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eCraft2Learn

Digital Fabrication and Maker Movement in Education
Making Computer – supported Artefacts from Scratch

Deliverable D5.4

Impact of the Pilots on Learners Report

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E-Mail:	office@ecraft2learn.eu

Consortium:

University of Eastern Finland, Finland, (UEF), Coordinator

Edumotiva, Greece (EDUMOTIVA)

Mälardalen University of Sweden, Sweden (MDH)

Zentrum für Soziale Innovation, Austria, (ZSI)

The University of Oxford, United Kingdom, (UOXF)

SYNYO GmbH, Austria, (SYNYO)

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Authors:	**Margit Hofer, Neela Salamon, Christian Voigt,** ZSI
	Mareena Hyypiä, Calkin Suero Montero, UEF
	Emmanouil Zoulias, Rene Alimisi, EDUMOTIVA
	Afshin Ameri, Baran Cürüklü, B. Sauter, MDH
Reviewers:	**Konstina Zachari,** TECHNOPOLIS COA **Stela Shiroka,** SYNIO (Part 1)

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EXECUTIVE SUMMARY

This report presents the impact findings from the eCraft2Learn project pilots on participating teachers and students. In complement to the D5.3 Recommendations for Ecosystem Refinement and Improvement report, this report outlines the impacts on different aspects and provides recommendations on how to leverage the impact potential of this different approach of learning for the major stakeholder groups of teachers and students in formal and informal learning settings.

Several qualitative and quantitative data sets were used including interviews, questionnaires and diaries for teacher and students, observation sheets from the pilots as well as small-scale interviews during events with teachers, students and visitors.

Given the extensive amount of data and the thorough analysis, the document is structured for the readers' convenience in three parts. The **first part is summarizing the results** on a rather 'easy reading' way by presenting the major findings from the analysis. The **second part goes into details of the analysis of the entire pilots**, documents the work done and outlines also the respective data analysis of all pilots for those readers who are more deeply interested in some specific aspects. Due to the different nature of the pilot projects in the respective countries, a **third part outlines in-depth an analysis of both piloting countries** Greece and Finland to allow the reader an analysis per country. This third part also includes an additional work on the impact of AR on 3D printing that has been researched.

The impact analysis concludes with some reflections and recommendations.

PART I – IMPACT OF THE ECRAFT2LEARN PILOTS (IN SHORT)

"*These projects are worth to do even more.*" (Student from Finnish Pilot)

THE BACKGROUND: DIGITAL FABRICATION AND MAKING TECHNOLOGIES

Seeking to test the created eCraft2Learn learning ecosystem and receive feedback from teachers and students as a means of improving the ecosystem on a participatory-design approach, the project carried out two pilots' phases in Greece and Finland. The pilots included activities that aim at reinforcing personalized learning and teaching in science, technology, engineering, arts and math (STEAM) education and by doing so fostering also interpersonal skills, assisting the development of 21st century skills that promote inclusion and employability for youth in the EU. Prior to deploying the pilots in formal and informal learning settings, the involved teachers and coaches received specialized training on using the technical tools and the corresponding pedagogical model. The trained teachers and coaches enabled students aged 13-17 years old to work on digital fabrication and making technologies for creating computer-supported artifacts. Embedded in an appropriate pedagogical model that supports different steps and phases, the teachers and students were provided with digital fabrication, making technologies, and programming tools within two pilots in Finland and Greece.

THE METHODOLOGY: QUALITATIVE AND QUANTITATIVE ANALYSES

The main aim of the inquiry from the pilots was the impact of the eCraft2Learn methodologies on teachers and students when performing different projects. In addition, eCraft2Learn was also interested in drawing in recommendations for teachers that could support the development of a sound pedagogical methodology. To answer the questions, several analyses were performed on qualitative data (19 teacher and 43 student interviews, 469 student diary entries, 113 teacher diary entries and 154 student questionnaires) as well as quantitative data sets (student questionnaires, observation sheets, teacher diaries). The single analysis of these data gave valuable insights on the impact of the pilots. In combination, they allowed to extract similarities and differences, but also complemented each other.

