RoboSTEAM Pilot Phase 2 – A4
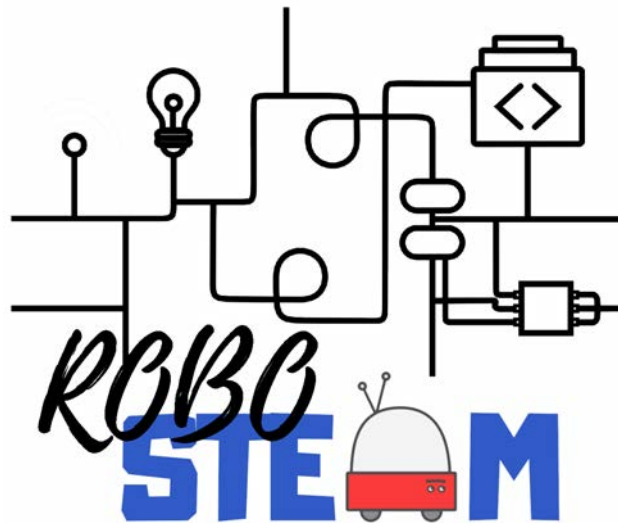
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Version	Date	Comments
0.1	31/03/2020	Pilot Phase 2 and COVID impact
0.2	31/12/2020	Pilot Phase 2 finish with COVID
0.3	31/01/2021	Reporting pilots with template
1.0	31/03/2021	Summary of the different reports

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1. Pilot Phase 2 – A4

This document describes the second pilot described in RoboSTEAM project [1-8]. The different guides, kits and designs defined during O2 and O3 should be tested in an educational context so this will be done in the involved high schools with students in the range from 12-16. In this case instead of using a challenge defined by the school involved in the testing, the challenge should be one of the defined by other partners, so later it was possible to compare the results. More specifically this activity is described as follows:

> "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".

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-19 [9-21] 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 [22]. In fact, in the case of pilot2 in most of the cases should be delayed until M26 (after the authorization of the agency for extending the project). The schools commented that they have to devoted 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

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change in the pilot is that due to COVID-19, the pilot 2 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.

2. The piloting

2.1. The involved schools

Piloting requires of a set of schools where the different kits, methodologies and tools were going to be tested. They were the same identified during first year in O2.A3 [23] and that are described in pilot phase1 report [REF]. Specifically, they were:

- I.E.S. Eras de Renueva. High School (León - Spain).
- Carl Benz School Karlsruhe, Vocational school (Germany).
- Agrupamento de Escolas Emídio Garcia (Bragança – Portugal).
- Colégio Internato dos Carvalhos (Pedroso – Portugal).
- University of Eastern Finland, Educators School (Joensuu – Finland).

From them in the second phase of the piloting, as there is not a diagnosis phase only students from 15 to 16 were involved although due to COVID-19 not all of the involved in first pilot 1 were in pilot 2.

2.1. The sample of students

In all the involved schools except the students chosen were those of technological activities.

The number of students involved per each school could be seen in Table 1. It is necessary to take into account the changes doubt to COVID-19, on the table the color of the data is different if the students are the same than in pilot 1 (in black) or if some have changed (in blue). In the cases that some of the students have changed more of them have been included in the pilot so numbers have grown. In the German pilot we should point out that there was one student of 18 years

old. In Finland 5 of the students involved in pilot1 finished their studies so only 5 remain and this data is marked in red.

Table 1. - Average values for each area and each involved school

School Name	Students	Gender	Age
I.E.S. Eras de Renueva	13	6F – 7M	15-16
Carl Benz School Karlsruhe	17	1F – 16M	16-18
Agrupamento de Escolas Emídio Garcia	31	14F – 17M	15-16
Colégio Internato dos Carvalhos	25	6F – 19M	15-16
University of Eastern Finland	5	5M	15-16

Once described the sample and the way in which the involved students were affected by COVID the next section is devoted to describing the pilots in each institution.

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2. THE PILOT

During the pilot phase 2, the idea was that that the teachers use the same students of pilot phase 1 to address some challenges from a different socioeconomic context with different kits. In this case each school choose a challenge defined by other partner. To evaluate the students' work, we have used indicators such as time, objective assessment a collaboration test and a computational thinking instrument. These tools were chosen from the defined in [24].

