etc. Observation sheets will be used by KIT researchers and student mentors. All items are clearly described by the indicators to be observed. →The RoboSTEAM survey will be used where applicable.	

Table 14. – Second Nanochallenge used by KIT in the Carl Benz School

Title	"Cable spaghetti? – develop a circuit!" (using conductive yarn and conductive material)

Research question or problem addressed by this mini-challenge
How can we connect electronic components and make it work? Explore wiring electronic circuits using crocodile clips, (later electronic yarn), by connecting pins, and construct a circuit with a sensor and LED

Description
Write in this field the description for the mini-challenge Pupils are asked to wire electronic components to develop a circuit.
Goal/s
Describe in this field the goals of the mini-challenge The goal is to enable pupils to wire a circuit (consisting of motherboard, sensor and LED)
Evaluation
Describe what you want to evaluate during the pilot and how to measure the grade of success, the instruments used, etc. Teams will be observed by student mentors using an observation sheet

Table 15. – Third Nanochallenge used by KIT in the Carl Benz School

Title	"Do you speak computer?"

Research question or problem addressed by this mini-challenge
What is an Algorithm? Understanding if-then relations without using a computer, but using the laying technique with paper elements (if…then…)

Description
Write in this field the description for the mini-challenge Pupils learn about the meaning of algorithms as recipes for activities. They learn to understand if-then relations without using a computer, but using the laying technique with paper elements (if…then…)
Goal/s
Describe in this field the goals of the mini-challenge The goal: After the challenge pupils know the basics of algorithms, as recipes for activities
Evaluation
Describe what you want to evaluate during the pilot and how to measure the grade of success, the instruments used, etc. Observation sheet by student mentors, RoboSTEAM survey, if applicable

The kit employed is shown table 16.

Table 16. – Arduino Lilipad KIT

Title	Arduino LilyPad
Reference	Arduino LiliyPad (former eduwear starter kit) and amici software (open source), available at Watterott online
Description	
The challenge is based on project work for collaborative prototyping	
Proposal	
Describe in this field the proposal of the kit	

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Arduino LilyPad components and amici software (open source available at http://dimeb.informatik.uni-bremen.de/eduwear/ Smart textiles offer many possibilities for creative engagement with so-called "intelligent" attractable media (wearables). They form a new generation of systems embedded in textiles and establish a link to mobile technologies that can be worn on the skin; the implemented computer becomes visible. New interfaces - sewn, woven or embroidered - between body, clothing and environment are made tangible.
Components The "kit" is rather a collection which consists of single electronic components, such as sensors, actuators and the LilyPad main board: Smart Textiles (for example conductive yarn and fabrics), LEDs, vibrating motors, buzzers, light sensors, heat sensors, motion detectors and a small and handy micro-controller which can be used for the construction of intelligent clothes. Amici is a visual programming language which enables programming novices to program Arduino boards without having to master the textual programming language Arduino. Amici is since the Arduino software is based on the open-source open (source code on request), released under the GPL.
Components conductive fabrics
Components conductive yarn
Components LED in different colours and with changing colours
Components vibrating motors
Components buzzers
Components light sensors
Components (heat/temperature sensors)
Components motion detectors
Components micro-controller, main board
Components Adapter and USB cable to transfer the amici program onto the LilyPad main board
Describe the components of the kit with specifying what each can do, how to use and how to install it. The sensors can realize the environment related to   - Heat/Temperature   - Motion   - Light   The actuators can respond to generate outputs such as   - Light/LED   - Sound   - Vibration (motor)
Sample of use
Describe a sample of use for the kit

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An interactive sneaker with LED and motion sensor can react to movements of a person with blinking lights. The main focus was on the development of own project idea (according to the topic "inventing new interactive objects for my favourite profession").

Through the creative examination of microcontrollers, the participants are to acquire a deeper technical understanding in the area of control and regulation and to experience the computer as an independently designable and controllable machine through programming. Also the learners experience self-efficacy. An iconic interface (AMICI) was used to be able to realize independent, module-based programming steps.

User Manual
Link the user manual for the kit if there is a web with it The overall handbook/Tutorial to get started with Smart textile/Wearables with Arduino LilyPad can be accessed at: http://www.taccle3.eu/deutsch/wp-content/uploads/sites/4/2015/12/Tutorial_Lilypad_aduino_ed.pdf
Other information
The hardware components are not available as a complete set anymore (the former eduwear starter kit), but the single components required can be bought one at a time (e.g., at watterott.com)
Other information related to the kit, more documentation, where to acquire it, cost, etc. Arduino LilyPad main board is around 22 EURO, Sensors and actuators around 4-6 EUR

CIC

The challenge is described in Table 17

Table 17. – Description of CIC Pilot1 Challenge

Title	*Logistic management of a warehouse*
Description	
This challenge aims to present a problem inspired on the deployment of autonomous mobile robots on a factory shop floor. One or more robots should be able to transport materials between warehouses or machines that process those materials.	
Goal/s	
The robots must collect, transport and deliver the materials, self-localize and navigate in a maze.	
Evaluation	
The robot with the highest total number of Final Parts placed on the outgoing warehouse is the winner. If there are teams with the same total number of parts, the team that took less time to achieve that has the advantage.	

It can be divided in the minichallenges described in Tables 18, 19 and 20.

Table 18. – Machine Supply minichallenge in CIC Pilot1 Challenge

Title	Machine supply (from incoming warehouse to machine)
Research question or problem addressed by this minichallenge	
Navigation and decision on part type	
Description	
In this minichallenge, the robot should pick a part from the warehouse and deliver it to the machine, depending on the RFID TAG identification	
Goal/s	

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The main goal is to pick and deliver a part correctly from the incoming warehouse to the machine while navigating on the shop floor
Evaluation
A part should be placed correctly on the destination machine.

Table 19. – Final Delivery minichallenge in CIC Pilot1 Challenge

Title	Final delivery (from machine to outgoing warehouse)
Research question or problem addressed by this minichallenge	
Navigation through the middle maze	
Description	
In this minichallenge, the robot should pick a part from the machine and deliver it to the outgoing warehouse.	
Goal/s	
The main goal is to pick and deliver a part correctly from the machine to the outgoing warehouse while navigating on the shop floor	
Evaluation	
A part should be placed correctly on the destination warehouse.	