THE IMPACT: OUTCOMES AND FINDINGS

- ### IMPACT ON KNOWLEDGE AND ABILITIES

The eCraft2Learn pilots included more long-term project work compared to the normal school work. These projects helped students to develop skills in planning and testing as well as recovering after a failure and finding ways to cope with challenges and difficulties. Students reported in the final questionnaires that they now feel more comfortable than before the pilots to work with electronics, make and create things, program and solve problems (see section 5. Quantitative data analysis). **Teachers also** outlined that they have observed **improvements on students' collaboration skills, methodological skills, creativity, programming and robotics**.

In both sites, **the more students gained experience in making, electronics and programming, the more comfortable they were than before to tackle and solve problems**. The close connection between problem solving and making was also reported by teachers in their interviews.

Some students (in particular introverted students) **improved their self-confidence and courage** when taking over responsibility in working with electronics. Several teachers mentioned that they were surprised about the performance and abilities of the students and mentioned that they saw new sides of their students (change of view of students abilities and competencies).

It can be said that eCraft2Learn projects increased students' level of digital competency in multiple areas and on different levels. Still, all teachers agreed that all students got at least familiar with these technological skills even though some of them acquired greater skills than others.

- ### Impact on Motivation

Students showed **increased motivation to find solutions** in emerging problems.

The **connection to real life examples or problems as well as the enabling of individual working style enhances the motivation of students**. Interesting in this respect is the fact that the arts and visual aspect of the project especially had impact on girls' motivation and interest towards the project.

Students with lower time management skills were in danger of losing motivation. Consequently one important task of the coach is to lead the time management of teams. Another task that is also vital for students' motivation is the provision of support by the coach in a timely manner. That is considered to decrease the frustration level of students as well.

In both countries in formal as well as informal settings, students had a **positive learning experience** on the project as a majority of the students had liked the project.

- ### Impact on Roles, Working Style and Attitude

The eCraft2Learn teaching/learning approach requires a change of the role of teacher (acting as coach) AND students (acting increasingly self-driven and self-determined). Thus, not all students could develop their self-regulatory skills in a limited time frame. It has been argued that this change requires some time to adapt accordingly from both target groups, teachers and students.

When investigating which dimensions had the biggest effect on the students' overall liking of the project, the correlation matrix indicated these variables being **innovativeness**, **problem solving**, **collaboration** and **creativity** in both informal and formal contexts. Thus, **the more students experienced being able to be innovative, collaborative and creative, and the more comfortable they felt after the project to tackle and solve problems than before, the more positive was their experience of the project**.

The project **did not change teachers' basic attitude towards technology** but their role instead: the more the teacher acts as coach, the better students can act self-driven. Especially those teachers that were not familiar with the concept of coaching reported positive impacts in relation to the potential of their students, own perception of technology as well as on learning concepts of children.

It was observed that many students are proud of their work and **enjoyed presenting and sharing their work** on different occasions. The students gained much more feedback on their work during the

eCraft2Learn project than during the normal school lessons which had a positive influence on their self-confidence and self-esteem.

Several teachers agreed that the project **decreased students hesitations and fear towards technology** and provided a new way to see technology, while others were of the opinion that student do not fear technology at all.

The teachers found that eCraft2Learn pilots are a great way to **open a new perspective** for students. Many students mentioned that the pilots had an impact on their options, perspectives and/or interest in general.

Teachers and students highly valued their involvement in **hands-on activities and showed strong sense of ownership** of the final artifacts, explaining every aspect of the technical solution and the related STEAM concepts.

