O2.A6 – Evaluation of the experiences

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1.0	15/01/2021	Results of first pilot
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1.2	29/05/2021	Final Results

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1. O2.A6 – Evaluation of the experiences

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

> "Once the pilots are finished it is necessary to analyze the results and describe in the guides how kits can be designed to be applied in a more efficient way depending on students and contexts. Issues such as the challenge achievement, degree of achievement, time and resources employed, quality of the solution, etc. should be taken into account".

It is necessary to consider that the evaluation has been partially conditioned by COVID-19 [22-34] and that although we have selected several evaluation instruments not all have been considered in the same way.

2. THE PROCESS

The process followed was the selection of the tools to be employed, later it is described how they are applied in each of the pilots and finally the results obtained from application of the tools in the experiments.

2.1. The tools and the reason to use them

Regarding the evaluation instruments they were also discussed during the Karlsruhe meeting, taking into account those described in O2.A2 and also those found when carrying out the Systematic Mapping [8].

Regarding the indicators it is necessary to take into account the time employed to complete the challenge, the number of persons involved in each team and the grade (that could later be compared with previous editions of the same subject).

In addition, the perceptions of students and teachers are gathered in several of the pilots.

This is provided by the pilot hosting institution, but grades are measured taking into account their own experiments, so the results are not always comparable.

Regarding the evaluation instruments we decided to employ three:

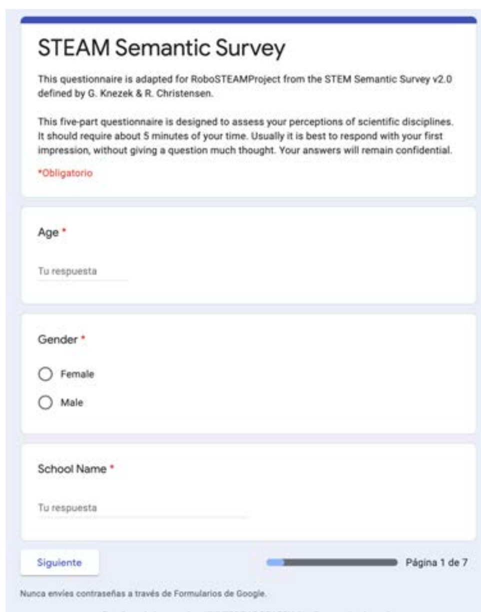
- The STEM Semantic Survey is a 25-item instrument that measures interest in science, technology engineering and mathematics as well as interest in STEM careers more generally. The Career Interest Questionnaire is a 12-item instrument that measures interest in careers in broad science areas [35]. It is applied during two phases of the pilots:
    - In the diagnosis phase and with all the available students at the school in the age range. In this way it would be possible to obtain a view of the current landscape of STEAM in the involved institutions.
    - During the pilot with the experimental groups, in this case the people involved in the pilots will carry out the instrument before the first pilot and at the end of the experience.
- Computational thinking test. It is a instrument initially aimed at Spanish students between 12 and 13 years old. It includes several to evaluate different areas related with computational thinking. The test has been properly validated and from the initial version of 40 items length it was depurated to a 28 items [36]. It is applied at the end of the pilot 2 to see the computational thinking level of the students.
- Co-Measure Rubric. This instrument is defined for researchers and educators to use to assess student collaboration, at the individual level, when students are working in K-12 STEAM activities. It has been validated through several iterations and has been published [37]. During the project it is applied to assess the collaboration between team members in the pilot

activities, but also during the exchanges when the students from the different schools have worked together.

2.1. The evaluation tools adaption

Although the instruments were well known and have been validated for the project students age, it is necessary to adapt them. First of all it was necessary to facilitate the delivery of the instruments and also to make some adaptions. Specifically, these adaptions were:

- STEM Semantic Survey. It was transformed in STEAM Semantic Survey 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.



STEAM Semantic Survey

This questionnaire is adapted for RoboSTEAMProject from the STEM Semantic Survey v2.0 defined by G. Knezek & R. Christensen.

This five-part questionnaire is designed to assess your perceptions of scientific disciplines. It should require about 5 minutes of your time. Usually it is best to respond with your first impression, without giving a question much thought. Your answers will remain confidential.

*Obligatorio

Age *

Tu respuesta

Gender *

Female

Male

School Name *

Tu respuesta

Siguiente Página 1 de 7

Nunca envíes contraseñas a través de Formularios de Google.

Este formulario se creó en UNIVERSIDAD DE LEON. Notificar uso inadecuado

Figure 1. – Anonymous information of the STEAM Semantics Survey

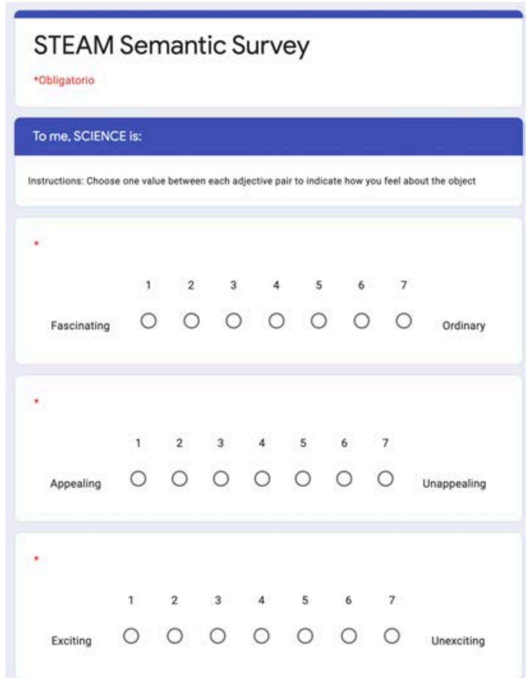
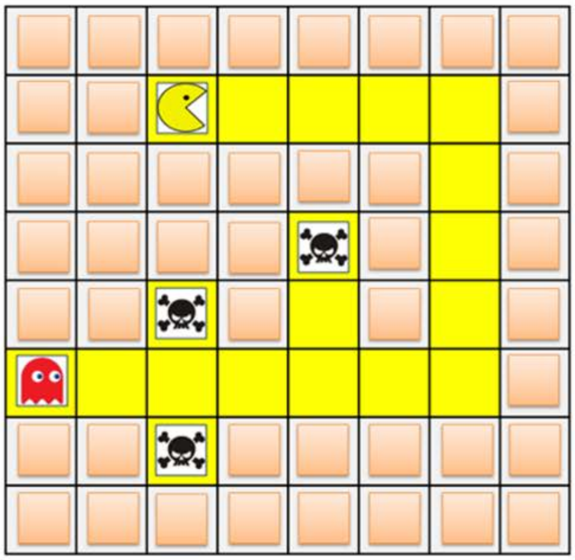


Figure 2. – Science Area valoration in the STEAM Semantic Survey

It was also translated into German and delivered in paper for the students of the Karl Benz School. In the case of the version for the diagnosis phase it was anonymous, in the case of the experimental group.

- Computational thinking test. The computational thinking test has 28 items and covers several dimensions. For the project we select Loops and conditionals operations and items from 9 to 12. The test was presented in a word and in several cases, it was translated into other languages, in order to do this, an as the images included in the test were using scratch the items selected were translated in English and German (the base questionnaire and the scratch items are included in the RoboSTEAM platform forums [38]). Figure 3 shows one of the adapted questions.

ITEM 1 What order sequence will allow Pacman to reach the Ghost by following the highlighted path?



A)

B)

Figure 3. – Sample of a translated item of the CT test

- The Co-Measure Rubric was not adapted, it was fulfilled sometimes in paper and other digitally.

2.1. How the tools are applied during the pilots

As mentioned above the order of the application of the different instruments and tools is the following:

1. Pilot 1. During pilot 1 schools involved in the partnership will address some challenges defined by themselves and using the kits they have.
    a. Diagnosis phase with the STEAM Semantic Survey: all the possible students in age range from 12 to 16 should fulfil the questionnaire. This questionnaire is anonymous (the task is open until the end of pilot that is the M27.
    b. STEAM Semantic Survey for the involved in the pilot 1. In order to gather their initial perception about STEAM
    c. Pilot development
    d. During the pilot development collaboration between students is measured with the Co-Measure Rubric
    e. Other indicators: time, people involved, summative assessment of the tasks, perceptions, competences acquisition, etc.

Figure 4 Illustrates the process.

Pilot 1

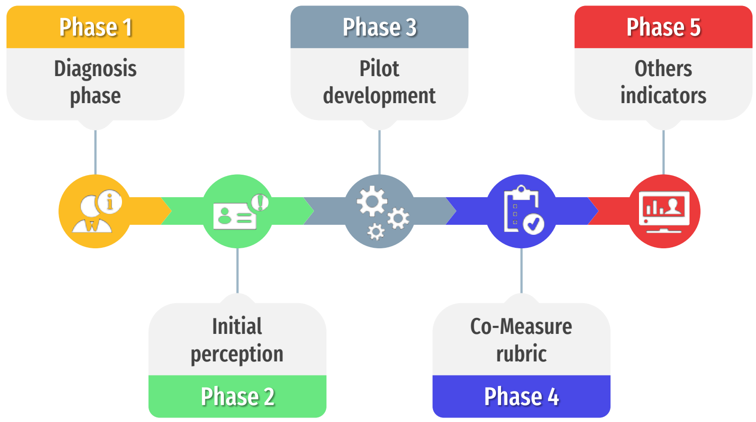


Figure 4. – Pilot 1 Evaluation Process

2. Pilot 2. In these pilots the students address a challenge defined by other partner.
    a. Development of the pilot 2
    b. During the pilot measuring collaboration of teams by using Co-Measure Rubric
    c. Computation Thinking Test after the pilot
    d. STEAM Sematic Survey after the pilot
    e. Other indicators: time, people involved, summative assessment of the tasks, perceptions, competences acquisition, etc.

Figure 5 shows the process.