Table 20. – Direct Delivery minichallenge in CIC Pilot1 Challenge

Title	Direct delivery (from incoming to outgoing warehouse)
Research question or problem addressed by this minichallenge	
Navigation between warehouses	
Description	
In this minichallenge, the robot should pick an item from the incoming warehouse and deliver it to the outgoing warehouse, depending on the RFID TAG identification	
Goal/s	
The main goal is to pick and deliver a part correctly from the incoming warehouse to the outgoing warehouse while navigating on the shop floor	
Evaluation	
A part should be placed correctly on the destination machine.	

Previous minichallenges can be divided in nanochallenges, CIC has defined a nano-challenge to show how each of the minichallenges is addressed (Tables 21, 22 and 23).

Table 21. – Line follower nano-challenge in CIC Pilot1 Challenge

Title	Line follower
Specific Issue to deal with	
To control the mobile robot direction through a line and crosses	
Description	
In this nanochallenge, it is desired to develop low level control algorithms to keep the robot drive through a line and crosses	
Goal/s	
The main goal is to navigate on a floor line following it	
Kits to use	
Warehouse robot kit	
Evaluation	

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The robot should comply the navigation on a line and crosses	

Table 22. – RFID identification nano-challenge in CIC Pilot1 Challenge

Title	RFID identification
Specific Issue to deal with	
Identify the different type of parts	
Description	
In this nanochallenge, it is desired to read a RFID tag that differentiates the part (each one has its own ID)	
Goal/s	
The main goal is to read a RFID tag based on a RFID reader module	
Kits to use	
Warehouse robot kit	
Evaluation	
The robot should acquire the ID of the part	

Table 23. – Navigation on site nano-challenge in CIC Pilot1 Challenge

Title	Navigation on site
Specific Issue to deal with	
Localize and navigation of the robot	
Description	
The robot should localize in the maze, based on the crosses and turns. With that information, a state machine should be developed to perform the movements.	
Goal/s	
To navigate in the maze based on the localization	
Kits to use	
Warehouse robot kit	
Evaluation	
This nanochallenge is correctly performed if the robot is able to move from the source to the destination.	

Regarding the kits employed to develop these nano-challenges the kit used is the described in Table 24.

Table 24. – Logistic management kit

Title	*Logistic management of a warehouse*
Reference	
Description	
This challenge aims to present a problem inspired on the deployment of autonomous mobile robots on a factory shop floor. One or more robots should be able to transport materials between warehouses or machines that process those materials.	
Proposal	
Arduino based robot inspired in the Robot@Factory Lite competition.	
Components (Repeat these rows as many times as components you have)	
2 wheels; 2 motors, 1 motor driver	
parts printed by a 3d printer	
line sensor with 5 emitter and infrared receiver and an Arduino board	
Sample of use	
User Manual	

Other information

UEF

The challenge is described in Table 25.

Table 25. – UEF pilot1 challenge

Title	Well-being of senior citizens
Description	
Life of senior citizens is not always easy, and they don't have enough support or activity in their everyday life. Make suggestions how senior citizens standard of living could be improved.	
Goal/s	
- learn about senior citizens life - consideration of different approaches - making of research and working plan - know about implements tools, communication possibilities and entertainment - using of robotics and computational thinking - collaboration	
Evaluation	
During this challenge we can evaluate: - collaboration - self-guidance - understanding the concept - documentation - STEAM-skills and computational thinking	

A mini-challenge to implement this challenge could be the one described in Table 26.

Table 26. – UEF pilot1 mini-challenge

Title	Implement tools
Research question or problem addressed by this mini-challenge	
What kind of implement tools can we design using robotics?	
Description	

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Senior citizens may have restrictions in their moving, immobilization in their limbs or difficulties in communication. A possible solution to solve these problems could be implementations of robotics. Find out what kind of restrictions senior citizens have and think how mobile robots or different implementations could solve these problems.	
Goal/s	
- study robotics and CT - study and design possible ways to apply robotics to improve senior citizens weel-being - find out about senior citizens life, make an interview or questionnaire - design a possible solution using robotics kit	
Evaluation	
Describe what you want to evaluate during the pilot and how to measure the grade of success, the instruments used, etc. - self-evaluation - group-evaluation - documentation of challenge - self-assessment of STEAM-skills and CT before and after the challenge	

That is divided in several nano-challenges such as the ones in tables 27, 28 and 29.

Table 27. – UEF pilot1 nano-challenge

Title	Follow lines and avoid walls and obstacles with a mobile robot
Specific Issue to deal with	
Design a mobile robot to follow line, turn before wall and avoid obstacles	
Description	
Senior citizens may have restrictions in their moving, immobilization in their limbs or difficulties in communication. A possible solution to solve these problems could be implementations of robotics. Design and built a moving robot which can follow line, turn before walls and avoid obstacles.	
Goal/s	
- study mobile robots - study sensors - study possible way to control the robot - study senior citizens life	

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- design and built a possible approach of a mobile robot that can follow line, turn before wall and avoid obstacles - collaboration	
Kits to use	
Hummingbird (microbit-based extension kit), Lego EV3-kit, makeblock-kit (m Bot)	
Evaluation	
- self-evaluation - group-evaluation - documentation of challenge - self-assessment of STEAM-skills and CT before and after the challenge	

Table 28. – UEF pilot1 nano-challenge

Title	Grab or collect an item with mobile robot
Specific Issue to deal with	
Design a mobile robot to grab or collect an item	
Description	
Senior citizens may have restrictions in their moving, immobilization in their limbs or difficulties in communication. A possible solution to solve these problems could be implementations of robotics. Design and built a moving robot which can grab or collect an item and move it.	
Goal/s	
- study mobile robots - study sensors - study possible way to control the robot - study senior citizens life - design and built a possible approach of a mobile robot that can grab or collect an item and move item - collaboration	
Kits to use	
Hummingbird (microbit-based extension kit), Lego EV3-kit, makeblock-kit (m Bot)	
Evaluation	
- self-evaluation - group-evaluation - documentation of challenge - self-assessment of STEAM-skills and CT before and after the challenge	