- ### IMPACT ON LEARNING ECOSYSTEM

There is **conflict between the open nature** of the eCraft2Learn learning intervention **and the timely predefined school sessions** (i.e. by the Greek Ministry of Education). Several teachers struggle with the amount of hours needed to complete a project and to acquire knowledge to a specific topic (issue of time and efficiency). Due to restrictions of the curriculum the projects need to be very carefully timed and smartly solve this issue (ie. by integrating the eCraft2Learn workshop in 'the free and creative zone').

According to teachers students have better results if the level of pre-knowledge and abilities is mixed. Consequently it is recommended to **mix the students** according to their academic achievement.

Moreover, the support from their peers and the **teamwork encouraged students to make things and tackle problems and resulted in them feeling more competent** with these skills. Students who reported being more confident in solving problems had also been able to be innovative, creative and test and try out things.

Students who **collaborated with each other on planning, coordinating and sharing activities, felt being able to be creative and test things**. One important finding was that the informal site answers had in general less correlations between variables than the formal site. Innovativeness was included in all variables in the formal site but in the informal site only in overall liking and problem solving.

The own preferred way of working did not correlate in the informal setting with any other variable but **in the school setting** the correlations indicated that students willingly chose to work collaborating with others during the pilots and therefore **preferred working in teams**. In addition, **if students in school could do things the way they preferred**, they experienced **being able to be creative and test things**.

The ideal setting for these type of projects are **supported by different teachers as well as by the headmaster**. A smooth integration into the curriculum is to be preferred. Also the volunteer participation of the students is vital.

Teachers quote that the **learning analytics is necessary** and useful for the day-to-day school environment.

Students that have **worked with AR, are printing** their objects **earlier and are more self-confident** in comparison to students that have not used the AR.

Teachers emphasized that students learn different (or rather additional) things than at regular school classes. They observed students' different approaches to the project and several teachers emphasized that teaching technology in this way works the best for the younger students because they can think from their perspective how to implement it.

As positive aspect to the learning has been mentioned that the project allows students to **learn and create in a tangible way**. Students learn by a trial and error process from which they get valuable lessons, feeling also the success. "*That's probably the best thing in it. Many things will be better remembered when students are practicing and experimenting themselves*" (Finnish teacher). Also, for students with special needs, hands-on making is a suitable and great way to learn.

- ## NATIONAL DIFFERENCES - IMPACTS

The independent samples t-test indicated scientifically significant differences between Greece and Finland in answers with collaboration and problem solving in the informal setting and with making and problem solving in the formal setting.

In the informal setting, the **Finnish students reported having been slightly less able to plan, coordinate and share with others than the Greek students.** These differences emerged in the second pilot round answers only. Moreover, the **Finnish students felt in some extent less comfortable to tackle problems and find solutions** for issues than the Greeks after the project. In the formal setting, after the first pilot round, the **Greek students felt significantly more comfortable to solve problems and to make, work with electronics and program than the Finnish students**.

Although some differences between the two countries were made, all in all **the quantitative results suggested that** despite where the eCraft2Learn ecosystem is used, who are the actors, what type of projects are created and what tools are used**, the student experience is received in a very similar way**. This indicates that **when the teachers and coaches are provided with similar guidelines for the teacher training on the eCraft2Learn pedagogical framework and the technical environment, the outcomes of the student learning can be gained anywhere by anyone**.

- ## THE RECOMMENDATIONS: DO'S AND DON'TS IN SHORT

→ **Integrate and foster digital hands-on activities in classroom as well as in informal learning settings** - it allows students to learn and create in a tangible way as well as foster their creativity and problem solving.

→ **Re-think the role as teacher and rather act as a facilitator or coach** - it will improve your relationship to your students and will ease the different learning of your students.

→ **Consider that this change of adaptation to a new role and behavior requires some time also for the students** - students will learn to work independently, self-directed and self-driven.

→ **Support your students by setting time frames.** Many of them will have difficulties to steer their timing in the first projects.