Pilot 2

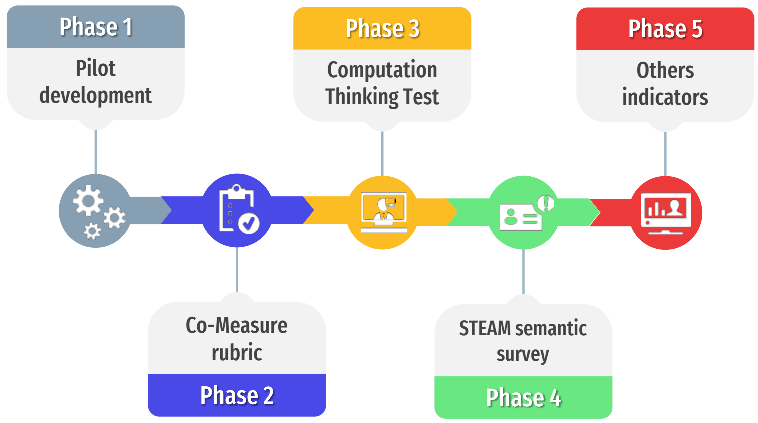


Figure 5. – Evaluation process during pilot 2.

It is necessary to point out that this was the initial plan for the instruments application but that the pilots have been delayed because of the COVID-19 and that this has also mean a difficulty regarding the use of all these tools. Moreover, with the COVID-19 delay, some of the pilots began in an academic year and ended in the next, which in some cases means that the students have leave the school and there is not a match between the initial results gathered and the final ones.

3. PILOT 1 RESULTS

This section summarizes the results to evaluate the pilots. As commented above first we consider the diagnosis phase and later the results of each partner

3.1. Diagnosis Phases

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.

3.1. IES Eras

First, we present the basic indicators

- Students involved: 13
- Students ages: 15-16
- Teachers involved: 2
- Subjects: Control and Robotics, Technology and Coding.
- Number of nanochallenges addressed: 4
- Time devoted: 10 hours individually and 10 working in groups

Regarding the grades using the institutional assessment tools they were:

STEM Semantic Survey as commented is applied before the first pilot and after the second the results can be seen in Table 3.

Table 3. – Students results for the STEAM Semantic Survey pre-test IES ERAS

STUDENTS	SCI	MATHS	ENG.	ARTS	TECH	CAREER
ST1	6.4	6.4	5.4	6.4	6.4	6.4
ST2	6.4	6.4	6.4	1.2	5.4	6.4
ST3	6.4	6.4	6.4	3.4	5.4	6.4
ST4	6.4	6.4	6.4	6.4	5.4	6.4
ST5	6.4	5.6	6.4	4.6	5	6.4
ST6	6.4	5.6	6.4	5.4	5.4	6.4
ST7	6.4	2	5.4	6	4.8	5
ST8	6	5.6	5.2	6.4	5.2	6.2
ST9	5	6.2	5.8	4.6	5	5.2
ST10	5.2	4.8	5.8	4.4	4.8	4.4
ST11	5.8	5.8	5.6	5.6	5.4	6
ST12	4	2.6	4.4	3.8	4.4	3.4
ST13	6.2	6,2	6.4	4.8	5.2	6.4

From a global perspective the average values are shown in Table 4.

Table 4. – Average values for the involve students in the pilot 1 IES ERAS.

Area	Avg. Pilo1	Avg. Diagnosis
SCIENCE	5.92	4.45
MATHS	5.38	4.30
ENGINEERING	5.85	4.37
ARTS	4.85	3.99
TECHNOLOGY	5.89	4.47
CAREER	5.77	4.65

It should be noted that the values in all the areas are higher than the average of the areas for the school. The only value that is lower than 5 is ARTS which is normal in a context of technology.

The commeasure rubric was also applied, and the results are shown in Table 5A,5B,5C and 5D. It is possible to see that from the teachers' point of view that were who vale the students all the students in all the groups developed properly skills related with collaboration while doing the project

Table 5A. – Co-Measure rubric results per group IES ERAS – Peer Interactions

		1 - Peer Interactions								
		Monitors tasks and checks for understanding withe peers			Negotiates roles, and divides work to complete task			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X			X
	Student 2			X			X			X
	Student 3			X			X			X
Grupo 2	Student 4			X			X			X
	Student 5			X			X			X
	Student 6			X			X			X
	Student 7			X			X			X
Grupo 3	Student 8			X			X			X
	Student 9			X			X			X
	Student 10			X			X			X
Grupo 4	Student 11			X			X			X
	Student 12			X			X			X
	Student 13			X			X			X

Table 5B. – Co-Measure rubric results per group IES ERAS – Positive Comunication

		2 - Positive Comunication								
		Respects others' ideas and compromises			Respects others' ideas and compromises			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X			X
	Student 2			X			X			X
	Student 3			X			X			X
Grupo 2	Student 4			X			X			X
	Student 5			X			X			X
	Student 6			X			X			X
	Student 7			X			X			X
Grupo 3	Student 8			X			X			X
	Student 9			X			X			X
	Student 10			X			X			X
Grupo 4	Student 11			X			X			X
	Student 12			X			X			X
	Student 13			X			X			X

Table 5C. – Co-Measure rubric results per group IES ERAS – Inquiry Rich/Multiple Paths

		3 - Inquiry Rich / Multiple Paths					
		Develops appropriate questions and methods towards solving the problem			Develops appropriate questions and methods towards solving the problem		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X
	Student 2			X			X
	Student 3			X			X
Grupo 2	Student 4			X			X
	Student 5			X			X
	Student 6			X			X
	Student 7			X			X
Grupo 3	Student 8			X			X
	Student 9			X			X
	Student 10			X			X
Grupo 4	Student 11			X			X
	Student 12			X			X
	Student 13			X			X

Table 5D. – Co-Measure rubric results per group IES ERAS – Transdisciplinary Approach

		4 - Transdisciplinary Approach					
		Negotiates relevant method or materials to solving the problem posed			Negotiates relevant method or materials to solving the problem posed		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X
	Student 2			X			X
	Student 3			X			X
Grupo 2	Student 4			X			X
	Student 5			X			X
	Student 6			X			X
	Student 7			X			X
Grupo 3	Student 8			X			X
	Student 9			X			X
	Student 10			X			X
Grupo 4	Student 11			X			X
	Student 12			X			X
	Student 13			X			X

Regarding the teachers' perception they pointed out the following: "Students were really motivated with the topic of the project. Even though they had no previous knowledge, they managed to acquire the necessary skills and competences to solve each of the challenges posed."

3.2. AEEG

This pilot was different because it involves students from Spain and Portugal as it is carried out during the first exchange, given this situation only the Portuguese results are shown:

- Students involved: 11 from Portugal
- Students ages: 15-16
- Teachers involved: 5 teachers and 4 researchers
- Subjects: Arts and Technology
- Number of nano-challenges addressed: 3
- Time devoted: 35 hours

AEEG did not use a personal rubric or scale. Regarding the STEAM Sematic Review surveys, they are shown in Table 6.

Table 6. – Students results for the STEAM Semantic Survey pre-test AEEG

STUDENTS	SCI	MATHS	ENG.	ARTS	TECH	CAREER
ST1	4	5	2.4	6.2	1.6	4.6
ST2	2	4.6	5	5.8	4.4	4
ST3	4.4	2.8	4.8	6.4	6.4	4.6
ST4	4	4.2	4.6	6.4	6.4	5.4
ST5	3.4	4.2	4.2	6.2	5.4	3.2
ST6	6	6.4	6.2	5.4	6.4	6.4
ST7	6.4	6.4	5.4	4.2	6.4	6.4
ST8	3.2	6.4	6.4	5.8	6.4	6.2
ST9	5	5	3.6	6.4	6	5.8
ST10	6	5	3.8	3.2	5.8	6
ST11	3.4	4	3.8	5.8	4.4	5.4

From a global perspective the average values are shown in Table 7.

Table 7. – Average values for the involve students in the pilot 1 AEEG.

Area	Avg. Pilot 1	Avg. Diagnosis
SCIENCE	4.35	4.69
MATHS	4.44	4.21
ENGINEERING	4.56	3.84
ARTS	5.62	4.00
TECHNOLOGY	5.42	4.51
CAREER	5.27	4.77

It should be noted that the values in all the areas except in SCIENCE are higher than the average, especially relevant is the arts area, something probably motivated by the students involved in the pilot that are mainly from this area.

The commeasure rubric was also applied, and the results are shown in Table 8A, 8B, 8C and 8D. It is possible to see groups of less students than the defined of 3 or 4 components, but in this case, we are only including the Portuguese students of AEEG.

Table 8A. – Co-Measure rubric results per group AEEG– Peer Interactions

		1 - Peer Interactions								
		Monitors tasks and checks for understanding with peers			Negotiates roles, and divides work to complete task			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1		X			X			X	
	Student 2		X			X			X	
Grupo 2	Student 3			X			X			X
	Student 4			X			X			X
	Student 5			X			X			X
Grupo 3	Student 6			X			X			X
	Student 7			X			X			X
	Student 8									
Grupo 4	Student 9	X			X			X		
	Student 10	X			X			X		
	Student 11	X			X			X		

Table 8B. – Co-Measure rubric results per group AEEG – Positive Comunication

		2 - Positive Comunication								
		Respects others' ideas and compromises			Respects others' ideas and compromises			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1		X				X		X	
	Student 2			X		X			X	
Grupo 2	Student 3			X			X			X
	Student 4			X			X			X
	Student 5									
Grupo 3	Student 6			X			X			X
	Student 7			X			X			X
	Student 8			X			X			X
Grupo 4	Student 9		X			X			X	
	Student 10		X			X			X	
	Student 11		X			X			X	

Table 8C. – Co-Measure rubric results per group AEEG – Inquiry Rich/Multiple Paths

		3 - Inquiry Rich / Multiple Paths					
		Develops appropriate questions and methods towards solving the problem			Develops appropriate questions and methods towards solving the problem		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1		X				X
	Student 2		X			X	
Grupo 2	Student 3		X			X	
	Student 4		X			X	
	Student 5		X			X	
Grupo 3	Student 6			X			X
	Student 7			X			X
	Student 8			X			X
Grupo 4	Student 9		X			X	
	Student 10		X			X	
	Student 11		X			X	

Table 8D. – Co-Measure rubric results per group AEEG – Transdisciplinary approach

		4 - Transdisciplinary Approach					
		Negotiates relevant method or materials to solving the problem posed			Negotiates relevant method or materials to solving the problem posed		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X
	Student 2			X			X
Grupo 2	Student 3			X			X

	Student 4			X			X
	Student 5			X			X
Grupo 3	**Student 6**			X			X
	Student 7			X			X
	Student 8			X			X
Grupo 4	**Student 9**		X			X	
	Student 10		X			X	
	Student 11		X			X	

The results show that groups 2 and 3 have very good values regarding collaborative work, but other such as group 4 really needs to improve their way to work together. It should be noted that students 3 and 6 have produced results with higher quality than the rest of the class.

