RoboSTEAM Pilot Phase 1 – A3

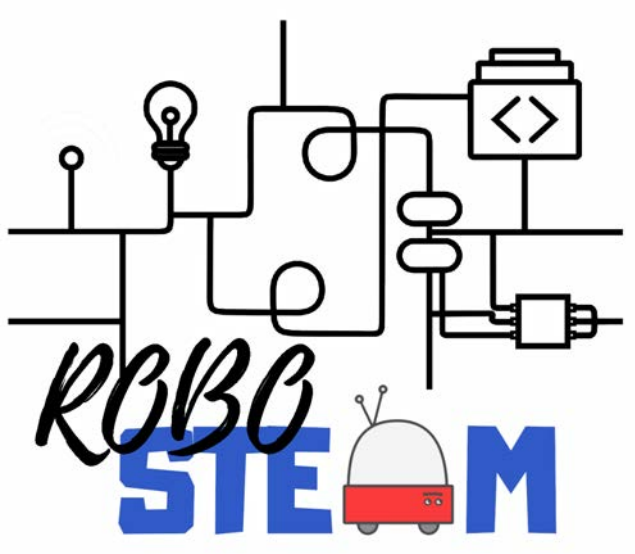

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Table of Contents

1. Pilot Phase 1 - A3 4
2. The piloting context 5
2.1. The involved schools 5
2.2. The diagnosis phase 5
3. Pilot phase1 development 9
3.1. The sample of students 9
3.2. Eras de Renueva Pilot 1 10
3.3. - Carl Benz School Pilot 1 18
3.4.- Agrupamento de Escolas Emídio Garcia Pilot1 24
3.5.- Colégio Internato dos Carvalhos Pilot1 29
3.6. - University of Eastern Finland Pilot 1 33
4. Conclusion 40
5. References 40

1. Pilot Phase 1 - A3

This document describes the first 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. More specifically this activity is described as follows:

> "A3 will launch the testing of both RoboSTEAM methodology and PD&R testing kits. During this pilot the 5 secondary schools are involved with their students from 12 to 16 years old. The pilots consist of a first diagnostic phase, later challenges will be posed for small students' groups, and finally the results will be analysed. During the diagnostic phase all students in the previous commented range of ages will fulfil a questionnaire about their perception about STEAM and how it is taught in their school. After this, 4 challenges will be posed to a class of secondary students. They will solve these problems and the results will be analysed and compared with the students that do not participate in the challenge. Indicators to be used could include: the time employed, the grade obtained, the external people involved, the assessment of computational thinking and STEAM related competences acquisition by using the instruments and methods defined in O1, and students self-perception about the experiment.".

The activity was scheduled to be completed between months M9 and M17 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 COVID-19 pandemic [9-21] situation arises on M18, classes were discontinued, and the partners should look for ways to finish both this pilot phase and pilot phase 2 in most of the cases this implies use virtual tools or to finish the piloting in smaller groups [22]. On the next sections we will comment the diagnosis phase, how the pilot1 has been developed in each school and the results obtained on them.

2. The piloting context

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 identified during first year in O2.A3 [23]. 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 were involved all the students in the age range of 12-16 in the diagnosis phase and concrete subset of students during the pilot experiments.

2.2. The diagnosis phase

As commented in the previous section all the involved partners carried out a diagnosis phase in order to understand the present landscape about STEAM in the different institutions where the project results were going to be tested. In order to do so, the students in the range from 12 to 16 were asked to answer anonymously the STEAM Semantics Survey as commented in O2.A5 report first version published in the first year of the project [24].

The STEM Semantic Survey is a 25-item instrument that measures interest in science, technology engineering and mathematics as well as interest in STEM careers more generally. The Career Interest Questionnaire is a 12-item instrument that measures interest in careers in broad science areas [25]. It has been validated and tested in different context and for the current project we adapted it to include the "A" of ARTS in STEAM and applied in the different partners schools. The form is accessible through the following link: https://forms.gle/vNQ8QCXkgtdTDGP57.

On Figure 1 we can see the first part in which personal information is asked and in Figure two a sample of one of the areas that should be valued by the students.