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Table 29. – UEF pilot1 nano-challenge

Title	Reacts to different kinds of detects
Specific Issue to deal with	
Design a robot to react sound, touch or rotational motion	
Description	
Senior citizens may have restrictions in their moving, immobilization in their limbs or difficulties in communication. A possible solution to solve these problems could be implementations of robotics. Design and built a moving robot which detects and is controlled by sound, touch and rotational motion.	
Goal/s	
- study mobile robots - study sensors - study possible way to control the robot - study senior citizens life - design and built a possible approach of a mobile robot that is controlled by sound, touch or rotational motion - collaboration	
Kits to use	
Hummingbird (microbit-based extension kit), Lego EV3-kit, makeblock-kit (m Bot)	
Evaluation	
- self-evaluation - group-evaluation - documentation of challenge - self-assessment of STEAM-skills and CT before and after the challenge	

The kit employed for these tasks is Hummingbird robot and it is described in table 30.

Table 30. – UEF pilot1 kit

Title	Well-being of senior citizens
Reference	
Description	
Life of senior citizens is not always easy, and they don't have enough support or activity in their everyday life. Make suggestions how senior citizens standard of living could be improved.	
Proposal	
Hummingbird	

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Components (Repeat these rows as many times as components you have)
Hummingbird Bit Premium Kit Contents: • 1 - Bit Controller • 1 - Terminal Tool • 1 - Battery Pack (4x AA) • 1 - Green LED • 1 - Red LED • 1 - Yellow LED • 2 - Tri-color LED • 2 - FS5103B Servo • 2 - FS5103R Servo • 2 - Servo Wheels • 2 - Lego Adapters • 4 - Servo Extension Cables • 1 - Light Sensor • 1 - Dial Sensor • 1 - Distance Sensor • 1 - Sound Sensor • 1 - User Manual • 1 - Premium Kit Case
Sample of use
You can build many different types of robots with the Hummingbird kit. Some robots are stationary, and others move around their environment. A wheeled robot is called a mobile robot or a rover.
User Manual
https://store.birdbraintechnologies.com/collections/hummingbird-bit/products/hummingbird-bit-premium-kit
Other information
https://www.birdbraintechnologies.com/hummingbirdbit/

3.2. Short description of the application

In report A3 there is a deeper explanation of each of the pilots, the results and the assessment, in this section we summarize each application and include a photo with the results.

AEEG

This pilot was carried out in an Arts context, so the students were not so customed to technology and programming, in order to facilitate the development of the pilot it was carried out at the same time than the exchange C3, with students of the IES Eras de Renueva. The challenge was carried out by 7 Art Portuguese students (5 boys and 2 girls), 4 Science and Technologies students (3 boys and 1 girl) and 8 Spanish students with an educational background related to technologies (4 girls and 4 boys); All of them are fifteen-year-olds. There were four groups which were

made up of Portuguese and Spanish students: all of them with mixed abilities concerning STEAM related competences. Therefore, the groups were heterogeneous. Some results are shown in Figure 3.

Figure 3. – Wildfire challenge in AEEG pilot 1

IES Eras

The pilot 1 was carried out in I.E.S. Eras de Renueva in the context of RoboSTEAM project in October 2018 - January 2019. it involved 13 students 6 Female and 7 Male, with an age from 15 to 16, from three subjects: Control and Robotics, Technology and Coding. Some results can be seen in Figure 4.

Figure 4. -Eras de Renueva results and presentation for pilot1

KIT

The pilot was held with trainees of the Carl-Benz-School Karlsruhe, a vocational school located in the city of Karlsruhe, for the professional fields of vehicle and metal engineering (commercial-technical field). The participants involved in the pilot were 17 trainees of metal technology/engineering as well as 6 university students of engineering pedagogy bachelor (5) and master level (1) to teach and support them as mentors. The school project entitled "smart clothes can do more" was implemented in five teaching blocks of 180 minutes each. The students were divided into five groups and each group was assigned a supervising student. Some results of the pilot are shown in Figure 5.

Figure 5. – Students working in KIT pilot1

CIC

Pilot 1 was carried out by students of the Electronics and Telecommunications course of Colégio Internato dos Carvalhos. The challenge is developed thinking on a warehouse context, it is intended to place an autonomous robot capable of navigating inland by moving the goods between several points. The students who performed this challenge were a total of 12 where 6 are girls and the other 6 are boys, divided into 6 groups, aged between 15 and 16 years. Some results can be seen in Figure 6.
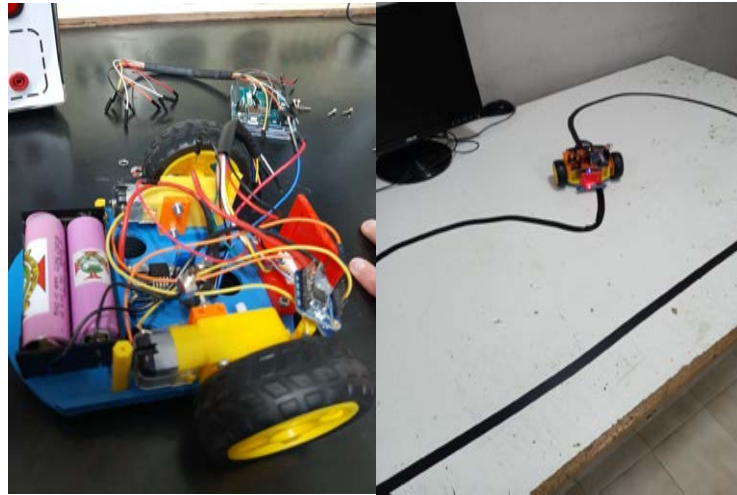
Figure 6. – Robot following the line in CIC pilot 1