2.1.1 Pilot 1 – 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 (description of the challenge is visible in Table 2).

Table 2. – 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. • Bluethooth to control the motor of the barrier.	
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 reduce energy consumption	

iv)	build a possible approach to the different problems
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
ii)	Degree of success producing a solution
iii)	Number of people involved in the challenge
iv)	Perception about STEAM
v)	Assessment of STEM perceptions and CT skills before and after the challenge

This mini-challenge is addressed in several nano-challenges showed in Tables 3, 4, 5, 6.

Table 3. – 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	
1. 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	

Table 4. - 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	

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- 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 5. - 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

Table 6. - 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

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- 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	

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 an specific temperature	

Title	Blinds rise or fall depending on the light
How can we make decisions depending on a light sensor?	
Type of motor? Programing 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	

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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, 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 9. - 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 Programing 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), an 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	

Regarding the kits employed they are described in table 9

Table 10. – IES Eras de Renueva Kit Pilot 2

Title	**Arduino 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 the LEDs of the illuminated sign on 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	

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

Regarding the results obtained and the evaluation of students work, Eras used the following instruments:

- **Time for solving the nano-challeges of pilot phase 1.** Students worked one hour a week individualy and one hour a week in teams during the first term, approximatly 10 hours individually and 10 hours in teams.

- **Team work.** Students worked in teams of 3 to 4 members from the different subjects. All the teams worked in a coordinated way to solve the challenges proposed, obtaining good results both in the programming part,

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as well as the physical construction of the model and the presentation of their proposals (A sample can be seen in Figure 1 and Figure 2).

Figure 1. - Eras students working collaboratively in the projects

Figure 2. - Eras students working collaboratively in the projects

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- **Assessment instruments.** Regarding the assesment instruments we used they were:
    - o STEAM Semantics Survey. Before starting with the different projects, this survey was carried out to assess learners' starting points. At the end of the Project, the survey will be carried out again to evaluate their progress in skills related to control, robotics and physical devices. This first pilot phase will be decisive in the overall progress of our students.
    - o Co-Measure rubric. A rubric to assess student collaboration in STEAM units. This rubric was used for the evaluation and co-evaluation of the work developed by each of the groups. It values both teamwork and the variety of solutions provided by each team, and the problem-solving process as well. All the teams finished the nano-challenges proposed, coding, connecting the circuit and implementing it in the model in a satisfactory way. Students had not work before with these applications and Ardunio kits but they improved their skills very quickly.
    - o CT Questionnarie. Students participanting in the project took this questionnaitre.
    - o Check list. A double entry table was used to follow the progress of the teams in the achievement of the challenges. This table contained the nanochalleges to be achieved and the teams, and it was noted if the challenges were completed correctly or not.
    - o Models. Teams designed and made a model to check and show their proposal and how it worked (Figure 3 and Figure 4).
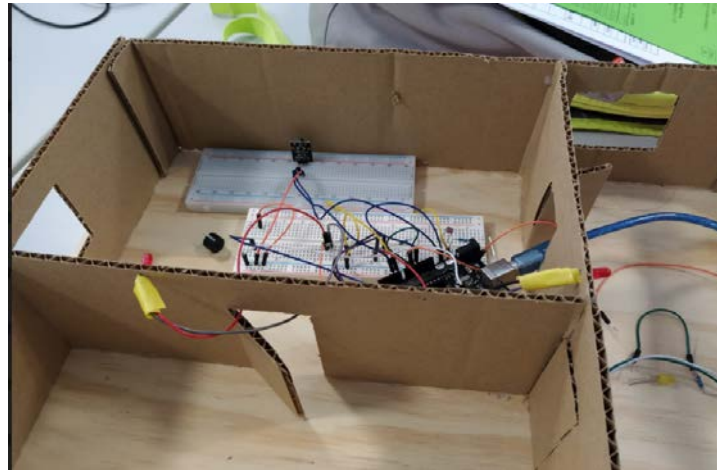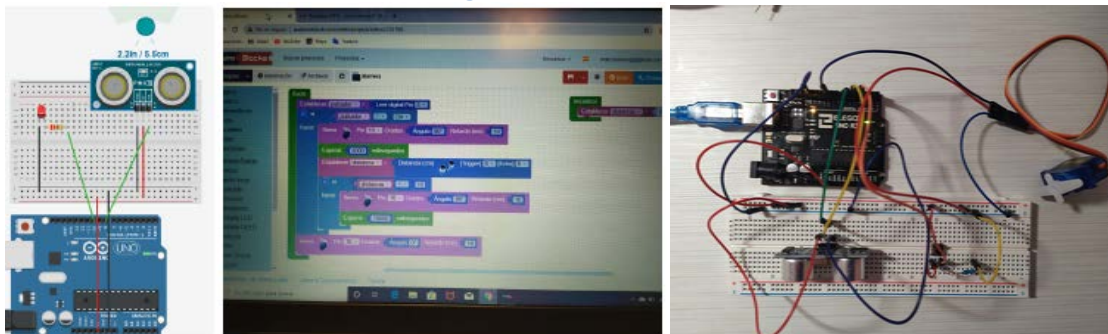
Figure 3. – Model1 Photo