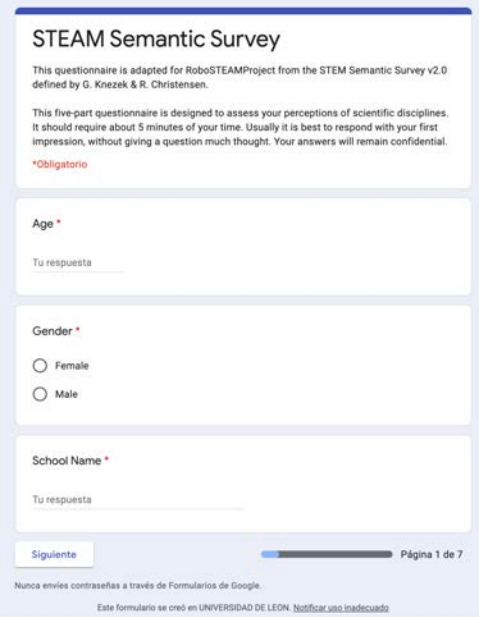

Figure 1. – Anonymous information of the STEAM Semantics Survey

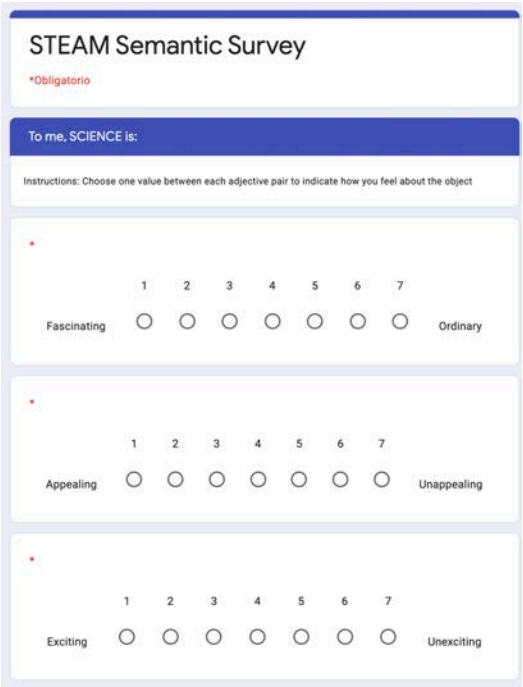

Figure 2. – Science Area valorisation in the STEAM Semantic Survey

The STEAM Semantic survey can provide us during the diagnosis phase an idea about the interest of the piloting students' contexts in STEAM areas. It is also applied during the pilots to check if the results change. Although during this stage

we expected to compile 3150 answers, taking into account a first estimation about the students in each of the schools involved, however due to the difficulty to contact students and the lockdown in several countries in different moments of the second year of the project finally the number of results were 1042 excluding the ones involved in the pilots.

The distribution of answers attending to the different schools is shown in Table 1.

Table 1.- Distribution of students answers per institution

School Name	Number of answers
I.E.S. Eras de Renueva	308
Carl Benz School Karlsruhe	13
Agrupamento de Escolas Emídio Garcia	227
Colégio Internato dos Carvalhos	462
University of Eastern Finland	32

We should point out that the numbers are lower both in Finland and in Germany because in the former the educational model is different and participation of the students in this kind of forms is not popular; and for the latter because there were not too many students in the school in the age range.

The answers are now presented as an average number per each of the schools (Table 2). As some of the questions are asked in positive and the others are reversed the values has been calculated to represent something positive if the values are close to 7 and negative if they are close to 1. In the German school the form should be adapted because the nature of the vocational school and only Science, Engineering and Technological areas were considered, so their results were excluded for the averages in the next tables.

Table 2.- Average values for each area and each involved school

School Name	Average values
I.E.S. Eras de Renueva	
Science	4.45
Math	4.30
Engineering	4.37
Arts	3.99
Technology	4.47
Career	4.65
Carl Benz School Karlsruhe	
Science	4.52
Math	-
Engineering	4.29
Arts	-
Technology	4.75
Career	4.23
Agrupamento de Escolas Emídio Garcia	
Science	4.69
Math	4.21
Engineering	3.84
Arts	4.00
Technology	4.51
Career	4.77
Colégio Internato dos Carvalhos	
Science	4.60
Math	3.86
Engineering	4.26
Arts	3.83
Technology	4.80
Career	4.62
University of Eastern Finland	
Science	3.49
Math	3.58
Engineering	3.40
Arts	3.65
Technology	4.09
Career	3.72

From the information gathered in this diagnosis phase we should comment:

- In Spain school the values about the perception regarding the five areas is higher than the average value, with more relevant values in Science and Technology. Arts has he lower value and for the students a career with based on any of the areas is attractive.