UEF

The pilot 1, in University of Eastern Finland, was carried out in the Teacher Training School. Pilot was arranged as extra course for students interested in robotics and international student exchange. Students were not required any knowledge of computational thinking or robotics. The participants in the pilots were 10, distributed in groups of 3 or 4 persons. Some results can be seen in Figure 7.
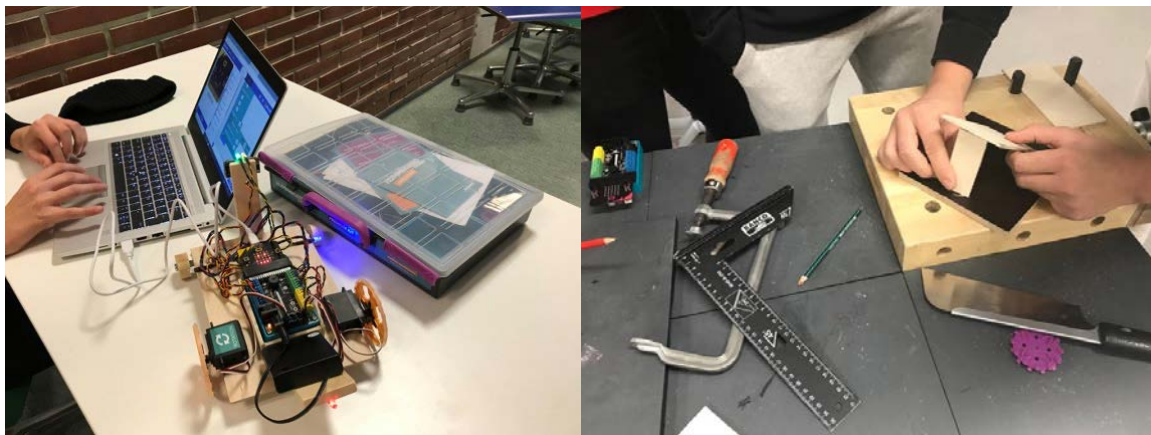

Figure 7. – UEF Students programming humming bird robot

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3.2. Changes motivated by COVID-19

In our initial Schedule the pilot phase 1 should finish for all the partners at the end of M17, but this task was one or two months delayed because of the delay in the project to be granted. In M18, with the transnational meeting students and teachers were going to finish this first stage but the COVID-19 situation arises. This mean that the end of pilot 1 should be delayed for most of the partners (all except KIT). In most cases it was delayed until July (M22). The causes were that there was a lockdown in several of the partners countries (Spain, Portugal and Germany), the classes were discontinued so they should be completed online. This implies more work from teachers and students and has also special impact in the Project because the nature of the pilots was to work together. This was possible once the classes end, and the restrictions were not so hard. This also provides us an idea that other tools can be necessary in order to facilitate completing the pilots.

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4. PILOT PHASE 2 AND CHANGES MOTIVATED BY COVID-19

3.1. Pilot Phase2

A4 will launch a second testing stage. The secondary schools will be involved again. They should develop the same activities than in Pilot 1, and the same students' groups are involved in the challenges. In this case students can choose the instruments, methods and tools from other socioeconomic contexts present in RoboSTEAM environment. The idea is analysing how PD&R kits work in a different socioeconomical context. Later the results will be compared with students that do not participate in the challenges, and with the results obtained during Pilot1. The indicators to be used are the same of Pilot1. As we commented in the first section the partners exchange the challenges so below there are the tables only of those partners that adapted the challenges to their contexts.

AEEG

AEEG did not need to adapt the Eras de Renueva challenges, so they use the challenge of Table 7 and the nano challenges of Tables 8, 9, 10 and 11. Also in this case the kit employed was the defined in Table 12.

IES Eras

This partner employs part of the wildfires challenges but adapted to a domotic concept. The challenge is described in table 30.

Table 30. – MiniChallenge about domotics defined by IER

Title	Domotics
Description	

The school wants to improve our energy consumption. They want to control some situations for decrease it. To do this you will have to design different nanochallenges that controls operations such as:

- The bell rings when each class stars or ends.
- Make some LEDs turn on and off depending on the light
- Barrier motor stops when an obstacle is detected.
- The heating turns on or off depending on the temperature
- Sound the alarm if it detects a fire
- Blinds rise or fall depending on the light
- IoT (Internet of Things) to control the lights and motor of the project.

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• Bluethooth to control the motor of the barrier.	
Goal/s	
vi) Improve Environment; vii) Define the proper research question(s) for the problem mentioned above viii) look for successful strategies in order to reduce energy consumption ix) build a possible approach to the different problems x) be a team player. Find out a collaborative solution/strategy that involves students, parents, teachers and experts in this field.	
Evaluation	
During this challenge we can assess: vi) Time employed to solve the challenge vii) Degree of success producing a solution viii) Number of people involved in the challenge ix) Perception about STEAM x) Assessment of STEM perceptions and CT skills before and after the challenge	

This mini-challenge is addressed in several nano-challenges showed in Tables 31, 32, 33, 34, 35, 36 and 37.

Table 31. – IES Eras de Renueva Nanochallenge 1 Pilot 2

Title	The bell rings when each class stars or ends
Which are the parts of a Bell	
What type of component is a Bell? How is it connected? How to program ring sequence?	
Description	
- Research into the necessary components for the circuit to work correctly. - Types of Bell - Create a program to ring a bell - Create a program to ring a bell sequentially - Connect the components to the breadboard. - Power on the Arduino board by connecting it to a computer using an USB cable. - Check that the real circuit works. - Evaluate the possible types of bell	
Goal/s	
2. Know how to program a Bell	
Kits to use	
Simulator program, Arduino Uno or similar Arduino board, a breadboard (preferably with a positive and negative rail), a Bell, jumper wires, USB cable, a computer, Arduino Blocks	
Evaluation	
The students should connect correctly all the components and test the program	

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Table 32. - Eras de Renueva Nanochallenge 2 Pilot 2