Figure 4. Photo of the model and the simulation environment

- o Presentations. Each team made a presenttion to explain their project, encountered difficulties and adopted solutions. This was done taking into account the COVID-19 restrictions.

- o Knowledge Surveys: Digital applications to test individual progress. Quizziz and Kahoot were used to create questionnaires to assess the individual progress of each student on the contents related to the Project (Figure 5 and Figure 6).

- o Time for solving the nano-challeges of pilot phase 1.

- o Written test. Students also took the traditional class written tests with short answer questions about components and connections and exercises about electric circuits.

- o Coding test. Every student had to design a program, coding with Scratch to solve the challenge posed.

Figure 5. – Quizziz used for knowledge assesment

Figure 6. – Quizziz results

The results obtained that are useful to evaluate the experiment are not shown in this report but in the report of activity O2.A5.

2.1.2 Pilot 2 – Carl Benz School, Karlsruhe

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), in the framework of the German dual system of Vocational education and training. Specifically, it is developed with students of the course "Metal Engineering". The trainees were enrolled in the apprenticeship of Metal Technology, which leads to the desired profession of precision mechanic. The first year of training is completed almost entirely at the

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school. In addition, an internship takes place fortnightly on two days, if possible, in the company where the training will later take place. At the end of the school year, a practical examination is taken. If passed, the vocational school is credited as the 1st year of training. There are no costs for the vocational school. At the Carl-Benz-Schule, the one-year vocational school is offered in metal technology and automotive engineering.

The participants involved in the pilot were described in Table 3. They 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 (Figure 7).

Figure 7. -Pedagogy students working with the vocational school students

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. The KIT (university) students'

(engineering pedagogues who are trained to become e.g., vocational school teachers) tasks were to plan, moderate and supervise teaching blocks and observe pupils. Working groups were set up for this purpose. All processes of the collaborative and creative prototype development were defined as challenges.

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.

In teaching blocks 3 and 4, the basic concepts of computer science already mentioned in block 2 were deepened and the students' projects were designed in groups and the 'smart textiles' were completed as far as possible. This implies the development of a circuit, the coding of the functionality of the work piece as well as a manual implementation by sewing and gluing. In block 5, the developed competences and interests of the pupils were to be assessed by means of questionnaires and the work pieces were to be completed and presented.

Lesson block 5 was the last lesson of the project, which was intended to measure the success of the project. A small group survey already conducted in block 1 was repeated so that the results could be compared with each other in the following. In addition, the research project prescribed the CT test (see O2.A5), which was also intended to measure learning success, but by transferring knowledge. After completion of their projects the pupils were to prepare a presentation about their project work and the results of their project. This allowed slower groups to gain time to complete their work, while faster groups could focus on their presentation. The presentation of the results of the work by the students could allow for reflection on mistakes and successes as well as the presentation of their individual ideas (Figure 8 show these presentation).

In the following Block 5, the 5 workings groups' prototypes were presented: 3 different interactive caps, an interactive hoodie as well as a shirt with the KIT Logo consisting of LED (Presentation pictures are seen Figure 8).

Figure 8. – Students' presentation of the results

The minichallenge addressed is shown in table 11 and is complemented by the nanochallenges of the Tables 12 and 13 during this first pilot.