Regarding the teachers' perception they pointed out the following: "In a global perspective the Challenge was achieved successfully. The Artwork didn't pose any kind of problems since all students took part in it actively and enjoyed building the forest, no matter their educational background"

3.3. KIT

This pilot involves students from a vocational school in Germany, the main indicators were:

- Students involved: 17 from Portugal
- Students ages: 16-18
- Teachers involved: 6 university students and 1 teacher
- Subjects: Metal Engineering
- Number of nano-challenges addressed: 3
- Time devoted: 9 hours

Beyond the common assessment instruments, KIT employ their own observation sheet along the creative processes of collaborative prototyping of the pupils by the university students.

Regarding Students Semantic Survey Results, they can be seen in Table 9, from the 17 students we have only 15 answers to the survey, as commented in O2.A5 the areas of Math and Arts were removed in the German context.

Table 10. – Students results for the STEAM Semantic Survey pre-test KIT

STUDENTS	SCI	MATHS	ENG.	ARTS	TECH	CAREER
ST1	4	-	2.4	-	3.6	4.2
ST2	5	-	6.2	-	5.2	6.2
ST3	3.4	-	4.4	-	4.4	6.4
ST4	4	-	6.4	-	6.4	6.4
ST5	3.6	-	5	-	3.6	4
ST6	3.8	-	4.4	-	4	5
ST7	3	-	4	-	4.6	4.8
ST8	2.8	-	4.4	-	5	3.8
ST9	2.6	-	1.6	-	3.8	0.4
ST10	5.8	-	6	-	6.4	6.2
ST11	2.4	-	5.8	-	4.4	4.2
ST12	3.4	-	6.4	-	4.2	6.4
ST13	5.2	-	4.4	-	5.2	3
ST14	2.2	-	3.6	-	6	5.4
ST15	3.4	-	5.4	-	5.4	3.6

From a global perspective the average values are shown in Table 10.

Table 10. – Average values for the involve students in the pilot 1 KIT

Area	Avg. Pilot 1	Avg. Diagnosis
SCIENCE	3.51	4.52
MATHS	-	-
ENGINEERING	4.75	4.29
ARTS	-	-
TECHNOLOGY	4.88	4.75
CAREER	4.58	4.23

It is possible to see lower values in the SCIENCE area than the media of the institution, but the rest of the values are higher.

The commeasure rubric was also applied, and the results are shown in Tables 11A, 11B and 11C. The students were divided in five working groups.

Table 11A. – Co-Measure rubric results per group KIT– Peer Interactions

		1 - Peer Interactions								
		Monitors tasks and checks for understanding with peers			Negotiates roles, and divides work to complete task			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X						X
	Student 2									X
	Student 3		X							X
Group 2	Student 4			X	X				X	
	Student 5			X	X				X	
	Student 6			X	X				X	
Group 3	Student 7		X			X			X	
	Student 8		X		X				X	
	Student 9		X			X				X
Group 4	Student 10	X			X				X	
	Student 11			X		X			X	
Group 5	Student 12									
	Student 13			X			X			X
	Student 14	X								
	Student 15		X			X			X	

Table 11. – Co-Measure rubric results per group KIT – Positive Comunication

		2 - Positive Comunication								
		Respects others' ideas and compromises			Respects others' ideas and compromises			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X			X
	Student 2			X			X			X
	Student 3		X			X				X
Grupo 2	Student 4			X		X			X	
	Student 5			X			X		X	
	Student 6			X			X		X	
Grupo 3	Student 7	X				X			X	
	Student 8		X			X			X	
	Student 9			X	X				X	
Grupo 4	Student 10	X				X		X		
	Student 11			X			X			X
Group 5	Student 12					X			X	
	Student 13			X			X			X
	Student 14		X			X				
	Student 15			X			X	X		

Table 12. – Co-Measure rubric results per group KIT – Inquiry Rich/Multiple Paths

		3 - Inquiry Rich / Multiple Paths					
		Develops appropriate questions and methods towards solving the problem			Develops appropriate questions and methods towards solving the problem		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1		X			X	
	Student 2		X			X	
	Student 3						
Grupo 2	Student 3			X	X		
	Student 4			X	X		
	Student 5			X	X		
Grupo 3	Student 6	X				X	
	Student 7		X			X	
	Student 8		x		X		
Grupo 4	Student 9		X			X	
	Student 10		X		X		
	Student 11		X				X
Group 5	Student 12						
	Student 13		X				
	Student 14	X					
	Student 15			X			X

In this case the 4th dimension of the commeasure rubric is not considered because the transdisciplinary approach was not applicable. In addition, some variables are not valued as there are not evidences to do so. We should point out that in this case each group was graded by a university student so the criteria could not be exactly the same for all the groups.

The final remarks and observations for this pilot are described in the pilot 2 section of this report as they include issues that affect both of them.

3.4. CIC

This pilot involves students from the Colegio Internato dos Carvalhos in Portugal, the main indicators were:

- Students involved: 12 students.
- Students ages: 15-16.
- Teachers involved: 2.
- Subjects: Electronics and Telecommunications.
- Number of nano-challenges addressed: 3
- Time devoted: 20 hours

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 school employed for the evaluation the project instruments but also other. Table 12 shows the results attending to these observations.

Table 12. – Grades assigned by CIC teachers depending on students' achievements

		1º Event (s)	2º Event (s)	Total Time	Position
Grupo 1	**Student1**	31.3	54.4	85.7	**5**
	Student2				
Grupo 2	**Student3**	32.9	52.5	85.4	**4**
	Student4				
Grupo 3	**Student5**	31.8	54.3	86.1	**6**
	Student6				
Grupo 4	**Student7**	32.1	52.1	84.2	**2**
	Student8				
Grupo 5	**Student9**	33.3	51.2	84.5	**3**
	Student10				
Grupo 6	**Student11**	30.1	52.4	82.5	**1**
	Student12				

Regarding the STEAM Semantic Survey results, they can be checked in Table 13, only five students fulfil the form.

Table 13. – Students results for the STEAM Semantic Survey pre-test CIC

STUDENTS	SCI	MATHS	ENG.	ARTS	TECH	CAREER
ST1	4.8	4.6	6.4	2.2	6.4	6.4
ST2	6	3.2	3	3.2	6.4	6
ST3	4	4	4.8	4.6	6	4.2
ST4	5	5	5.6	3.2	5.2	3.4
ST5	6.4	3.6	6	4.8	6.2	6.4
ST6	3.2	5.2	6.4	1	6	6

From a global perspective the average values are shown in Table 14.

Table 14. – Average values for students in the pilot vs those of the diagnosis phase in CIC

Area	Avg. Pilot 1	Avg. Diagnosis
SCIENCE	4.90	4.60
MATHS	4.27	3.86
ENGINEERING	5.37	4.26
ARTS	3.17	3.83
TECHNOLOGY	6.03	4.80
CAREER	5.40	4.62

In the tables it is possible to see that the values for all areas for the pilot1 students are higher than the average of the school except the case of arts than for the students is even lower, something that can be understood as normal given the student technological background.

Regarding the Co-Measure rubric results they can be seen in Tables 15A, B, C and D.

Table 15A. – Co-measure Rubric in pilot 1 CIC – Peer Interactions

		1 - Peer Interactions								
		Monitors tasks and checks for understanding with peers			Negotiates roles, and divides work to complete task			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student1		X				X			X
	Student2			X			X			X
Group 2	Student3			X			X			X
	Student4			X			X			X
Group 3	Student5			X			X			X
	Student6			X			X			X
Group 4	Student7			X			X			X
	Student8			X			X			X
Group 5	Student9		X				X			X
	Student10		X			X				X
Group 6	Student11		X			X				X
	Student12			X		X				X

Table 15B. – Co-measure Rubric in pilot 1 CIC – Positive Comunication

		2 - Positive Comunication								
		Respects others' ideas and compromises			Uses Socially appropriate language and behavior			Listens and takes turns		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student1		X				X			X
	Student2			X			X			X
Group 2	Student3			X			X			X
	Student4			X			X			X
Group 3	Student5			X			X			X
	Student6			X			X			X
Group 4	Student7			X			X			X
	Student8			X			X			X
Group 5	Student9			X			X			X
	Student10		X				X			X
Group 6	Student11			X			X			X
	Student12		X				X			X

Table 15C. – Co-measure Rubric in pilot 1 CIC – Inquiry Rich /Multiple Paths

		3 - Inquiry Rich / Multiple Paths					
		Develops appropriate questions and methods towards solving the problem			Verifies information and sources to support inquiry		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student1		X				X
	Student2		X				X
Group 2	Student3			X			X
	Student4			X			X
Group 3	Student5			X			X
	Student6		X				X
Group 4	Student7			X			X
	Student8			X			X
Group 5	Student9		X				X
	Student10			X		X	
Group 6	Student11		X				X
	Student12			X		X	

Table 15D. – Co-measure Rubric in pilot 1 CIC – Transdisciplinary Approach

		4 - Transdisciplinary Approach					
		Discusses and approaches problem solving incorporating multiple disciplines			Shares connections to research or relevant Knowledge		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student1			X			X
	Student2			X			X
Group 2	Student3			X			X
	Student4			X			X
Group 3	Student5			X			X
	Student6			X			X
Group 4	Student7			X			X
	Student8			X			X
Group 5	Student9			X			X
	Student10			X			X
Group 6	Student11			X			X
	Student12			X			X

3.5. UEF

The pilot 1, in University of Eastern Finland, was carried out in the Teacher Training School, the main indicators were:

- Students involved: 10 students.
- Students ages: 16.
- Teachers involved: 2.
- Subjects: Extra course
- Number of nano-challenges addressed: 3
- Time devoted: 30 hours

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 which results will be shown in pilot 2.