Title	Make some LEDs turn on and off depending on the light
What type of component is a light-dependent resistor?	
What is a LED used for?	
What is a LDR used for?	
Description	
- Research into different types of LDR - Decide which is more suitable for the project - Create a program to turn on an LED with a LDR. - Simulate the circuit - Connect the components to the breadboard. - Power on the Arduino board by connecting it to a computer using an USB cable. - Check that the real circuit works.	
Goal/s	
Know how to control an LED using a LDR	
Kits to use	
Simulator program, Arduino Uno or similar Arduino board, a breadboard (preferably with a positive and negative rail), an LED, a resistor, a LDR, jumper wires, USB cable, a computer, IDE Arduino	
Evaluation	
The students should connect correctly all the components	

Table 33. - Eras de Renueva Nanochallenge 3 Pilot 2

Title	Barrier motor stops or light an LED when an obstacle is detected
How can we use a position sensor?	
Is it possible act depending on a sensor?	
Type of position Sensor?	
Description	
- Try different type of position sensors. - Create a program to check and act depending on position sensor - Connect the position sensor with a servo and a button - Simulate the different sequences using, for example, Tinkercad. - Connect the components to the breadboard. - Power on the Arduino Uno or similar Arduino board by connecting it to a computer using an USB cable. - Check that the real circuit works properly.	
Goal/s	
Know how to connect a position sensor, a servo and a button	
Kits to use	
Simulator program, Arduino Uno or similar Arduino board, a breadboard (preferably with a positive and negative rail), temperature sensor (e.g: DHT 11), a LED, jumper wires, USB cable, a computer, IDE Arduino	
Evaluation	
The students should design a program to use the position sector and acts properly depending on it	

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Table 34. - Eras de Renueva Nanochallenge 4 Pilot 2

Title	The heating turns on or off depending on the temperature
How can we use a temperature sensor?	
What type of component temperature sensor? How is it connected? What is required?	
Description	
- Research into different types of temperature sensors - Decide which is more suitable for the project - Create a program to turn on an LED depending on a temperature sensor. - Simulate the circuit - Connect the components to the breadboard. - Power on the Arduino board by connecting it to a computer using an USB cable. - Check that the real circuit works.	
Goal/s	
Know how to design and make a model	
Kits to use	
Simulator program, Arduino Uno or similar Arduino board, a breadboard (preferably with a positive and negative rail), temperature sensor (e.g.: DHT 11), a LED, jumper wires, USB cable, a computer, IDE Arduino	
Evaluation	
The students should design a program to use the temperature sensor and acts properly depending on it	

Table 35. - Eras de Renueva Nanochallenge 5 Pilot 2

Title	Sound the alarm if it detects a fire
How can we use a temperature sensor to use and alarm?	
Alarm systems? Evacuation protocol?	
Description	
- Research into different types of temperature sensors - Decide which is more suitable for the project - Create a program to turn on a buzzer depending on a temperature sensor. - Simulate the circuit - Connect the components to the breadboard. - Power on the Arduino board by connecting it to a computer using an USB cable. - Check that the real circuit works.	
Goal/s	
Know how to design and make a model	
Kits to use	
Simulator program, Arduino Uno or similar Arduino board, a breadboard (preferably with a positive and negative rail), temperature sensor (e.g.: DHT 11), a buzz, jumper wires, USB cable, a computer, IDE Arduino	
Evaluation	
The students should design a program to use the temperature sensor and play the buzz if the temperature pass a specific temperature	

Table 36. - Eras de Renueva Nanochallenge 6 Pilot 2

Title	Blinds rise or fall depending on the light
How can we make decisions depending on a light sensor?	
Type of motor? Programming turns and speed engine	
Description	
- Research into type of motors - Decide which is more suitable for the project - Create a program to run a motor depending on a light sensor. - Simulate the circuit - Connect the components to the breadboard. - Power on the Arduino board by connecting it to a computer using an USB cable. - Check that the real circuit works.	
Goal/s	
Know how to design and make a model	
Kits to use	
Simulator program, Arduino Uno or similar Arduino board, a breadboard (preferably with a positive and negative rail), an servo, a resistor, a LDR, jumper wires, USB cable, a computer, IDE Arduino	
Evaluation	
The students should design a program to run a servo if a LDR does not detect light	

Table 37. - Eras de Renueva Nanochallenge 7 Pilot 2

Title	Bluetooth to control the motor of a barrier
Control a servo by using Bluetooth	
Interaction through Bluetooth Programming turns a servo remotely	
Description	
- Research in the remote-control using Bluetooth - Decide which is more suitable for the project - Create a program to run a motor controlled by Bluetooth - Simulate the circuit - Connect the components to the breadboard - Power on the Arduino board by connecting it to a computer using an USB cable - Check that the real circuit works	
Goal/s	
Know how to design and make a model	
Kits to use	
Simulator program, Arduino Uno or similar Arduino board, a breadboard (preferably with a positive and negative rail), a servo, jumper wires, USB cable, a computer, IDE Arduino	
Evaluation	
The students should design a program to run a servo if a LDR does not detect light	

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Regarding the kits employed were the described in Table 12.

KIT (Karl Benz School)

In this case the challenge was the same than in pilot 1 (defined in Table 13) but the nano-challenges addressed the same problem (illuminating LEDs) than the IES Eras de Renueva School defined for pilot1. The tables of the specific nano-challenges dealing with this can be seen in Tables 38 and 39.

Table 38 – Nanochallenge1 used by KIT in the Carl Benz School

Title	Make it shine!
Research question or problem addressed by this mini-challenge	
How to make the LED shine? Programme your circuit and let the LED shine with Amici	
Description	
Write in this field the description for the mini-challenge Pupils use the circuit (light sensor, LilyPad Arduino board, power holder, battery and LED) and programm to make the LED shine using Amici environment	
Goal/s	
Describe in this field the goals of the mini-challenge Teams of pupils get familiar with the interface of amici using the different functions e.g. loop, If…on/if…off…	
Evaluation	
Describe what you want to evaluate during the pilot and how to measure the grade of success, the instruments used, etc. Observation sheets will be used by student mentors, RoboSTEAM survey if applicable	

Table 39 – Nanochallenge2 used by KIT in the Carl Benz School

Title	"Pimp it up! Test your program! Does the LED shine? Test and correct, improve it.
Research question or problem addressed by this mini-challenge	
How to make the LED shine? Programme your circuit and let the LED shine with Amici	
Description	
Write in this field the description for the mini-challenge Pupils use the circuit (light sensor, LilyPad Arduino board, power holder, battery and LED) and programm to make the LED shine using Amici environment	
Goal/s	
Describe in this field the goals of the mini-challenge Teams of pupils get familiar with the interface of amici using the different functions e.g. loop, If…on/if…off…	
Evaluation	
Describe what you want to evaluate during the pilot and how to measure the grade of success, the instruments used, etc. Observation sheets will be used by student mentors, RoboSTEAM survey if applicable	

CIC

CIC adopts UEF first pilot challenge, that is shown in Table 25, although they defined their own mini-challenge. It is described in tTble 40.