- In Portugal there are two schools, one with a background more related to arts (AEEG) and other with a more related with technology (CIC). For both of the values are higher than the mean and are especially relevant for Science and Technology. However, it should be pointed out, that in AEEG the value for arts is higher than in the rest of the involved schools. For the careers as in Spain the tendency is a positive perception towards careers with the background on these areas.
- In Germany, as commented, the form was adapted so only Science, Engineering and Technology was studied and the results are similar to the ones obtained in Spain and Portugal, although with lower values for careers
- In Finland the values are lower than in the other countries, especially in Engineering, which is probably because the educational model in this country. The most positive value is Technology in this case.

3. Pilot phase1 development

During the pilot phase 1, the idea was that that the teachers choose a group of students and define some challenges and some kits to address them. In this section we present a general view of the sample, the kits and challenges for each of the schools and the results. 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 [26].

3.1. The sample of students

In all the involved schools except for AEEG the students chosen were those of technological activities. In the case of AEEG they select students with an arts background. In this case it was possible to cover students related to all STEAM areas.

The number of students involved per each school could be seen in Table 3. In such table, it is possible to see that the students ages are in most cases from 15 to 16. In the German pilot we should point out that there was one student of 18 years old. Regarding the gender distribution it is balanced in most cases except in Finland and in Germany that was conditioned by the students enrolled in the subjects.

Table 3.- 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	16	7F – 9M	15-16
Colégio Internato dos Carvalhos	12	6F – 6M	15-16
University of Eastern Finland	10	10M	15-16

3.2. Eras de Renueva Pilot 1

This section describes Pilot 1 carried out in I.E.S. Eras de Renueva in the context of RoboSTEAM project at October 2018 - January 2019. As mentioned above it involves 13 students 6 Female and 7 Male, with an age from 15 to 16, from three subjects: Control and Robotics, Technology and Coding.

The minichallenge to be addressed during the pilot was the one described in Table 4.

Table 4.- Minichallenge addressed during Pilot1

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 signalling. Design a program to get 8 different coloured 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 5,6,7,8.

Table 5. – 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 6. – 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 7. – 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 8. – 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 9

Table 9. – -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
Other information
Other information related to the kit, more documentation, where to acquire it, cost, etc.

Regarding the results obtain 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, as well as the physical construction of the model and the presentation of their proposals (A sample can be seen in Figure 3).

Figure 3. - Eras students working collaboratively in the projects

- **Assessment instruments.** Regarding the assesment instruments we used they were:
    - 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.
    - 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.

- CT Questionnarie. Students participanting in the project took this questionnaitre.
- 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.
- Models. Teams designed and made a model to check and show their proposal and how it worked (Figure 4).

Figure 4. – Model Photo

- Presentations. Each team made a presenttion to explain their project, encountered difficulties and adopted solutions. It was evaluated through an assessment guide. A sample of the the students presenting their proposals is seen in Figure 5.

Figure 5. – Presentation Sample

- 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 6 and Figure 7).
- Time for solving the nano-challeges of pilot phase 1.
- Written test. Students also took the traditional class written tests with short answer questions about components and connections and exercises about electric circuits.
- Coding test. Every student had to design a program, coding with Scratch to solve the challenge posed.