4. PILOT 2 RESULTS

4.1. IES Eras

First, we present the basic indicators

- Students involved: 13
- Students ages: 15-16
- Teachers involved: 2
- Subjects: Control and Robotics, Technology and Coding.
- Number of nanochallenges addressed: 4
- Time devoted: 10 hours individually and 10 working in groups

STEM Semantic Survey as commented is applied before the first pilot and after the second the results can be seen in Table 16. This is a summary of the students results for the first and second pilot.

Table 16. – Students results for the STEAM Semantic Survey pre-test IES ERAS

STUDENTS	SCI	MATHS	ENG.	ARTS	TECH	CAREER
ST1	0.6	1.4	2.4	2	0.6	2.2
ST2	6.4	6.4	6.4	1.4	4.4	5.2
ST3	6	3	2.6	5.2	2.8	4.2
ST4	3.6	4	4	5.2	3.6	4
ST5	6	5.6	6.4	4.8	5.6	6.4
ST6	4.2	4.8	4.6	2.4	5	4.4
ST7	5.2	5.4	5	4.2	4.8	5.8
ST8	4.2	2.8	3.2	3.8	3.6	4.2
ST9	5.8	5	4.2	2.6	4.6	3.8
ST10	1.8	2	5.4	0.4	5.4	0.4
ST11	5.6	4.4	5	3.2	5.6	3.6
ST12	4.2	4.2	4.4	3.6	4.2	4.8
ST13	2.8	4.8	6	3.6	5.4	2.6

From a global perspective the average values are shown in Table 17.

Table 17. – Average values for the involve students in the pilot 1 IES ERAS.

Area	Avg. Pilot1	Avg. Pilot2	Avg. Diagnosis
SCIENCE	5.92	4.34	4.45
MATHS	5.38	4.15	4.30
ENGINEERING	5.85	4.58	4.37
ARTS	4.85	3.26	3.99
TECHNOLOGY	5.89	4.28	4.47
CAREER	5.77	3.97	4.65

It should be noted that the values in all the areas are lower for the second pilot and are lower even than the average value of the school. This could be motivated because the problems related with COVID-19 and a kind of technology haste motivated for this pandemic situation.

The commeasure rubric was also applied, and the results are shown in Tables 18A, 18B, 18C and 18D. It is possible to see groups of less students than the defined of 3 or 4 components, but in this case, we are only including the Portuguese students of AEEG.

Table 18A. – Co-Measure rubric results per group IES ERAS pilot 2 – Peer Interactions

		1 - Peer Interactions								
		Monitors tasks and checks for understanding with peers			Negotiates roles, and divides work to complete task			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X			X
	Student 2			X			X			X
	Student 3			X			X			X
Grupo 2	Student 4			X			X			X
	Student 5			X			X			X
	Student 6			X			X			X
	Student 7			X			X			X
Grupo 3	Student 8			X			X			X
	Student 9			X			X			X
	Student 10			X			X			X
Grupo 4	Student 11			X			X			X
	Student 12			X			X			X
	Student 13			X			X			X

Table 18B. – Co-Measure rubric results per group IES ERAS pilot 2 – Positive Comunication

		2 - Positive Comunication								
		Respects others' ideas and compromises			Respects others' ideas and compromises			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X			X
	Student 2			X			X			X
	Student 3			X			X			X
Grupo 2	Student 4			X			X			X
	Student 5			X			X			X
	Student 6			X			X			X
	Student 7			X			X			X
Grupo 3	Student 8			X			X			X
	Student 9			X			X			X
	Student 10			X			X			X
Grupo 4	Student 11			X			X			X
	Student 12			X			X			X
	Student 13			X			X			X

Table 18C. – Co-Measure rubric results per group IES ERAS pilot 2 – Inquiry Rich/Multiple Paths

		3 - Inquiry Rich / Multiple Paths					
		Develops appropriate questions and methods towards solving the problem			Develops appropriate questions and methods towards solving the problem		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X
	Student 2			X			X
	Student 3			X			X
Grupo 2	Student 4			X			X
	Student 5			X			X
	Student 6			X			X
	Student 7			X			X
Grupo 3	Student 8			X			X
	Student 9			X			X
	Student 10			X			X
Grupo 4	Student 11			X			X
	Student 12			X			X
	Student 13			X			X

Table 18D. – Co-Measure rubric results per group IES ERAS pilot 2– Transdisciplinary Approach

		4 - Transdisciplinary Approach					
		Negotiates relevant method or materials to solving the problem posed			Negotiates relevant method or materials to solving the problem posed		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X
	Student 2			X			X
	Student 3			X			X
Grupo 2	Student 4			X			X
	Student 5			X			X
	Student 6			X			X
	Student 7			X			X
Grupo 3	Student 8			X			X
	Student 9			X			X
	Student 10			X			X
Grupo 4	Student 11			X			X
	Student 12			X			X
	Student 13			X			X

It is possible to see that there are not changes regarding previous pilot and that the students working is well appreciated.

In this stage also a computational thinking test is carried out the results of such test can be seen in Table 19.

Table 19. – Computational thinking Questionnaire results

	IF/ELSE				LOOPS						
CT Questionnarie	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Wrong	Correct	Grades
	B	A	B	C	D	C	C	A			0 - 10
Student1	B	A	B	C	D	C	C	A	0	8	10
Student2	B	A	B	C	D	C	C	A	0	8	10
Student3	B	A	B	C	D	A	C	A	1	7	8,75
Student4	B	A	B	C	D	C	C	A	0	8	10
Student5	B	A	B	C	D	D	C	D	2	6	7,5
Student6	B	A	C	C	D	A	D	D	4	4	5
Student7	C	A	C	C	D	B	C	A	3	5	6,25
Student8	B	A	B	C	D	A	D	C	3	5	6,25
Student9	B	A	B	C	D	A	D	B	3	5	6,25
Student10	C	A	C	C	D	B	C	C	4	4	5
Student11	D	A	C	D	A	B	D	A	6	2	2,5
Student12	A	A	B	C	D	A	C	D	3	5	6,25

	2,66	5,58	6,91

The results of the CT shows that all the students except one pass the exam and around a 40% of the students have a good grade regarding the selected items. The average grade for the students is 6,91 over 10.

4.2. AEEG

First, we present the basic indicators

- Students involved: 31
- Students ages: 15-16
- Teachers involved: 3
- Subjects: Sciences and Technologies and Arts.
- Number of nanochallenges addressed: 4
- Time devoted: 8 hours per group

In the case of the STEAM semantic Survey as there are more students than in the previous pilot, we have only considered the answers of those that repeated in both of them, results can be seen in Table 20.

Table 20. – Students results for the STEAM Semantic Survey post-test AEEG

STUDENTS	SCI	MATHS	ENG.	ARTS	TECH	CAREER
ST1	4	4.6	2.4	6.2	1.6	4.6
ST2	6	6.4	6.4	6	6.4	6.4
ST3	5.8	6	3.2	3.8	6.2	4.8
ST4	3.8	4	3.4	6.4	5.4	4.8
ST5	4.6	5.4	3.4	6.2	4.6	5
ST6	4.8	4.8	5.6	3.4	5.6	5.6
ST7	2	3.8	5	5.8	4.4	4
ST8	5.2	3.6	1	6.4	5.4	5.2
ST9	4	3.4	3.4	6	5.4	4
ST10	4	4.6	2.4	6.2	1.6	4.6
ST11	5	2.8	4.6	6.4	6	5.2

From a global perspective the average values are shown in Table 22.

Table 21. – Average values for the involve students in the pilot 1 and 2 in AEEG.

Area	Avg. Pilot 1	Avg. Pilot 2	Avg. Diagnosis
SCIENCE	4.35	4.47	4.69
MATHS	4.44	4.49	4.21
ENGINEERING	4.56	3.71	3.84
ARTS	5.62	5.71	4.00
TECHNOLOGY	5.42	4.78	4.51
CAREER	5.27	4.93	4.77

In this case it is possible to see an improvement in the perception of students about the areas of SCIENCE, MATHS and ARTS which is especially high and a decrement in the rest of them, especially in Engineering.

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. These rubric results are show in Table 22A, B, C and D.

It was possible to evaluate 22/31 students.

Table 22A. – Co-Measure rubric results per group AEEG pilot 2– Peer Interactions

		1 - Peer Interactions								
		Monitors tasks and checks for understanding with peers			Negotiates roles, and divides work to complete task			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X			X
	Student 2			X			X			X
	Student 3		X			X			X	
	Student 4		X			X			X	
Group 2	Student 5			X			X			X
	Student 6									
	Student 7			X			X			X
	Student 8			X			X			X
Group 3	Student 9		X			X			X	
	Student 10		X			X			X	
	Student 11		X			X			X	
	Student 12		X			X			X	
Group 4	Student 13			X			X			X
	Student 14			X			X			X
	Student 15			X			X			X
	Student 16		X			X			X	
Group 5	Student 17									
	Student 18									
	Student 19									
Group 6	Student 20									
	Student 21									
	Student 22									

Table 22B. – Co-Measure rubric results per group AEEG pilot 2– Positive Communication

		2 - Positive Comunication								
		Respects others' ideas and compromises			Respects others' ideas and compromises			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X			X
	Student 2			X			X			X
	Student 3		X			X			X	
	Student 4		X			X			X	
Group 2	Student 5			X			X			X
	Student 6			X			X			X
	Student 7			X			X			X
	Student 8		X			X			X	
Group 3	Student 9		X			X			X	
	Student 10		X			X			X	
	Student 11		X			X			X	
	Student 12		X			X			X	
Group 4	Student 13			X			X			X
	Student 14			X			X			X
	Student 15			X			X			X
	Student 16		X			X			X	
Group 5	Student 17		X			X			X	
	Student 18		X			X			X	
	Student 19		X			X			X	
Group 6	Student 20		X			X			X	
	Student 21		X			X			X	
	Student 22		X			X			X	

Table 22C. – Co-Measure rubric results per group AEEG pilot 2– Inquiry Rich/Multiple Paths