→ **Promote a change in attitude and performing the activities under the premise that failing is not equal to 'not learned' something** - it will help the students to understand that failing is a chance to improving.

→ **Exploit different ways of sharing and presenting**- it will support students to gain new skills of collaboration, idea generation and entrepreneurship.

→ **Invest some time and get familiar with different pedagogical teaching methods and the technology** (i.e. within a training) - it will support teachers to feel more confident and handling their new role as coach and facilitator.

→ **Ideally, organize the sessions in longer working periods** - it will support the feeling of continuity of the project work and sense the "flow" in the work.

→ **Organize the setup of your projects at one place -** it will ease the organization and will save time.

→ **Seek support and communicate with an experienced community group that is well-versed** - the group might have valuable tips and tricks for your student groups.

→ **Seek support from other stakeholders in your learning environment (director, other teachers, parents, local industry or SME's)** - it might enrich the work of the students to a great extend.

→ **Foster projects that have connection to real life** - it will have a positive influence on the students motivation and eases to make partnerships with stakeholders.

→ **Mix the students in teams according to their pre-knowledge and abilities** - it will help them to learn from each other and to achieve better learning results.

→ **Provide support only if needed but in time** - it will support the self-confidence of the students, avoiding frustration.

PART II – DETAILED ANALSYS OF PILOTS

1 INTRODUCTION

The approach taken in this deliverable is to analyze the impact potential of the eCraft2Learn ecosystem on different levels and in particular for the stakeholder groups of learners, teachers. In doing so, we point out the used impact assessment tools for the reader's reference.

This deliverable serves as a guideline to point out the different impacts the UUI had within the two pilots performed, outlines the possible potentials that this type of learning holds for various stakeholder groups and deviate recommendations for shaping next generations learning. Consequently this deliverable reports on how these findings were analyzed (methodology and evaluation tools used - chapter 2). Within chapter 3, we detail the impact findings of the different sources from the two pilot rounds in Finland and Greece. Consequently suggestions for refinement and improvement will be listed on a rather global level that will lead us to recommendations for the different stakeholders (chapter 4), summarizing the document in chapter 5.

On the level of a learner or teacher, the question needs to be how different stakeholder groups benefit from the eCraft2Learn activities and what the positive and negative externalities on its learning environment are.

Impact assessment on this level serves as an initiative's self-control mechanism to ascertain whether desired impacts are really achieved. For external reporting purposes, impact assessment also functions as the process of developing evidence that an activity had effects. Being clear about the impact allows also to recommend actions or directions in a changing world with different request and demands on the next generation of employees or entrepreneurs. To provide operational tools for these purposes, a variety of sources were used and analyzed. They are focusing on different criteria to be assessed and employing different methods to assess them.

2 RATIONALE AND METHODOLOGY

An underlying challenge in WP5 of the eCraft2Learn project and also of the overall evaluation and impact design is the need to balance the uniqueness of each pilot with the requirements of a common base, able for formulate insights and findings. Thus, already aiming for comparable conditions at the different pilot sites for several evaluation instruments, we took care of having clear instructions on the evaluation design for the questionnaires, the interviews as well as the diaries. For instance, while instructions for carrying out the questionnaire have been formulated in detail and standardized and had to be followed as closely as possible by the different pilots, there is much more freedom and less standardization with others, as e.g. the feedback of participating children or the student interview setting.

The major aim of this deliverable is to understand if there is any impact - in terms of changes in different dimensions like behavior, knowledge, own perception of role, a.s.o - for both, students as well as teachers. Therefore several instruments were used to gain insights on how the eCraft2Learn project had influenced the users.