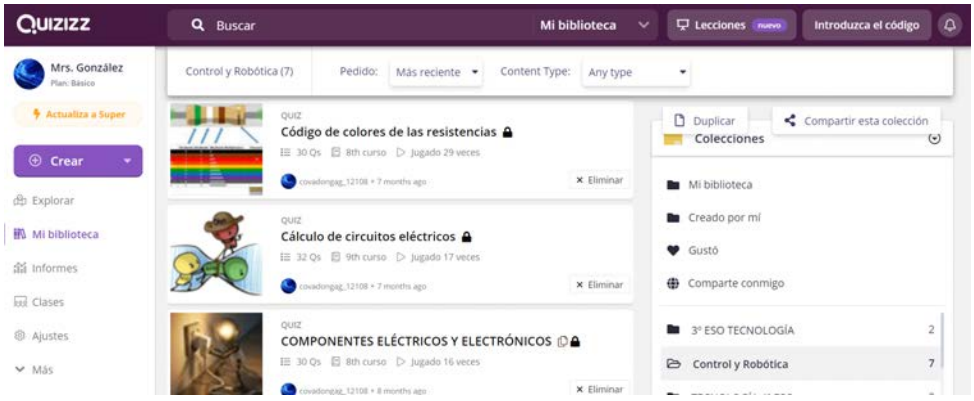

Figure 6. – Quizziz used for knowledge assessment

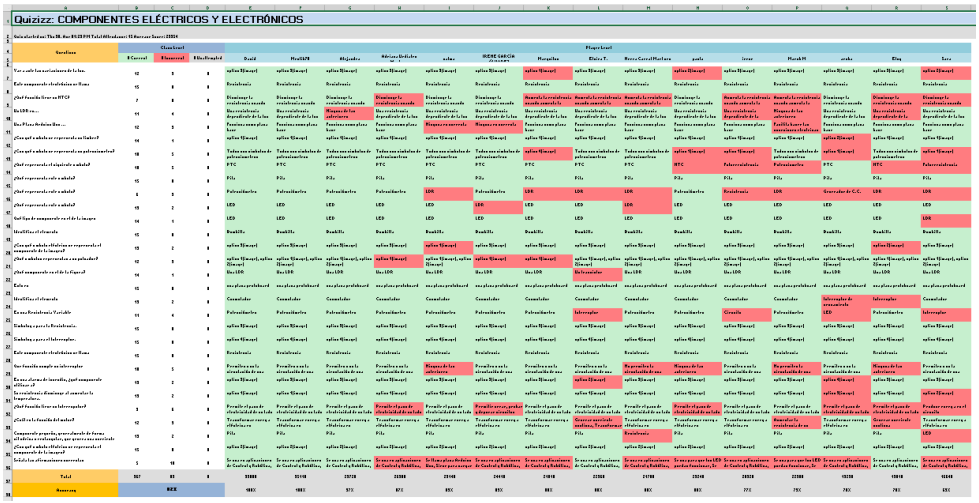

Figure 7. – Quizziz results

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

3.3. - Carl Benz School Pilot 1

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 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.

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.

In teaching block 1 (first pilot), the aim was for students and pupils to get to know each other with the help of a short round of introductions of all participants. This was followed by an introduction to the topic of smart textiles, in which already constructed "wearables" were researched and the first circuits with previously determined components were also laid.

The minichallenge addressed is shown in Table 10 and is complemented by the nanochallenge of the Tables 11 and 12 during this first pilot.

Table 10. – 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 11. – 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 12. – 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 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 13.

Table 13. – 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 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 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 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 produced in the project challenges are shown in Figure 8 and in Figure 9 we can see the students working together in teams.

Figure 8. Results produced by KIT in Pilot 1

Figure 9. Results produced by KIT in Pilot 1

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

3.4.- Agrupamento de Escolas Emídio Garcia Pilot1

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, that also 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 Technology 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.

The challenge to address was the described in table 14.

Table 14. – Description of the challenge carried out by 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 15.

Table 15. – Minichallenges addressed in the pilot

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; 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 16-18)

Table 16. – 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).

Table 17. – 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 18. – 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); 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 19.

Table 19. – 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.

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.A4 report.

The results of the students' activities can be seen in Figure 10 and the students working in Figure 11.

Figure 10. – Wildfire challenge result

Figure 11. – Students working on the challenge

In addition, it is possible to see the result produced in the following video link: https://drive.google.com/file/d/1grYJ3rqFLh5z6LpgaN2ud79uK8EqKMRI/view?usp=sharing.

3.5.- Colégio Internato dos Carvalhos Pilot1

Pilot 1 was carried out on the premises of Colégio Internato dos Carvalhos, by students of the Electronics and Telecommunications course. 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. Students using the RoboSTEAM methodology will try to find the solution using a PD&R testing kit. 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.

The challenge is described in Table 19.

Table 19. – 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 20, 21 and 22

Table 20. – 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	
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 21. – 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 22. – 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 a part 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 23,24 and 25), although several more can be necessary to complete each of them.

Table 23. – 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	
The robot should comply the navigation on a line and crosses	

Table 24. – 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 25. – 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 26.