		3 - Inquiry Rich / Multiple Paths					
		Develops appropriate questions and methods towards solving the problem			Develops appropriate questions and methods towards solving the problem		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X
	Student 2			X			X
	Student 3		X			X	
	Student 4		X			X	
Grupo 2	Student 5			X			X
	Student 6			X			X
	Student 7			X			X
	Student 8		X			X	
Grupo 3	Student 9		X			X	
	Student 10		X			X	
	Student 11		X			X	

		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
	Student 12		X			X	
Grupo 4	**Student 13**			X			X
	Student 14			X			X
	Student 15			X			X
	Student 16		X			X	
Grupo 5	**Student 17**		X			X	
	Student 18		X			X	
	Student 19		X			X	
Grupo 4	**Student 20**		X			X	
	Student 21		X			X	
	Student 22		X			X	

Table 22D. – Co-Measure rubric results per group AEEG pilot2– Transdisciplinary approach

		4 - Transdisciplinary Approach					
		Negotiates relevant method or materials to solving the problem posed			Negotiates relevant method or materials to solving the problem posed		
		Needs work	**Acceptable**	**Proficient**	**Needs work**	**Acceptable**	**Proficient**
Group 1	**Student 1**			X			X
	Student 2			X			X
	Student 3		X			X	
	Student 4		X			X	
Grupo 2	**Student 5**		X			X	
	Student 6		X			X	
	Student 7		X			X	
	Student 8						
Grupo 3	**Student 9**		X			X	
	Student 10		X			X	
	Student 11		X			X	
	Student 12		X			X	
Grupo 4	**Student 13**			X			X
	Student 14			X			X
	Student 15			X			X
	Student 16		X			X	
Grupo 5	**Student 17**		X			X	
	Student 18		X			X	
	Student 19		X			X	
Grupo 6	**Student 20**		X			X	
	Student 21		X			X	
	Student 22		X			X	

Regarding the teachers' perception they pointed out "In a global Assessment the Challenge was achieved successfully. Nevertheless, the teachers noticed that the hardest thing for the students had to do with the welding task. Most of them must improve their fine motor skills. On the other hand, the theory and computational thinking didn't pose significant issues".

4.3. KIT

This pilot involves students from a vocational school in Germany, the main indicators were:

- Students involved: 17 from Portugal
- Students ages: 16-18
- Teachers involved: 6 university students and 1 teacher
- Subjects: Metal Engineering
- Number of nano-challenges addressed: 2
- Time devoted: 9 hours

Beyond the common assessment instruments, KIT employ their own observation sheet along the creative processes of collaborative prototyping of the pupils by the university students.

Regarding Students Sematic Survey Results, they can be seen in Table 23, from the 17 students we have only 15 answers to the survey, as commented in O2.A5 the areas of Math and Arts were removed in the German context.

Table 23. – Students results for the STEAM Semantic Survey pre-test KIT

STUDENTS	SCI	MATHS	ENG.	ARTS	TECH	CAREER
ST1	4	-	3.4	-	3.4	3
ST2	5	-	6.2	-	5.4	6
ST3	2.4	-	3.4	-	3.4	4.8
ST4	3.4	-	6.4	-	5.2	6.4
ST5	4.6	-	6.4	-	6.4	6
ST6	4.2	-	5.4	-	5.4	5.4
ST7	3	-	3.4	-	5.2	3
ST8	3.4	-	3.8	-	4.6	3.4
ST9	0.8	-	0.4	-	0.4	0.4
ST10	5.8	-	5.6	-	6.2	5.8

ST11	2.4	-	5.4	-	4.8	5.4
ST12	3.4	-	6.4	-	6.4	6.4
ST13	1.2	-	5.2	-	3.8	3.4
ST14	0.6	-	0.4	-	6	3.4
ST15	3.2	-	3.8	-	3.6	3.8

From a global perspective the average values are shown in Table 24.

Table 24. – Average values for the involved students in the pilot 1 vs pilot 2 and average KIT

Area	Avg. Pilot 1	Avg. Pilot2	Avg. Diagnosis
SCIENCE	3.51	2.95	4.52
MATHS	-		-
ENGINEERING	4.75	4.31	4.29
ARTS	-		-
TECHNOLOGY	4.88	4.72	4.75
CAREER	4.58	4.43	4.23

It is possible to see even lower values in the SCIENCE area than in pilot 1 and in the media of the institution, this can be caused because students should fulfill many forms beyond the development work.

The commeasure rubric was also applied, and the results are shown in Tables 25A, 25B and 25C. The students were divided in five working groups.

Table 25A. – Co-Measure rubric results per group KIT pilot2– Peer Interactions

		1 - Peer Interactions								
		Monitors tasks and checks for understanding with peers			Negotiates roles, and divides work to complete task			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1		X			X			X	
	Student 2		X		X				X	
	Student 3		X			X			X	
Group 2	Student 4	X				X			X	
	Student 5			X		X			X	
	Student 6			X		X				X
Group 3	Student 7			X	X				X	
	Student 8			X		X				
	Student 9	X				X				X
Group 4	Student 10		X				X		X	
	Student 11		X			X			X	
Group 5	Student 12		X		X				X	
	Student 13		X		X				X	
	Student 14		X		X				X	
	Student 15		X			X				X

Table 25B. – Co-Measure rubric results per group KIT pilot 2– Positive Comunication

		2 - Positive Comunication								
		Respects others' ideas and compromises			Respects others' ideas and compromises			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X		X				X
	Student 2		X			X				X
	Student 3			X		X				X
Grupo 2	Student 4			X			X			X
	Student 5			X			X			X
	Student 6			X			X			X
Grupo 3	Student 7			X			X		X	
	Student 8			X		X			X	
	Student 9		X		X			X		
Grupo 4	Student 10		X				X		X	
	Student 11		X			X			X	
Group 5	Student 12			X		X			X	
	Student 13			X			X	X		
	Student 14			X		X			X	
	Student 15			X		X			X	

Table 25C. – Co-Measure rubric results per group KIT pilot 2– Inquiry Rich/Multiple Paths

		3 - Inquiry Rich / Multiple Paths					
		Develops appropriate questions and methods towards solving the problem			Develops appropriate questions and methods towards solving the problem		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1		X				
	Student 2		X				
	Student 3	X					
Grupo 2	Student 4	X			X		
	Student 5		X			X	
	Student 6		X			X	
Grupo 3	Student 7		X				X
	Student 8						
	Student 9		X		X		
Grupo 4	Student 10		X			X	
	Student 11		X			X	
Group 5	Student 12	X					
	Student 13	X					
	Student 14	X					
	Student 15	X					

In this case the 4th dimension of the commeasure rubric is not considered because the transdisciplinary approach was not applicable. In addition, some variables are not valued as there are not evidences to do so. We should point out that in this case each group was graded by a university student so the criteria could not be exactly the same for all the groups. Compared with the previous application of the rubric results seems to be better.

Regarding the Computational Thinking test the results can be seen in Table 26.

Table 26. – Computational Thinking Test Results for KIT

	IF/ELSE				LOOPS						
CT Questionnarie	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8	Wrong	Correct	Grades
	A	C	B	B	D	C	C	A			0 - 10
Student1	B	B	B	B	D	A	C	D	4	4	5
Student2	C	A	B	B	B	B	C	D	5	3	3,75
Student3	A	B	D	C	D	A	D	A	5	3	3,75
Student4	C	D	B	D	D	C	D	B	5	3	3,75
Student5	A	B	B	B	D	A	C	A	2	6	7,5
Student6	A	B	B	B	D	A	C	D	3	5	6,25
Student7	A	B	B	B	D	A	D	B	4	4	5
Student8	A	B	B	B	D	A	C	B	3	5	6,25
Student9	A	B	B	B	D	A	C	D	3	5	6,25
Student10	A	B	B	B	D	C	C	C	2	6	7,5
Student11	A	A	C	B	D	B	C	D	4	4	5
Student12	A	B	C	B	D	A	B	C	5	3	3,75
Student13	A	B	D	B	D	B	C	A	3	5	6,25
Student14	A	B	C	B	D	A	C	A	3	5	6,25
Student15	A	B	B	B	D	A	C	A	2	6	7,5
Student16	A	B	C	B	D	A	C	A	3	5	6,25
Student17	A	B	B	B	D	D	C	A	2	6	7,5
									3,41	4,59	5,73

It is necessary also to include in this report the results of the observation list and the partner final remarks.

***Participatory Observation*[1] of the pupils by the university students**

During the project, the student mentors had to fulfil two roles: Firstly, they supervised the students when developing, designing, programming, testing and

[1] Translated form the German term of "Teilnehmende Beobachtung"

debugging their prototypes. Secondly, they were actively involved in the observation of the teams of pupils using 2 different observations sheets. The first one set up by KIT and validated in former school projects was developed along the processes of collaborative prototyping, so to speak tailor-made (see at RoboSTEAM platform [38]). The second was given by the project's coordinator addressing group interactions of pupils. In the following, the challenges for the students who have used all instruments, are described. They were discussed with the students in the university seminar bevor the school project:

1. In the project, the issue of using the additional compulsory observation sheet (co-measure) selected by the coordinator, was a big issue of debate, since the additional value was not obvious, nor was it practicable for students who were also busy mentoring and observing at the same time. In terms of contents, it was not possible to be done after the lessons, as suggested by the project's coordinator. Therefore, the mentors were extremely busy, taking notes of their observations and key issues during the lessons when they were to support the pupils as well.
2. Translation: The compulsory use of the STEAM questionnaire (before and after the classroom session) turned out to be tricky. In terms of contents was perceived not conclusive or significant. It was translated into German for the mentors. However, it was communicated the questions (topics) were not addressing the STEM subjects (German MINT), but addressing a rather general attitudes towards Science, Technology, Art[2] and career in general. Since the German term of "Naturwissenschaften" in Germany contains a bundle of disciplines such as Physics, Biology and Chemistry, but the questionnaire asking for the Naturwissenschaften (Plural), is not to be evaluated purely. Answers and accordingly the results remain on the surface.

[2] Arts is not included in MINT (STEM), since STEAM does not exist as a Germany term or concept. In Germany there is rather arts education approach to media education (such as realized in the MediaArt@Edu research project).