2.1. METHODOLOGY FOR IMPACT ASSESSMENT

For impact assessment we applied a mixed methods approach using qualitative and quantitative data (methodological triangulation). It has been decided that this approach is an ideal technique to assess the complex interventions during the two pilot stages. The term “mixed methods” refers to an emergent methodology of research that advances the systematic integration, or “mixing,” of quantitative and qualitative data within a single assessment. The basic premise of this methodology is that such integration permits a more complete and synergistic utilization of data than do separate quantitative and qualitative data collection and analysis (Jick 1979, Flick 2011, Kelle 2008).

This triangulation design typically involves two phases: (1) an initial quantitative phase, followed by (2) a qualitative data collection phase, in which the qualitative phase builds directly on the results from the quantitative phase. In this way, the quantitative results are explained in more detail through the qualitative data.

Thus, the findings from the questionnaire can be explored further with qualitative interviews with teachers and students to better understand how the personal experiences of individuals match up to the questionnaire results. Consequently we used the qualitative data to explore quantitative findings. By doing so, we collected from different sources data that are listed below:

2.2. EVALUATION TOOLS USED

The collection quantitative and qualitative data based on the major defined pillars of:

A) Expectations

B) Impact social, skill and cognitive

C) Ecosystem

D) Pillar - UUI

E) Gender

Align these pillars, sub-questions were formulated and adapted to the respective target group (teacher and students) for the qualitative data collection as well as for the quantitative methods. As

regarding the qualitative questions, it was explicitly fostered to have a semi-structured approach, meaning that the questions are guiding through the interviews but not restricting to exclusive questions. Guidelines were instruction, that any other interesting upcoming topic shall be followed up to insure that other relevant information or topic that has not been tackled will be followed up. While some methods exclusively collected qualitative data (i.e. interviews) other methods collected both, quantitative data as well as some qualitative data:

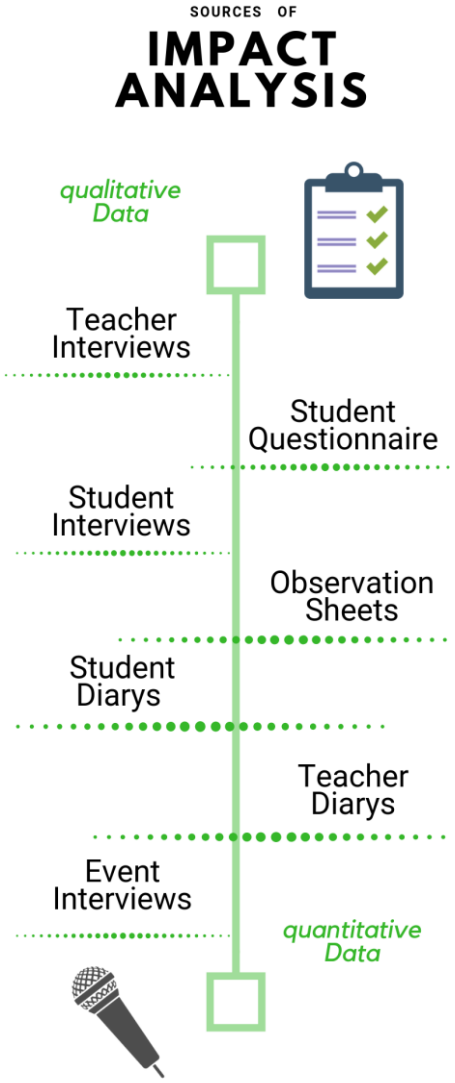

Figure 1 Means and tools for analyzing impact - quoting approx. amount of qualitative and quantitative data

Based on the first pilots a set of qualitative tools was developed. Consequently several interviews were done with teachers and students, which are the basis for the qualitative data analysis at hand (January 2018 - May 2018). In addition several 'short' interviews during events were integrated to the data set, since valuable information could be extracted from this source as well (video clips). The transcript interviews were used to create 34 codes in the qualitative analysis software called MaxQDA. The data material was assigned to these codes and served as basis to structure the analysis.