Table 40. – Minichallenge defined from UEF Pilot1 challenge

Title	Dancing Robot
Research question or problem addressed by this minichallenge	
Dancing to the music	
Description	
In this minichallenge, the robot must be able to perform a dance according to the music.	
Goal/s	
The main objective is for the robot to perform a dance according to the music, that is, perform a choreography synchronized with the music in a limited space.	
Evaluation	
Due to the poor mobility and health conditions of senior citizens, the robot dance has a limited space and time and should please them with its choreography and synchronism with the music.	

CIC employed the same kit they use for pilot 1, that is, the described in Table 24.

UEF

This partner adopted the challenge define by CIC in Tables 20, 21, 22 and 23, to address the same problem they were dealing with in their pilots, that is senior citizens well-being.

4.2. Short description of the application

In report A4 there is a deeper explanation of each of the pilots, the results and the assessment, in this section we summarize each application and include a photo with the results.

AEEG

Pilot2 was carried in COVID-19 situation in the context of RoboSTEAM project from 19th November 2020 to 5th January 2021 at AEEG. It was carried out by two classes. The class D, eleventh grade (secondary level) in Sciences and Technologies, made up of 21 students (17 boys and 4 girls), with an average age is 16 years old; and the Art class (11th E), that is made up of ten students with

also an age of 16. Actually, due to the restrictions related with this pandemic context, it was not possible to gather students from the two different classes. Being so, the Art students did the artwork and class D, after being given the art crafts. Photos of the results are shown in Figure 8.

Figure 8. – Students working in AEEG pilot 2

IES ERAS de Renueva

I.E.S. Eras de Renueva carried out the project with students aged 14-16. They are students of the subjects of Control and Robotics (3rd Course of Secondary Education) and Technology and Coding (4th Course of Secondary Education). The students did not have previous knowledge about Robotics, although all of them acquired basic skills regarding electric circuits in Technology class (1º ESO).

The minichallenge to be addressed was chosen from the use of heat sensors employed in the Wildfire challenge developed by AEEG during the pilot1. The challenge was adapted but the concepts to manage it are similar

Figure 9 shows some of the results and the students working on them.

Figure 9. – Eras de Renueva students working in pilot2

KIT (Karlz Benz School)

In this case the context and students were the same of the first pilot. Teaching block 2 served as the pilot 2 and was aimed at developing a general basic understanding of computer science concepts and processes, including LED on and off task (challenge adapted from the defined by I.E.S Eras de Renueva during the pilot 1). This included above all an understanding of algorithms, i.e., if-then-relations. Theoretical knowledge was planned by playfully introducing students to the first principles of computer science by guiding a 'robot' (person) through the classroom with the help of simple control commands (right, straight ahead, turn 90° to the left). The first basic ideas of loops were also discussed. Figure 10 shows the results presentation.

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Figure 10. – Students' presentation of the results

CIC

Pilot 2 was carried out on the premises of Colégio Internato dos Carvalhos, by students of the Electronics and Telecommunications course. Due to the pandemic situation, the time available for this challenge was too short and implemented with some restrictions. In this case they choose the challenge of UEF regarding Well-being of senior citizens. The students who performed this challenge were a total of 25 where 6 are girls and the other 19 are boys, divided into 11 groups, aged between 15 and 16 years. Figure 11 shows two images of the dancing robots.

Figure 11. – Two images of the dancing robots (in A4 report some videos are available)

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UEF

The pilot 2, in University of Eastern Finland, was carried out in the same context than pilot 1. It was arranged as extra course for students interested in robotics and international student exchange. Interested students made applications to course and the group involved was chosen by teachers. Students were not required any knowledge of computational thinking or robotics. The participants in the pilots were 10, distributed in groups of 3 or 4 persons. However, COVID-19 situation caused that part of the group finished their elementary school during the course so only 5 students carried out the course to end. In this case the hummingbird was use to solve CIC challenges. Figure 12 shows some of the results.
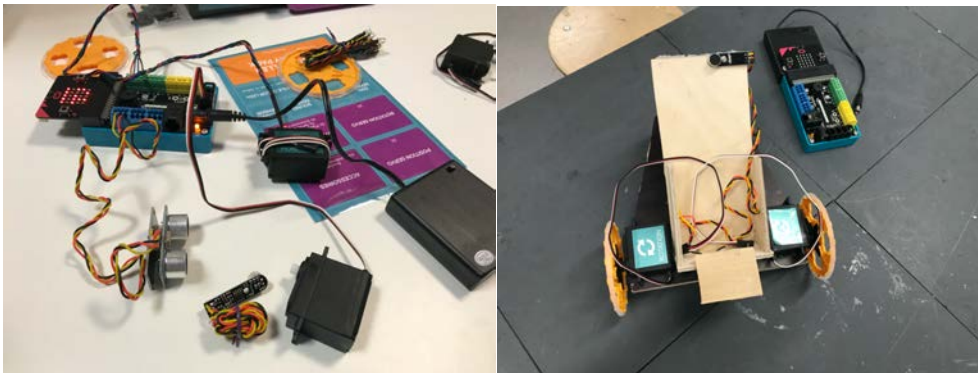
Figure 12. – Some of the kits and results

4.2. Changes motivated by COVID-19

The activity was scheduled to be completed between months M12 and M19 although we should consider that this task was a bit delayed because it needs to use the results of activities of O2 and O3 from the first year and the project grant approval was delayed several months and COVID pandemic situation arises on M18, classes were discontinued, and the partners should look for ways to finish both this pilot phase and pilot phase 1 in most of the cases this implies use virtual tools or to finish the piloting in smaller groups [35]. In fact, all partners except KIT (that carried out pilot phase 1 and 2 in the first semester of 2019/2020 academic year) have to delay the pilot2 until M26 (after the authorization of the agency for

extending the project). The schools commented that they have to devote more time in preparing and conducting classes in online mode and later with social distance, it was not possible to complete the pilots on time. Another change in the pilot is that due to COVID-19, the pilot2 was concluded in the next academic year 2020/2021 instead of 2019/2020, so some students were not in their institutions and therefore other students are involved.