3. The questions raised in the STEAM quiz were closely related to the introduction of loops controlling a robot. However, in wearable design it works the other way round, objects are created in the first place, loops are explained if necessary for the particular project if required. Accordingly, prototypes had to include loops. In terms of didactics, it was necessary to integrate the STEM-test into the pilot for the pupils to make a connection and bring it together. So, it was decided to make a connection to control a real person navigating the physical space, before handing out the test sheets. The letter was additional time not to be spent for the robotic objects.

However, all instruments were used in the project by the university students.

Observations of pupils

In the following the examples of two mentors' observations are described which turned out very meaningful:

The KIT-student (A.)'s group was the working group number four consisting of three students. The planned project of this group was called "Police Shoe". In addition to the LiyPad and the power supply, the students needed three blue LEDs, an acceleration sensor and two loudspeakers. The idea behind this was to develop a shoe that could imitate a police car and its siren and warning light when walking. Consequently, the LEDs and loudspeakers should come on when the wearer, and thus the shoe, starts to move and only go out when the wearer stops again. As time went on, however, the accelerometer was changed to a light sensor. The students decided to change the components because, even after several attempts, they were unable to program the LilyPad in such a way that the motion sensor would have transmitted the correct signals. The challenge in programming was that the motion sensor had to be programmed in x, y and z direction and in addition the appropriate value of the motion strength had to be determined.

Pupil No 1

The observed student was at the age of 16 years.

Already after the first programming and cabling, one could see that pupils showed a keen interest in the project. He always wanted to understand everything at all times during the project. After a little food for thought from the author regarding the if-then condition, he was able to work very well independently. Thus, in block two he was able to program almost all the tasks set by the moderators (such as LEDs lighting up when it's dark) on his own. Which was not to change much during the course of the project, so that the project "Police Shoe" was also almost completely programmed by him. This led to the fact that at the beginning, rather sporadically, but in the course of the following lessons, he searched more and more independently for problems that crept in and was able to solve many of them independently. In addition, he always looked for the best possible solution to realise the project.

Despite the previous task of preparing a list of instructions for a selected moderator so that he could follow a taped path, which he mastered well with his group, he found it difficult to convert to a computer. The way he approached programming the LilyPad was not the conventional way, instead of drawing up a plan and following it, he programmed on it and then looked step by step at where the mistakes were or could be.

He was also quick to understand the hardware and recognising the function of each component was not a big problem for him. Connecting the individual components with crocodile clips was also easy for him. When it came to connecting with conductive gran, he needed help from the author and finally left the sewing to student 3.

With regard to the upcoming project work, he had a little difficulty with creativity at the beginning of the brainstorming process, but that subsided as the common ideas started to flow in one direction. After defining the basic idea, he was able to illustrate well what was needed to realise the project. However, capturing the idea visually was not his area of expertise. Thus, the type sketch was often too small to see anything and the circuit diagrams were often drawn untidily to show possible errors. For this task (written presentation of the project) he therefore needed more pedagogical support than for programming. With some help, however, good results were always achieved.

As far as individual work was concerned, he was always careful and very independent. He took over many tasks in the team on his own initiative. In addition, his interest in the project meant that he was concentrated on working most of the time, with small exceptions where he chatted with classmates from other working groups and was distracted by them.

When it came to asking for help, however, he was very reserved.

Pupil one was quickly the one in the group who took over and tried to distribute the tasks, which usually did not work out, because he showed the desire to have to do everything himself. The reason for this was usually that the other group members were not working fast enough for him and were not completing the tasks as he would have liked. And if he left a task to someone else, he checked the result for correctness. On the one hand this leads to the fact that possible mistakes can be eliminated together as a group, on the other hand it leads to a strong discouragement of the other group members. So, it was usually difficult for the other group members to get involved, as most attempts were rejected. The cooperation initiative that came from him was greater at the beginning and gradually deteriorated until the fourth teaching block. After that, things got better again as student three became more involved in group work and repeatedly made him feel that this behaviour was not appropriate. The way he spoke with the other group members sometimes took getting used to and was unfriendly for a while.

During the presentation of the project work, he agreed to do most of the work. He could reflect on the project work and express his learning success.

Student’s observation No 2

The observed pupil was at the age of 16.

Pupil No 2 was a little more reserved from the beginning when it came to programming and wiring the individual components. It can be assumed that he had no previous knowledge and therefore had difficulty understanding how the if-then condition works. Another complicating factor was that his classmate didn't let him do very much in this area, thus discouraging him from getting involved. So his main occupation was to look over the shoulder of his pupil and see what he was doing. Besides, he was the one who documented the project work in the small group and filled out the worksheets, sometimes even for all group members. After some time at the beginning, he started asking questions, mainly to better understand the programming, but also the cabling. During the course of the group work this led to him beginning to understand the programme that was being worked with and sometimes even making suggestions for improvements.

He was very interested in the development of ideas and contributed well. His imagination was sufficient to clearly see which hardware components were needed for the idea that was found. It was difficult for him to understand which components had to be connected to each other and how, and which functions these would take over in the project (prototypes). His circuit diagram sketches were always neatly drawn and easy to understand, but at the beginning he mostly drew them from the group members and only in the course of time could he slowly make drawings relatively independently.

Whenever he was asked to take on a task in individual work, he usually carried it out. But as far as his independence was concerned, he still had to work on himself. He often sat there and did nothing for the project because his attention belonged to something or someone else. It must be said, however, that there was often nothing for him to do, because, as mentioned above, student one often wanted to do everything. In such a situation, the pedagogical supervisor of this group would have had to intervene and make sure that everyone in the team was equally involved in the project, so that the distraction of the others would not have been so great. This did not happen, however, because the author did not know exactly how to do it without the intervention being too great.

His ability to work in a team remained at a constant level throughout the whole group work. He was always cooperative and open to ideas and suggestions from other group members. It was not difficult for him to rely on the fact that the work of the others was right. Thus, he never checked what the others were doing or whether it was correct in any way. His communication with his group members was always appropriate for the given situation.

Since we wanted everyone in the group to participate in the presentation, students two also had to give a part. However, he had coordinated exactly who would say what in advance. His formulation of the results was sometimes incomplete and uncoordinated, so that his presentation sounded disinterested and, above all, choppy. This may be related to the fact that he had some problems in the project with understanding the components and programming. This can be improved in the future.

Student No 3

The observed student was at the age of 23.

The observation of pupil three turned out to be difficult because he was absent more often and thus missed many phases of the project work.

His interest both in the planned group work and in the scholar, in the form of programming work as well as the design of the project and its technical components, was very limited from the beginning of the project. At the beginning his interest was the highest and decreased more and more as the project progressed. Purely from my observation, I could not determine whether he had understood the meaning of the if-then condition and could apply it. However, it was possible to guess from some rare wiring that he understood what functions the components had and how they had to be connected. The only activity he devoted himself to intensively was the sewing of the components in the fifth teaching block. He did this, however, with a great deal of precession and dexterity, which suggests that he had good previous knowledge of sewing, which is very unusual for a boy of this age and therefore very unusual.

During the initial brainstorming process, three pupils kept in the background and took little part in the resulting discussion. Even when it came to the verbal and written description of the project, he only participated sporadically and often did not carry out given tasks. However, this was not due to a language barrier between him and his classmates or the tasks, but rather to a lack of interest in the project. His sketches and circuit diagrams were usually incomplete or difficult to understand.

As far as individual work was concerned, he was by no means independent. So it seldom happened that he voluntarily took on a task of his own accord. Most of the time his concentration was not on the group and its project but on other classmates who were also not interested in their project or his mobile phone.

Whenever he participated in group work, he was usually cooperative in his dealings with the other group members. His language was appropriate, but he did not care if his group members had problems and might have needed help.

Since three students also had to participate in the presentation, he inevitably and without much enthusiasm performed his part. From the author's point of view, he did not perceive what educational content the project might have had for him if he had been more involved or why he had been a part of it.

Challenges and concluding remarks

Looking back on the lessons held, the first two blocks did not run according to plan, as the students' sense of time for lesson planning was still missing. This was due to the fact that half of the student group consisted of students with no previous knowledge and thus had to enter uncharted territory, which of course had an impact on their planning ability. Particularly in the first teaching block, it was not correctly assessed how long the students would need for the planned tasks, and so it happened that the moderators finished 20 minutes too early despite the attempt to keep the students* busy. In addition, there were complications on the part of the pupils when they were labelling the STEAM survey sheets for the purpose of later assigning the questions 1 and 2, which we had not expected, so that we had to carry them out again in block two.

In the final fifth teaching block, the pupils' projects were to be completed, which unfortunately did not happen, despite the fact that the timetable was postponed at short notice. None of the work pieces were completely finished. Some had already sewn everything in place and were desperately looking for the built-in error and others had only managed to do the wiring with crocodile clips. For the future, more care should be taken to ensure that the groups do not drift apart too much in time. Another mistake in the preparation was that the presenters had set the presentations at seven minutes per group and three minutes for changing the respective groups. What they did not take into account was that none of the groups needed more than 3-5 minutes to present their projects, so there was also time left at the end for the students to complete their projects.

As far as the personal observation of A.'s group is concerned, her initial problem was that she did not know exactly what was important in the observation, despite the observation sheets provided. This, however, subsided with time and she slowly knew what she had to pay attention to. What made it even more difficult was the fact that in her group one person worked alone most of the time, so it was difficult for her to evaluate the other two[3].

[3] The observation was realized and described by A., KIT student, in the framework of her written formulation of the observations using the 2 observation sheets.

Scientific observation of a pupil (working group number 3)[4]

In the course of the teaching project, all pupils were divided into five groups. Each of these groups was supervised by a student, who entered his observations in observation sheets. These were developed along the work processes and competence building in the context of cooperative prototyping (Reimann, observation sheet 1). Observation sheet 2 dealt with the interaction of learners in the working group. By using these observation sheets the aim was to document and assess the process of learning design (constructivism). As observation as a method is a subjective and selective experience of the observer, the observation form was semi-structured in order to achieve results that are as objective as possible. The units to be observed were defined. At the same time, it was designed to be open enough to allow new findings to flow in.