Table 26. – 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	

The challenges took place over several weeks depending on the availability of students and accompanying teachers. In order for the challenges to be met, two main events were held and timed. The first event allowed to test the robot in following a line with light and tight curves and right angles. The second timed event simulated the robot taking a piece at the entrance off the warehouse and placing it at the exit. The result of the evaluation is described in O2.A4 report.
In figure 12 and 13.

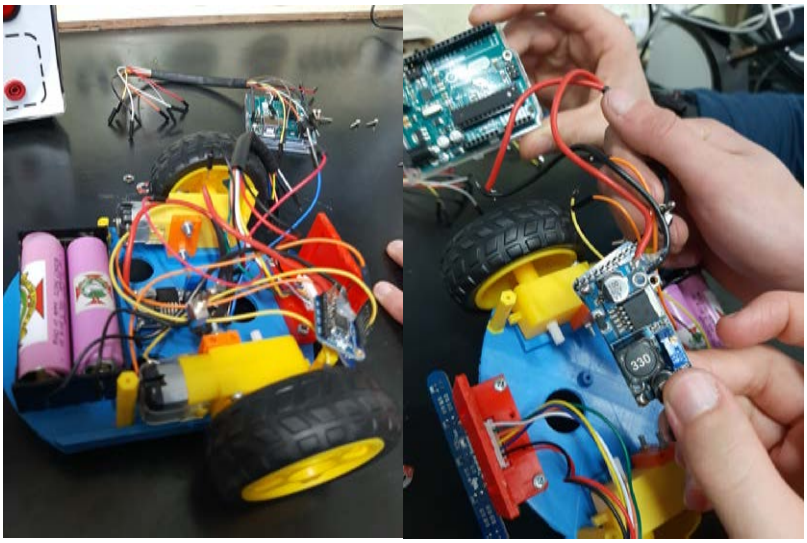

Figure 12. – Set up and deployment of the robots

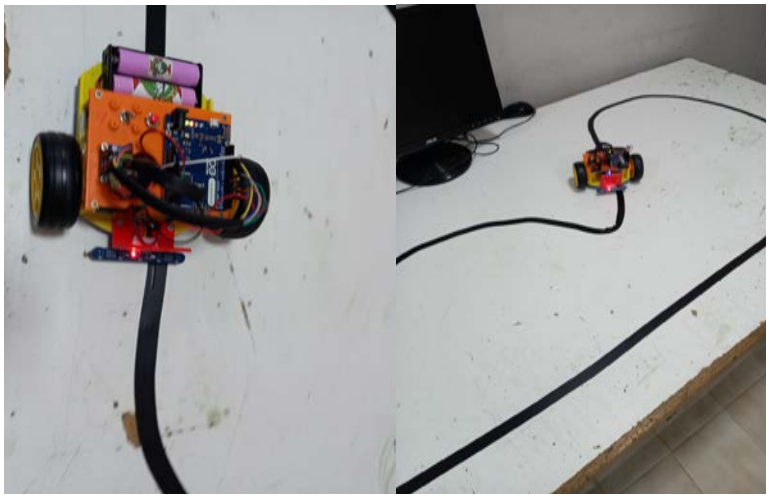

Figure 13. Robot Following the line

3.6. - University of Eastern Finland Pilot 1

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. 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.

Main goal of the challenge addressed was to design, construct and program a mobile robot using Hummingbird-kit with the aim of improving senior citizens life. The challenge is described in Table 27.

Table 27. – 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 28.

Table 28. – 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	
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 29, 30 and 31.

Table 29. – 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 - 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 30. – 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	

Table 31. – 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 32.

Table 31. – 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	
Components (Repeat this 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 the instruments applied in other, however the teachers employed self-evaluation and the assessment of STEAM skills by using their own systems as shown by Figure 14.