Table 11. - Minichallenge used by KIT in the Carl Benz School

Title	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	

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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 12. – 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 13. – 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

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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	

The eduwear "kit" used is based on Arduino LilyPad technology invented by Leah Buechley, former head of the research group "High-low tech" at MIT. It is used in the RoboSTEAM project by the partner KIT and extended by the software amici, which was selected for didactic (educational) reasons, as an iconic programming drag and drop environment is used to make visible the models the computer's operations are based on. More information is shown in table 14.

Table 14. – Nanochallenge2 used by KIT in the Carl Benz School

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 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	

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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

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

Regarding assessment the instruments used were the STEAM Semantic Survey the Co-Measure Rubric translated into German, the Computational Thinking tests translated into German and an observation rubric. The three formers have been yet described for Eras Pilot, so they are not repeated here. Regarding the other

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instrument used, it was the observation sheet along the creative processes of collaborative prototyping of the pupils by the university students. Validated in the framework of KIT's BMBF-funded MediaArt@Edu project.

We should point out that although the students have all the same time to complete the projects, they were asked about their estimation of required time to complete the tasks.

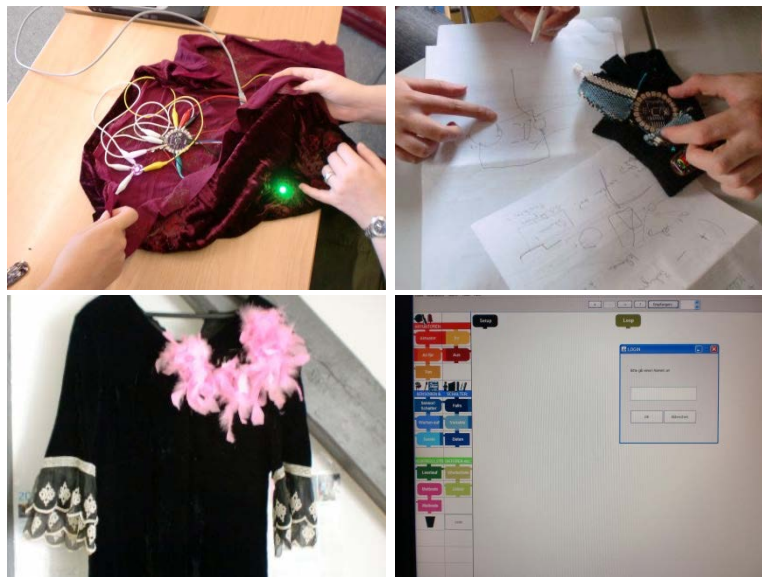Some of the results and photos of the pilot process are shown in Figure 9.

Figure 9. Results produced by KIT in Pilot 2

More information about the application of the pilots is shown in the report O2.A5 and the assessment results in the report O2.A6.

2.1.3 Pilot 1 – Agrupamento de Escolas Emídio Garcia

This pilot2 was carried in COVID situation in the context of RoboSTEAM project from 19th November 2020 to 5th January 2021 at AEEG. It involves a challenge choose from the used by IES Eras during the first piloting phase. It was carried out by two classes. The class D is attending eleventh grade (secondary level) in Sciences and Technologies. It is made up of 21 students (17 boys and 4 girls), the average age is 16 years old. The Art class (11th E) is made up of ten students at

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the same age as the Sciences and Technologies student. 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.

The Art students created their art crafts individually, during Design A classes. Regarding Class D, it was split into 6 groups, yet, owing to the fact that we had to keep social distancing, these groups worked mainly on Monday free afternoons (2 groups at a time – each week); the final step of the challenge was achieved during Physics and Chemistry classes. All groups showed mixed abilities concerning not only STEAM related competences but also hands on tasks. Therefore, the groups were heterogeneous.

AEEG also created a Team for the project on the official school Learning Platform (Microsoft Teams) on which the communication between both teachers and students had a quite good flow. It was also used to store all documentation and evidence (mainly photos) of the ongoing project.

The mini-challenge and nano-challenges, as commented above, was described in A3 as the IES Eras pilot1 minichallenge but it is reproduced again in Tables 15, 16, 17 18 and 19.

Table 15. - Minichallenge addressed by AEEG during Pilot2

Title	Illuminated sign
Description	
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.	

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- 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.

Table 16. – Nanochallenge1 of AEEG pilot2

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	

	2. 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 17. – Nanochallenge2 of AEEG pilot2

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 18. – Nanochallenge3 of AEEG pilot2

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	

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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 19. – Nanochallenge4 of AEEG pilot2

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	

The kit employed to carry out the challenge was the Arduino ELEGOO UNO that is described in Table 20.