With regard to the observation described in this paper, it should be mentioned that the pupil observed was in group 3, which was mainly supervised by Ms K. and only partly by me. My task was mainly to provide technical support to all groups in the classroom. However, this also gave me the opportunity to get a better overall picture of the performance of the other pupils and to analyse it more effectively.

With the help of his group members, the pupil was able to develop initial ideas for an interactive project and describe the structure as well as the associated functionality. The group developed a shirt that was to be illuminated by LEDs linked by a light sensor in the form of the KIT logo both in low light and in normal daylight. This idea was then drawn as a sketch by the student I observed and, with the help of a student, correctly cased on the worksheet. He also succeeded in transforming the concept into an interactive system. However, the time needed for sewing was greatly underestimated by the group, so they developed a work piece that was to exceed the time frame. This was mainly due to an underestimation of the time

[4] The observation based on the student V., KIT student, in the framework of her written formulation of the observations using the 2 observation sheets.

required for sewing, which is why there was not enough time to install approx. 20 LEDs on the workpiece. When this problem arose, the students decided to leave it to the students to plan their own time and only take on an advisory role. This proved to be unfavourable, however, as the learning guides had already gained more experience with the materials and requirements for the creation of the workpiece and were therefore able to estimate that it would not be possible to complete the work in the given time. The approach that the pupils should work as independently as possible, make their mistakes and learn from them is of course applicable in many cases, but the individual learning speed of the pupils should not extend beyond the course of the teaching project. In order to ensure optimum organisation of group work, coordination of the scope of work and time management would be useful. During the first handling of the hardware, the student was able to name and use the individual elements correctly, but it still proved difficult to connect the cable correctly without help. A functioning programme could not be created at the beginning, which is why frustration continued to build up in the group, slowing down the progress of the work. The problem analysis proved to be a decisive factor in this process, so the pupils did not look for a solution on their own but waited exclusively for outside help. However, after the problems had been successfully solved, the mood quickly improved and the extrinsic motivation increased, so that the students successfully managed to use the different media and materials in the sense of the project idea. In the process, a much more pronounced problem-solving competence could already be observed. However, these observations confirm the assumptions of the last section that learning success can be a great motivator.

In teaching block 2, in which the pupil exposed himself to the displeasure of his group and encouraged it by provocative and challenging behaviour towards the students, the student managed to fulfil the set tasks and work cooperatively at most at a satisfactory level. However, due to increasing motivation and a relaxed atmosphere, in block 4 he showed himself to be oriented and informed, encouraged his group members and gave instructions, but implied autonomy of the others. Nevertheless, less productive work phases appeared after the break, but these could be improved by small impulses.

Despite an unfinished work, the pupil's group was motivated to present their results. Difficulties with the programming interface were only minimally solved, which reflects the initial difficulty with probing strategies and reflection of the processes. Learning successes were strongly emphasised by the group, however, with an unsatisfied undertone due to the fragmentary work piece. Even after the end of the project, the group could not reflect on the fact that the unfinished/non-working work piece was the result of an underestimated workload.

In total, the pupil was able to show the results of the reflection process he had developed in the face of the challenges he had faced, by re-evaluating the group's scheduling mistakes. Despite the fact that the process of developing CF is difficult, if not impossible, for the learning process facilitator to grasp objectively, competence developments in the pupil could be determined on the basis of changed behavioural structures. According to this, differences in dealing with problems at the beginning and towards the end of the project could be observed. Here, possibilities were developed to solve the problems themselves or in the group. This could be clearly seen in the decreasing number of requests from students or other groups.

Scientific observation of two further pupils

The following describes the scientific observations of two different pupils in the same project group. Pupil one is a 16-year-old pupil, pupil two is a female pupil aged 18. [5]

Observation of Pupil No 1: Ideas and concept development

The pupil is very well involved in the idea generation phase, he comes up with many ideas and makes constructive suggestions, he is able to classify the

[5] The observation was carried out using a scientific observation sheet along the processes of collaborative prototyping by L. v. H. Only one female pupil was attending the course.

requirements of the project as far as possible and to imagine the future project very concretely at an early stage. He knows how to explain the project idea and its function to his group members in a suitable way. The required project sketch is kept rather simple, but the presentation of the components and their wiring then shows hardly any errors and is quite concrete. The pupil can determine the required materials. In order to translate the project idea into if-then relations, he needs the support of his group members, but he also accepts it.

Media use/media action

Here, the characteristics tended to be more pronounced overall, even though the readiness tended to fluctuate. At the beginning of the project the pupil made a very competent impression concerning the identification of the components and their connections. In the further course of the project, the observation of this characteristic becomes somewhat worse, the pupil works less concentrated, which is why the identification of the connections is more difficult for him than at the first project dates. The pupil also finds wiring very easy at the start of the project and with alligator clips, i.e. in a simplified form, whereas coordination with the group members is then necessary during the realization of the project.

With the programming in the software of the LilyPad (AMICI) the pupil is able to create the necessary program to a large extent independently, whereby the creation of the loop causes him somewhat more problems than the creation of if-then conditions, altogether the pupil moves rather in the middle field of the evaluation scale. At the beginning of the project, the pupil was very motivated to identify errors in the program and to debug them; accordingly, he proposes solutions and discusses them in the team. The lengthy debugging measures during the creation of the own project, let the emphasis of the debugging clearly sink.

Media design

The pupil attaches great importance to the design of the project work. At the beginning of the project, he is able to identify emerging difficulties quite quickly; towards the end of the project, he finds this more difficult.

The cooperative prototype development suits the pupil, he makes an effort to make agreements and to keep them, which he also succeeds in for the most part. In addition, he recognizes the ideas of the other team members and strives for a solution with which all group members are satisfied. The pupil agrees on the distribution of tasks as far as possible with the team colleagues and reliably takes over the tasks assigned to him. The ability to identify problems of other team members and to provide them with help is rather moderately pronounced, as is the joint solving of problems on the prototype.

Social and individual competence

The ability to communicate and cooperate is quite strong overall, and the pupil contributes very well to teamwork.

Individual competence is also more pronounced, with the pupil showing a high degree of commitment, independence and diligence. However, these decrease slightly with falling concentration and perseverance, which are somewhat weaker. If problems are not found promptly, the pupil begins to lose concentration and stamina, but once the error is corrected, he can motivate himself well again.

Media reflection and reflection on the processes

The pupil executed the presentation very well, he was able to convincingly present the functionality and area of application and reflect on problems that arose as well as present the corresponding solution path. The pupil can at least partially name learning successes, furthermore he was able to formulate a qualified feedback on the project and his own performance.

After initial hesitation, the pupil finds his way well into the project and is able to develop very well in it; his initial, obvious scepticism gives way to a kind of athletic fighting spirit; he wants to create a good prototype.

Observation of pupil no 2: Media Use/Media Action

At the beginning of the project, the pupil was interested in identifying the components and their connections; as the project progresses, she loses some of this interest and moves on to the more hands-on activity of sewing. Nevertheless, she is able to connect the wiring of the interactive system quickly and correctly.

Programming the software of the LilyPad (AMICI) is not easy for the pupil, but she lets herself be helped and shows moderate interest in the introduction to the program. In the further course of the project, she leaves the programming to other team members and reliably takes care of the wiring of the hardware and the connection of this to the textile.

The shaping of media (design)

On average, the pupil can recognize the emerging difficulties well, she occasionally checks the results.

The pupil is comfortable with cooperative prototype development, she is particularly committed to the completion of the prototype and pushes the group to make agreements together and to keep them, which she mostly does well. In addition, she recognizes the ideas of the other team members and strives for a solution with which the entire team agrees.

The pupil reliably takes on the tasks assigned to her, and she also has a knack for identifying other teammates' problems and offering them help or finding a solution to the problem. Final problems on the prototype spur her to give her all once again.

In summary, the pupil is a bit more sluggish at the beginning but becomes more active as the project progresses and finds interest in the project; the team tasks suit her much better than the individual tasks at the beginning.[6]

Concluding remarks, challenges and reflections

The teaching project aimed to train the students in computational thinking in view of applied constructionism and design-oriented teaching. The choice of a 'textile construction kit' as a medium seemed to make the most sense here. By using it, complex processes can be explained and used on a simple, abstract level. This has proven to be a particularly motivating factor in the development of a workpiece (prototype). By means of a project-oriented teaching structure, the pupils should acquire further competences or expand existing ones as independently and creatively as possible. The core competence here should be 'Computational Thinking'.

Computational thinking

It represents a universally applicable attitude and ability which everyone should learn and use, not only computer scientists [14]. Through 'computational thinking' the project should promote efficiency, functionality and abstraction, among other things. The design-oriented lesson planning enabled the pupils to construct and design functional work pieces or interactive prototypes. However, as I already pointed out in my observation of one student, efficiency remained only a marginal aspect in some cases. Nevertheless, most of the pupils gained first experiences in programming, whereby an easy and playful approach proved to be ideal.

Based on the developments of the observed pupils, which were observed by other learning facilitators in a similar way in other pupils, it can be said that the project

[6] Observations by L.v.H.

has achieved its goal of training pupil's idea of the concept of computational thinking. By observing the processes, the development of problem solving competences and processes of reflection and abstraction could be determined. However, it would have been an important motivational impulse for the students if their projects had been complete and comprehensive, so they could have completed their projects. In view of the course of the lessons, this would have been possible by extending the project, or by more restricting the scope of work by the teachers, in our case – the KIT student mentors. In this way, they could have paid more attention to the existing time frame and thus not only implied but actively avoided a possible explosion of this and the consequences of its occurrence.

3.4. CIC

This pilot involves students from the Colegio Internato dos Carvalhos in Portugal, the main indicators were:

- Students involved: 25 students (eleven groups of students).
- Students ages: 15-16.
- Teachers involved: 2.
- Subjects: Electronics and Telecommunications.
- Number of nano-challenges addressed: 3
- Time devoted: 20 hours

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 short and implemented with some restrictions. The challenge require a robot to dance depending on a music with the following 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. The results obtained taking into account teachers' observations can be seen in Table 27.