The quantitative analysis is based on student questionnaire, teacher diaries and observation sheet. As regards the student questionnaires, although there are several standardized published scales available

that measure self-confidence, self-efficacy or related constructs, such as FSKN (Deusinger, 1986), FKK (Krampen, 1991), PALS (Midgley et al., 2000) , and some sub-scales of PFK (Seitz & Rausche, 2004), none was suitable as it was for our purposes. Therefore a tailor made questionnaire for students was developed.

Due to the fact that the pilots allowed high adaptability to each preference of the teacher, the study environment of the students and the ecosystem in total, we analyzed each pilot on its own. Thus, in total we have four analyses that were compared with each other. In addition the students questionnaires were used to have a common analysis (Greece and Finland). This way, we were able to understand differences and similarities, barriers and facilitators in comparison to the results achieved and to the interviews analyzed. The collection of these data was usually during each pilot phase.

Table 1. Number of data collection per country

	Greek informal pilot site	Greek formal pilot site	Finnish informal pilot site	Finnish formal pilot site
Students' diaries	232	140	9	88
Teachers' diaries	47	49	9	8
Students' final questionnaire	41	37	20	56
Interviews with students	10*	6*	7	20*
Interviews with teachers	5*	4*	3*	7*
Observation forms	16	12	6	43
* Including short interviews taken in the context of the festivals with students & teachers				

3 IMPACT – QUALITATIVE ANALYSIS

3.1. SEMI-STRUCTURED IMPACT INTERVIEWS WITH TEACHERS

A significant input for the impact analysis were the semi-structured interviews (pl. see annex 1) with the pilot teachers that were involved in the eCraft2Learn pilots. In total, 10 long term teacher interviews were performed from the partners ZSI (interviews with teachers from Greece n=3 and Finland in English, n=1), EDUMOTIVA (interviews in Greek n=2 after the 1st pilot round and 4 shorter interviews during the Athens Science festival) and UEF (interviews in Finnish n=4). The interviews were transcribed and analyzed and represent the view of the teachers on the impact the pilots had on their students as well as on themselves. Several teachers commented also on future perspectives and potentials these type of projects (making, programming) will or might have. The following section summarizes these personal views.

3.1.1. EXPECTATIONS OF TEACHERS

This section asks for any expectations of the teachers and if those expectations were met. Many teachers spoke about the fact that the initial view was a rather hesitant one, respectively that the eCraft2Learn project will be difficult as the classes are diverse in terms of students' academic achievement. Some expectations were extremely low:

> *"They did not think the program would go well and they did it just to have a picture of how something different to the usual, would work. I would say that initially, they were negative to the program, so the approach at the beginning was «let's try to see if it can go on». They believed that the children would have the opportunity to see different programming environments and they did not believe they would respond to something that is free." (Teacher A GR)*

Teachers have groups where there are both well-performing and not so well performing students. In the eCraft2Learn projects these students were mixed in the student teams. Teachers noticed that **mixed groups lead to better learning experiences** and results than ability grouping of students.

> *"We thought that no, no, this they can never understand but well fortunately we were wrong." (Teacher A FIN)*

> *"I was wondering if this will be challenging when a young imagination produces a picture of an amazing project but will it be possible to implement in practice. And it will disappointing if the expectations are not met." (Teacher B FIN)*

> *"When they [students with different level of academic achievement] are working in groups it works well as they learn from each other". (Teacher D FIN)*

All participant teachers' expectations were met and some even excelled during the project:

> *"However, the low expectations were not confirmed. On the contrary there was a better outcome with a response higher than the one anticipated." (Teacher A GR)*

Students were competent on **acquiring knowledge and creating great projects based on their ideas and plans**.