5. ACKNOWLEDGEMENTS

6. REFERENCES

[1]   RoboSTEAM Consortium, "RoboSTEAM Project," presented at the RoboSTEAM Erasmus+ project Kick-Off, Bragança, Portugal, February 15-16, 2019, 2019. [Online]. Available: https://goo.gl/Ni43mK.

[2]   M. Á. Conde *et al.*, "RoboSTEAM - A Challenge Based Learning Approach for integrating STEAM and develop Computational Thinking," in *TEEM'19 Proceedings of the Seventh International Conference on Technological Ecosystems for Enhancing Multiculturality (Leon, Spain, October 16th-18th, 2019)*, M. Á. Conde-González, F. J. Rodríguez-Sedano, C. Fernández-Llamas, and F. J. García-Peñalvo Eds. New York, NY, USA: ACM, 2019, pp. 24-30.

[3]   J. Gonçalves *et al.*, "Educational Robotics Summer Camp at IPB: A Challenge based learning case study," in *TEEM'19 Proceedings of the Seventh International Conference on Technological Ecosystems for Enhancing Multiculturality (Leon, Spain, October*

16th-18th, 2019), M. Á. Conde-González, F. J. Rodríguez-Sedano, C. Fernández-Llamas, and F. J. García-Peñalvo Eds. New York, NY, USA: ACM, 2019, pp. 36-43.

[4] C. Fernández-Llamas and M. Á. Conde-González, "RoboSTEAM Project – A brief review," 2019. [Online]. Available: https://zenodo.org/record/3531941.

[5] M. Á. Conde, F. J. Rodríguez Sedano, C. Fernández-Llamas, J. Gonçalves, J. Lima, and F. J. García-Peñalvo, "RoboSTEAM Project Systematic Mapping: Challenge Based Learning and Robotics," in *2020 IEEE Global Engineering Education Conference (EDUCON), (27-30 April 2020, Porto, Portugal)*. USA: IEEE, 2020, pp. 214-221.

[6] M. Á. Conde *et al.*, "Exchanging Challenge Based Learning Experiences in the Context of RoboSTEAM Erasmus+ Project," in *Learning and Collaboration Technologies. Design, Experiences. 7th International Conference, LCT 2020, Held as Part of the 22nd HCI International Conference, HCII 2020, Copenhagen, Denmark, July 19–24, 2020, Proceedings, Part I*, P. Zaphiris and A. Ioannou Eds., (Lecture Notes in Computer Science, no. 12205). Cham, Switzerland: Springer Nature, 2020, pp. 442-455.

[7] M. Á. Conde *et al.*, "Adaption of RoboSTEAM Project to the Pandemic Situation," in *Proceedings TEEM'20. Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality (Salamanca, Spain, October 21st - 23rd, 2020)*, F. J. García-Peñalvo Ed., (ICPS: ACM International Conference Proceedings Series. New York, NY, USA: ACM, 2020.

[8] M. Á. Conde, F. J. Rodríguez-Sedano, C. Fernández-Llamas, J. Gonçalves, J. Lima, and F. J. García-Peñalvo, "Fostering STEAM through Challenge Based Learning, Robotics and Physical Devices: A systematic mapping literature review," *Computer Application in Engineering Education,* vol. 29, pp. 46-65, 2021, doi: 10.1002/cae.22354.

[9] E. Hamner and J. Cross, "Arts & Bots: Techniques for distributing a STEAM robotics program through K-12 classrooms," in *Proceedings of 2013 IEEE Integrated STEM Education Conference (ISEC) (March 9th, 2013, Princeton, NJ, USA)*. USA: IEEE, 2013, pp. 1-5.

[10] F. J. García-Peñalvo, "What computational thinking is," *Journal of Information Technology Research,* vol. 9, no. 3, pp. v-viii, 2016.

[11] F. J. García-Peñalvo, "Computational thinking," *IEEE Revista Iberoamericana de Tecnologías del Aprendizaje (IEEE RITA),* vol. 13, no. 1, pp. 17-19, 2018, doi: 10.1109/RITA.2018.2809939.

[12] F. J. García-Peñalvo and J. Cruz-Benito, "Computational thinking in pre-university education," in *Proceedings of the Fourth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'16) (Salamanca, Spain, November 2-4, 2016)*, F. J. García-Peñalvo Ed., (ICPS: ACM International Conference Proceeding Series. New York, NY, USA: ACM, 2016, pp. 13-17.

[13] F. J. García-Peñalvo and J. A. Mendes, "Exploring the computational thinking effects in pre-university education," *Computers in Human Behavior,* vol. 80, pp. 407-411, 2018, doi: 10.1016/j.chb.2017.12.005.

[14] J. M. Wing, "Computational Thinking," *Communications of the ACM,* vol. 49, no. 3, pp. 33-35, 2006, doi: 10.1145/1118178.1118215.

[15] Y. A. Caballero-González and A. García-Valcárcel, "¿Aprender con robótica en Educación Primaria? Un medio de estimular el pensamiento computacional," *Education in the Knowledge Society,* vol. 21, 2020, Art no. 10, doi: 10.14201/eks.21443.

[16] H. Montes-León, R. Hijón-Neira, D. Pérez-Marín, and R. Montes-León, "Mejora del Pensamiento Computacional en Estudiantes de Secundaria con Tareas Unplugged," *Education in the Knowledge Society,* vol. 21, 2020, Art no. 24, doi: 10.14201/eks.23002.