Table 20. – Kit for AEEG pilot2

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	

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

The teachers monitored the ongoing challenge and assessed students' performance and competences acquisition based on Direct Observation. Teachers also took into account the students' perception about the experiment in order to assess the Co-Measure Test. Moreover, each group appointed a spokesperson to give testimony of the experience. Throughout the challenge teachers gave students systematic feedback about their evolution and accomplishments in problem solving tasks. Results will be presented in O2.A5 report.

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The results of the students' activities and the progress addressing the challenge can be seen in Figure 10.
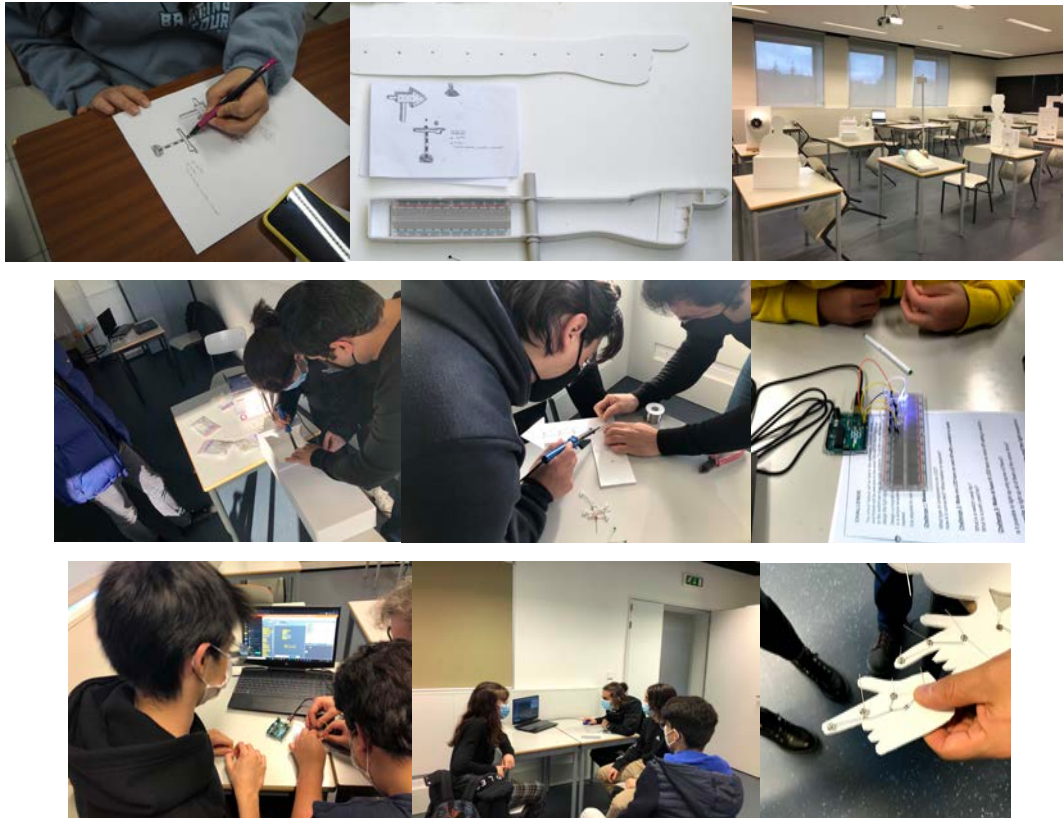

Figure 10. – Students working in pilot 2 and the results obtained

2.1.4 Pilot 1 – Colégio Internato dos Carvalhos

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. In this case they adapt the challenge to the development of a dance robot that develops a choreography synchronized with the music in a limited space.

The challenge is described in Table 21.

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Table 21. – UEF pilot 1 challenge adapted by CIC for pilot 2

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	

From it, one of the possible nano-challenges was adapted, specifically one devoted to do a dancing robot as described in Table 22.

Table 22. – Description of CIC Pilot1 Mini-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.	

Regarding the kits employed to develop these nano-challenges the kit used is the described in Table 23.

Table 23. – Logistic Management kit

Title	*Logistic management of a warehouse*
Reference	
Description	

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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

The challenges took place in a short period of time with very well-defined rules:

- The chosen music had to have a time between 30 seconds to 1 minute.