Table 27. – Grades assigned by CIC teachers depending on students' achievements

		Time (30s to 1 min)		Inside the square 2m x 2m	Synchronism	Choreography	Total
		Points	2	4	7	7	20
Group 1	Student 1 Student 2	34 s	2	4	5	4	15
Group 2	Student 3 Student 4	40 s	2	4	7	5	18
Group 3	Studen 5 Student 6 Student 7	30 s	2	4	5	4	15
Group 4	Student 8 Student 9	36 s	2	4	7	4	17
Group 5	Student 10 Student 11 Student 12	41 s	2	4	7	3	16
Group 6	Student 13 Student 14	40 s	2	4	7	6	19
Group 7	Student 15 Student 16 Student 17	30 s	2	4	7	6	19
Group 8	Student 18 Student 19	30 s	2	4	7	7	20
Group 9	Student 21 Student 22	37 s	2	4	7	6	19
Group 10	Student 23 Student 24	40 s	2	4	7	6	19
Group 11	Student 25 Student 26	31	2	4	7	5	18

In order to untie equal scores, criteria were also defined, which in essence were based on the delivery of materials: Program; Music; Video. These materials were subsequently analyzed and scored.

The Table 28 shows the final results.

Table 28. – Grades assigned by CIC teachers final results

		Total	Untie				Posição
			Programa	Musica	Video	Total	
		20	Program	Music			Position
Group 1	Student 1 Student 2	15	0	0	1	1	11
Group 2	Student 3 Student 4	18	1	1	1	3	6
Group 3	Student 5 Student 6 Student 7	15	1	1	1	3	10
Group 4	Student 8 Student 9	17					8
Group 5	Student 10 Student 11 Student 12	16					9
Group 6	Student 13 Student 14	19	1	1	1	3	2
Group 7	Student 15 Student 16 Student 17	19	0.5	0	1	1.5	5
Group 8	Student 18 Student 19	20					1
Group 9	Student 20 Student 21	19	0.8	1	1	2.8	3
Group 10	Student 22 Student 23	19	0.5	1	1	2.5	4
Group 11	Student 24 Student 25	18	0.5	1	1	2.5	7

Regarding the STEAM Semantic Survey results, they can be checked in Table 29, only 5 students answer the postest.

Table 29. – Students results for the STEAM Semantic Survey pre-test CIC

STUDENTS	SCI	MATHS	ENG.	ARTS	TECH	CAREER
ST1	3.4	3.4	3.4	3.4	3.6	4
ST2	6	4	6.4	3	6.4	5.8
ST3	6.4	4.8	6.4	1.4	6.4	6.4
ST4	5.6	3.2	6	2	5.4	5.8
ST5	5.6	5.6	5.6	5.4	6	6
ST6	6.2	6.4	6.2	6.2	6.4	6.4

From a global perspective the average values are shown in Table 30.

Table 30. – Average values for students in the pilot vs those of the diagnosis phase in CIC

Area	Avg. Pilot 1	Avg. Pilo2	Avg. Diagnosis
SCIENCE	4.90	5.53	4.60
MATHS	4.27	4.57	3.86
ENGINEERING	5.37	5.67	4.26
ARTS	3.17	3.57	3.83
TECHNOLOGY	6.03	5.70	4.80
CAREER	5.40	5.73	4.62

In the tables it is possible to see that the values for all areas for the pilot2 students are higher than pilot1 except for technology, this means that there is an improvement in the perception about STEAM areas after the second pilot.

Regarding the Co-Measure rubric results they can be seen in Tables 31A, 31B, 31C and 31D.

Table 31A. – Co-measure Rubric in pilot 2 CIC – Peer Interactions

		1 - Peer Interactions								
		Monitors tasks and checks for understanding with peers			Negotiates roles, and divides work to complete task			Provides peer feedback, assistance and/or redirection		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X			X
	Student 2			X			X			X
Group 2	Student 3			X			X			X
	Student 4			X		X			X	
Group 3	Student 5			X			X			X
	Student 6		X			X			X	
	Student 7		X			X			X	
Group 4	Student 8			X			X			X
	Student 9		X			X			X	
Group 5	Student 10			X			X			X
	Student 11		X			X			X	
	Student 12		X			X			X	
Group 6	Student 13		X			X				X
	Student 14			X			X		X	
Group 7	Student 15			X			X			X
	Student 16		X			X				X
	Student 17			X			X			X
Group 8	Student 18			X			X			X
	Student 19			X			X			X
Group 9	Student 20			X			X			X
	Student 21			X			X			X
Group 10	Student 22			X			X			X
	Student 23			X			X			X
Group 11	Student 24		X			X				X
	Student 25		X				X			X

Table 31B. – Co-measure Rubric in pilot 2 CIC – Positive Communication

		2 - Positive Comunication								
		Respects others' ideas and compromises			Uses Socially appropriate language and behavior			Listens and takes turns		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1		X				X			X
	Student 2			X			X			X
Group 2	Student 3			X			X			X
	Student 4			X			X			X
Group 3	Student 5			X			X			X
	Student 6			X			X			X
	Student 7			X			X			X
Group 4	Student 8			X			X			X
	Student 9			X			X			X
Group 5	Student 10			X			X			X
	Student 11		X				X			X
	Student 12			X			X			X
Group 6	Student 13			X			X			X
	Student 14		X				X			X
Group 7	Student 15			X			X			X
	Student 16			X			X			X
	Student 17			X			X			X
Group 8	Student 18			X			X			X
	Student 19			X			X			X
Group 9	Student 20			X			X			X
	Student 21			X			X			X
Group 10	Student 22		X				X			X
	Student 23			X			X			X
Group 11	Student 24			X			X			X
	Student 25		X				X			X

Table 31C. – Co-measure Rubric in pilot 2 CIC – Inquiry Rich / Multiple Paths

		3 - Inquiry Rich / Multiple Paths					
		Develops appropriate questions and methods towards solving the problem			Verifies information and sources to support inquiry		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X
	Student 2			X			X
Group 2	Student 3			X			X
	Student 4		X				X
Group 3	Student 5			X			X
	Student 6		X				X
	Student 7		X				X
Group 4	Student 8			X			X
	Student 9		X				X
Group 5	Student 10			X			X
	Student 11		X				X
	Student 12		X				X
Group 6	Student 13		X				X
	Student 14			X			X
Group 7	Student 15			X			X
	Student 16		X				X
	Student 17			X			X
Group 8	Student 18			X			X
	Student 19			X			X
Group 9	Student 20			X			X
	Student 21			X			X
Group 10	Student 22			X			X
	Student 23			X			X
Group 11	Student 24		X				X
	Student 25			X			X

Table 31D. – Co-measure Rubric in pilot 2 CIC – Transdisciplinary Approach

		4 - Transdisciplinary Approach					
		Discusses and approaches problem solving incorporating multiple disciplines			Shares connections to research or relevant Knowledge		
		Needs work	Acceptable	Proficient	Needs work	Acceptable	Proficient
Group 1	Student 1			X			X
	Student 2			X			X
Group 2	Student 3			X			X
	Student 4			X			X
Group 3	Student 5			X			X
	Student 6		X				X
	Student 7		X				X
Group 4	Student 8			X			X
	Student 9		X				X
Group 5	Student 10			X			X
	Student 11		X				X
	Student 12		X				X
Group 6	Student 13		X				X
	Student 14			X			X
Group 7	Student 15			X			X
	Student 16			X			X
	Student 17			X			X
Group 8	Student 18			X			X
	Student 19			X			X
Group 9	Student 20			X			X
	Student 21			X			X
Group 10	Student 22			X			X
	Student 23			X			X
Group 11	Student 24			X			X
	Student 25			X			X

Regarding the Computational Thinking Test results, they can be seen in Table 32.

Table 32. – Computational Thinking Results for CIC

CT Questionnaire	IF/ELSE				LOOPS				Wrong	Correct	Grades
	Item 1	Item 2	Item 3	Item 4	Item 5	Item 6	Item 7	Item 8			
	B	A	B	C	D	C	C	A			0 - 10
Student 1	B	D	D	C	D	D	C	B	4	4	5
Student 2	B	A	D	D	D	A	C	A	3	5	6.25
Student 3	B	A	B	C	D	C	C	A	0	8	10
Student 4	C	A	B	C	D	A	C	B	3	5	6.25
Student 5	B	B	C	A	D	C	C	D	4	4	5
Student 6	B	A	B	C	D	A	C	D	2	6	7.5
Student 7	B	A	B	C	D	A	C	C	2	6	7.5
Student 8	B	A	B	C	D	C	C	A	0	8	10
Student 9	A	B	B	C	D	A	B	A	4	4	5
Student 10	B	A	B	C	D	A	C	A	1	7	8.75
Student 11	B	A	B	C	D	C	C	A	0	8	10
Student 12	B	A	B	C	D	B	C	D	2	6	7.5
Student 13	B	A	B	C	D	D	C	A	1	7	8.75
Student 14	B	A	B	C	D	C	C	A	0	8	10
Student 15	A	B	C	C	D	A	C	A	4	4	5
Student 16	B	A	B	C	D	C	C	A	0	8	10
Student 17	A	B	C	C	D	C	C	D	4	4	5
Student 18	C	A	B	C	D	A	C	B	3	5	6.25
Student 19	B	A	B	C	D	A	C	A	1	7	8.75
Student 20	B	A	B	C	D	C	C	A	0	8	10
Student 21	B	A	B	C	D	C	C	A	0	8	10
Student 22	B	A	C	C	D	C	A	B	3	5	6.25
Student 23	B	A	B	C	D	C	C	A	0	8	10
									1.78	6.22	7.77

4.5. UEF

The pilot 2, in University of Eastern Finland, was carried out in the Teacher Training School, the main indicators were:

- Students involved: 5 students.
- Students ages: 16.
- Teachers involved: 2.
- Subjects: Extra course
- Number of nano-challenges addressed: 3
- Time devoted: 30 hours

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 which results will be shown Table 33.

Table 33. – STEAM Competences Assessment by UEF

	Problem Solving	**Computational Thinking**	**Communication Skills**	**Creativity**	**Cultural Knowledge**
St1	9	8	8	8	9
St2	10	10	10	9	10
St3	9	9	9	9	10
St4	10	10	10	9	9
St5	10	10	9	9	10

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