[17] E. Segredo, G. Miranda, and C. León, "Hacia la educación del futuro: el pensamiento computacional como mecanismo de aprendizaje generativo," *Education in the Knowledge Society,* vol. 18, no. 2, pp. 33-58, 2017, doi: 10.14201/eks20171823358.

[18] C. S. González-González, "State of the art in the teaching of computational thinking and programming in childhood education," *Education in the Knowledge Society,* vol. 20, 2019, Art no. 17, doi: 10.14201/eks2019_20_a17.

[19] F. J. García-Peñalvo, D. Reimann, and C. Maday, "Introducing Coding and Computational Thinking in the Schools: The TACCLE 3 – Coding Project Experience,"

in *Computational Thinking in the STEM Disciplines. Foundations and Research Highlights*, M. S. Khine Ed. Cham, Switzerland: Springer, 2018, ch. 11, pp. 213-226.

[20]   D. Reimann and C. Maday, "Smart Textile objects and conductible ink as a context for arts based teaching and learning of computational thinking at primary school," in *Proceedings of the Fourth International Conference on Technological Ecosystems for Enhancing Multiculturality (TEEM'16) (Salamanca, Spain, November 2-4, 2016)*, F. J. García-Peñalvo Ed., (ICPS: ACM International Conference Proceeding Series. New York, NY, USA: ACM, 2016, pp. 31-35.

[21]   D. Reimann and C. Maday, "Enseñanza y aprendizaje del modelado computacional en procesos creativos y contextos estéticos," *Education in the Knowledge Society,* vol. 18, no. 3, pp. 87-97, 2017, doi: 10.14201/eks20171838797.

[22]   H. Fardoun, C. S. González-González, C. A. Collazos, and M. Yousef, "Estudio exploratorio en Iberoamérica sobre procesos de enseñanza-aprendizaje y propuesta de evaluación en tiempos de pandemia," *Education in the Knowledge Society,* vol. 21, 2020, Art no. 17, doi: 10.14201/eks.23537.

[23]   F. J. García-Peñalvo, A. Corell, V. Abella-García, and M. Grande-de-Prado, "Online Assessment in Higher Education in the Time of COVID-19," *Education in the Knowledge Society,* vol. 21, 2020, Art no. 12, doi: 10.14201/eks.23013.

[24]   J. Cabero-Almenara and C. Llorente-Cejudo, "Covid-19: radical transformation of digitization in university institutions," *Campus Virtuales,* vol. 9, no. 2, pp. 25-34, 2020.

[25]   S. J. Daniel, "Education and the COVID-19 pandemic," *PROSPECTS,* 2020, doi: 10.1007/s11125-020-09464-3.

[26]   Á. Fidalgo-Blanco, M. L. Sein-Echaluce, and F. J. García-Peñalvo, "Hybrid Flipped Classroom: adaptation to the COVID situation," in *Proceedings TEEM'20. Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality (Salamanca, Spain, October 21st - 23rd, 2020)*, F. J. García-Peñalvo Ed., (ICPS: ACM International Conference Proceedings Series. New York, NY, USA: ACM, 2020.

[27] F. J. García-Peñalvo and A. Corell, "La COVID-19: ¿enzima de la transformación digital de la docencia o reflejo de una crisis metodológica y competencial en la educación superior?," *Campus Virtuales,* vol. 9, no. 2, pp. 83-98, 2020.

[28] F. J. García-Peñalvo, A. Corell, V. Abella-García, and M. Grande-de-Prado, "Recommendations for Mandatory Online Assessment in Higher Education During the COVID-19 Pandemic," in *Radical Solutions for Education in a Crisis Context. COVID-19 as an Opportunity for Global Learning*, D. Burgos, A. Tlili, and A. Tabacco Eds., (Lecture Notes in Educational Technology. Singapore, Singapore: Springer Nature, 2021, ch. 7, pp. 85-98.

[29] F. J. García-Peñalvo, A. Corell, R. Rivero-Ortega, M. J. Rodríguez-Conde, and N. Rodríguez-García, "Impact of the COVID-19 on Higher Education: An Experience-Based Approach," in *Information Technology Trends for a Global and Interdisciplinary Research Community*, F. J. García-Peñalvo Ed., (Advances in Human and Social Aspects of Technology (AHSAT) Book Series. Hershey, PA, USA: IGI Global, 2021, ch. 1, pp. 1-18.

[30] M. Nicola *et al.*, "The socio-economic implications of the coronavirus pandemic (COVID-19): A review," *International Journal of Surgery,* vol. 78, pp. 185-193, 2020, doi: 10.1016/j.ijsu.2020.04.018.

[31] W. Van Lancker and Z. Parolin, "COVID-19, school closures, and child poverty: a social crisis in the making," *The Lancet Public Health,* vol. 5, no. 5, pp. e243-e244, 2020, doi: 10.1016/S2468-2667(20)30084-0.

[32] R. M. Viner *et al.*, "School closure and management practices during coronavirus outbreaks including COVID-19: a rapid systematic review," *The Lancet Child & Adolescent Health,* vol. 4, no. 5, pp. 397-404, 2020, doi: 10.1016/S2352-4642(20)30095-X.

[33] R. Gil-Fernández, A. León-Gómez, and D. Calderón-Garrido, "Influence of COVID on the Educational Use of Social Media by Students of Teaching Degrees," *Education in the Knowledge Society,* vol. 22, 2021, Art no. e23623, doi: 10.14201/eks.23623.

[34] A. Corell and F. J. García-Peñalvo, "COVID-19: La encerrona que transformó las universidades en virtuales," *Gaceta Cultural,* no. 91, pp. 23-26, 2021.

[35]   M. Á. Conde *et al.*, "Adaption of RoboSTEAM Project to the Pandemic Situation," presented at the Eighth International Conference on Technological Ecosystems for Enhancing Multiculturality, Salamanca, Spain, 2020. [Online]. Available: https://doi.org/10.1145/3434780.3436620.