- The robot had to act on a 2-meter by 2-meter square.

- The choreography should be representative of the music.

- The robot's movements should be synchronized with the music.

- All groups had the same time to develop the dance robot.

In this scenario, a table of results was developed, which was full filled by the teachers during the competition. The results of these indicators and those common to the other partners and described before (STEAM Sematic Survey, CT test and Co-Measure Rubric) are shown in O2.A5 report.

Some of the dancing robots can be seen in the following videos:

- https://drive.google.com/file/d/1PEfz4Ufh1dcYPRwUoXsFMxvJwMfw_MHD/view?usp=sharing

- https://drive.google.com/file/d/1OgTQdFK2Io0yTvnw_lM9TlwUMR7NP8nI/view?usp=sharing

- https://drive.google.com/file/d/1Oyrren3A-J9KDoiKUzDUxOzbY3L_mGAS/view?usp=sharing

- https://drive.google.com/file/d/1On_BJsClF6rZUwITx_mewmSX0xNtCdJE/view?usp=sharing

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2.1.4 Pilot 1 – University of Eastern Finland

The pilot 2, 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. 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.

Main goal was to design, construct and program a mobile robot using Hummingbird-kit. They used challenge template as basis of the work (Table 24, but they concentrated on challenges, not senior citizens life. Students were able to use different materials for construction. After designing students programmed mobile robots. The nano-challenges although similar to the Pilot 1 challenges were also similar to the ones proposed by CIC in pilot phase 1.

Table 24. – UEF pilot 2 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 25.

Table 25. - UEF pilot2 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	
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 26, 27 and 28.

Table 26. – UEF pilot2 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 - 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 27. – UEF pilot2 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	

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- 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	

Table 28. - UEF pilot2 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	

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- 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 29.

Table 29. - UEF pilot2 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	
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/	

In order to evaluate the experiment in UEF, because of the nature of the institution and the features of the Finnish Educational System, it was not possible to apply

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the instruments applied in other, however the teachers employed self-evaluation an teachers evaluated students work with Qridi-platform which is digital platform that they use for evaluation their our school. Students made their self-evaluation in the beginning of the course and in the end of the course. Also teacher evaluation was made in the beginning of the course and in the end. Students used the same robots during the work. Figure 11 show such evaluation.

Figure 11.- Evaluation of competences for several UEF students

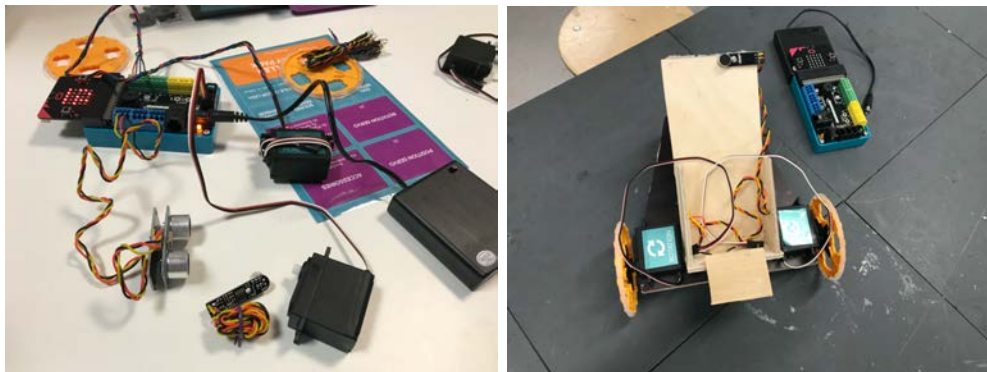Some of the results obtained can be seen in Figure 12 and 13.

Figure 12.- Robots build in UEF during the pilot 2

![ROBO STEAM logo]

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Figure 13.- Students working in the robots definition

3. Conclusion

This report has shown the second pilot process, how the different partners apply the challenges of other partners context constrained in many cases because of the limitations of their institutions, the necessity to integrate the pilots with the existing educational curriculum and the fear of the students and even more of the teachers to try to address challenges out of their comfort zone. In addition, COVID-19 crisis has changed the scheduled and has an impact in the student groups involved in the different challenge. In any case, as will be shown in O2.A6 when commenting the results, the perception of students and teachers was really positive.

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