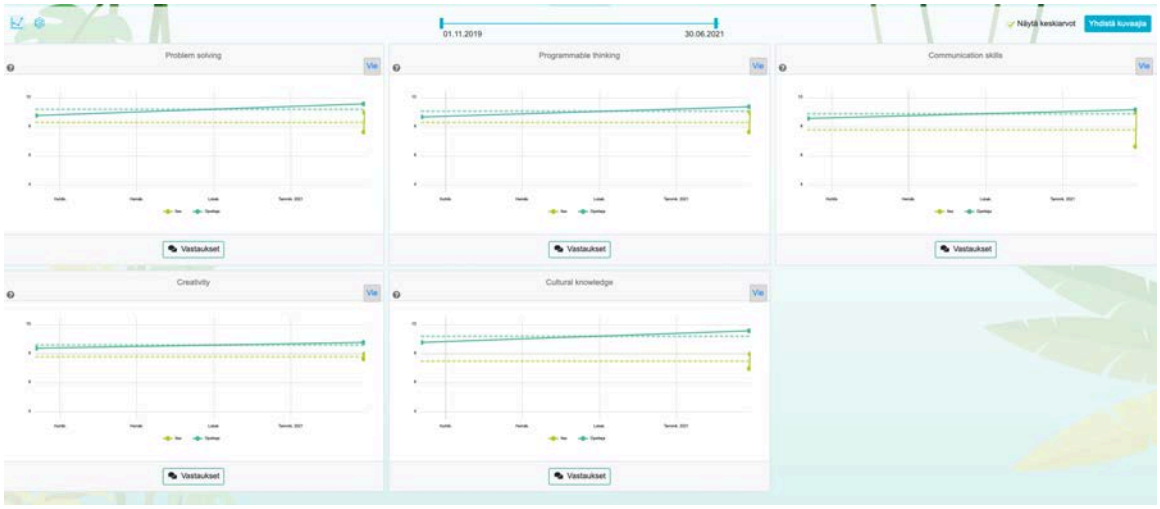

Figure 14.- Evaluation of competences for several UEF students

Some of the results obtained can be seen in Figure 15 and 16.

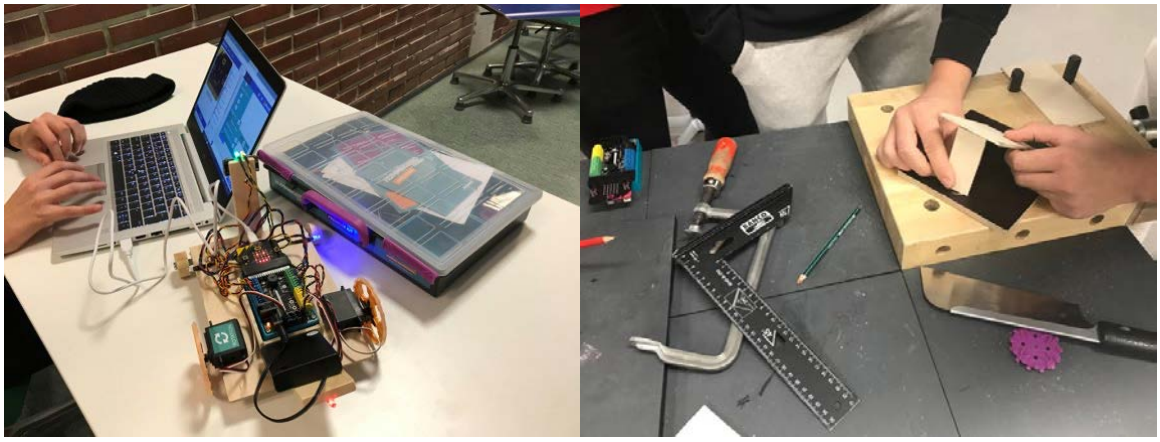

Figure 15.- Robots build in UEF during the pilot 1

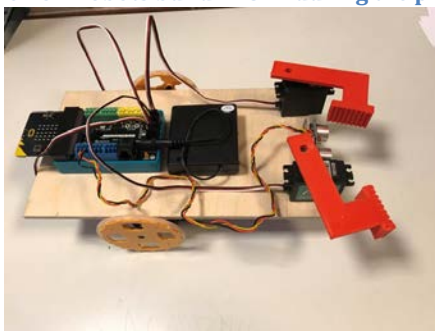

Figure 16.- Sample of UEF robot that can grab objects

4. Conclusion

This report has shown the first pilot process, how the different partners apply the challenges in their 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. However, and as, it will be shown in O2.A5 when commenting the results, the perception of students and teachers was really positive. It is necessary to point out that at the end of this pilot and during pilot phase 2, that at some months is carried out in parallel to pilot 1 COVID-19 crisis arises, which requires from an adaption of the teachers, students and schools because the different lockouts.

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