"We [teachers] were wrong. They [students] learned very quickly and they knew how to, just when they know what to do they did that. -- I have to say I was very surprised, but in a good way, in a very good way." (Teacher A FIN)

Even rather challenged students seemed to adapt well within the pilots:

"I was a little worried before the project what the students will come up with because the group I had is a little challenging in terms of school achievement. But I was positively surprised how all teams, except one, actually finished their projects and got great results." (Teacher C FIN)

Interesting in this respect is that even the teachers noticed that the **connection to real life has positive influence on the motivation**. Although prototyping, the students were able to work beyond theory and - at the same time - **work on an individual working style**.

"I feel that the outcomes of the project that students produced were actually realistic. And in that sense I think this project went better than I had imagined. Students could implement their ideas and they were working according to their personality." (Teacher B FIN)

"When they [students] got into the work they got really great outcomes. They were even asking that 'is this possible to do in this way, can we use that to make our plan work like this' so they were really interested in the project." (Teacher A FIN)

In line with the statistical data, the teachers reported, that the projects had a positive influence on the motivation of the students. However, these type of projects can be no guarantee that the motivation keeps up for the entire time but underlies (as the regular teaching as well) some certain aspects like support just in time or time management of certain task:

"When it was so time consuming and never finished, the team members lost

track and interest." (Teachers Groups EF_Teachers A&C, FIN)

Thus one task of the coach has to be to **estimate if the effort of the project** can be handled in the given time since this is very difficult to judge for inexperienced students.

Girls were engaging in the project much more than teachers expected. Teachers identified that the **arts and visual aspect** of the project **especially had impact on girls' motivation** and interest towards the project. Teachers also noticed that girls were eagerly working with programming as it was included in the project in a seamless way.

"Girls could carry out the projects in their own way. For me that was positive." (Teacher D FIN)

"And I think this was a girls' thing because the girls were very interested. Maybe was it a flower or what was it, because the girls were very excited. Boys weren't that keen on making the flower." (Teacher A FIN)

On the other hand, teachers have observed a change in behavior and that this change might also be tricky for (usually) rather good students:

"For example, someone who was a good fit, went to the other team to help and there was a general sharing of knowledge among groups. Some students who were negative about the class liked crafts more, while some good students had problems with crafts because they are different to traditional classes and they found them difficult." (Teacher A GR)

We can conclude that this **way of working is a change for teacher and students and this change requires from both target groups some time to adapt.** It is in question if (usually) competent students would adapt well, or if this way of working does not adapt well in general to their way of working or personality. Thus, one recommendation that can be given is that teachers or coaches need to understand how well students have acquired already this individual way of learning.

3.1.2. IMPACT SOCIAL SKILLS AND COGNITIVE SKILLS

- It has been expected that there will be changes in terms of social, cognitive and interpersonal skills. Consequently this section asked for any change that could be observed (way of working, interaction, behaviors, group dynamics).

The eCraft2Learn pilots included more long-term project work compared to the normal school work. These projects helped students to **develop skills in planning and testing** as well as **recovering after a failure and finding ways to cope with the challenges and difficulties**.

> *"...the understanding of doing things by themselves, building things, collaborating, learning through experience, make mistakes all those things are vital for their own mentality, for the future of their education and those things are difficult to learn, so through all those sessions and workshops the students I think realized how important it is for them to collaborate, go deeper, explore new tools and techniques, new approaches, this experiential learning procedure." (Teacher A, GR)*

Also, **the assignment and work itself had a bigger degree of openness which fostered students' self-regulation skills and metacognitive skills.** One participant teacher noted that the big amount of freedom led students to enjoy the project.

> *"How do you get over it and start planning again in case you fail." (Teacher E, FIN)*
>
> *"School work should have more these longer-lasting projects to help students to learn planning skills and strategies to cope with the failure." (Teacher D FIN)*
>
> *"They [students] liked to be in the project. Maybe this certain freedom had the biggest impact on 14-year-old students which they enjoyed. Although, students enjoy and exploit that freedom." (Teacher B FIN)*
>
> *"Long projects take the students out of their comfort zone and the long work may start being too difficult for some students. And then I saw some new features of students' traits and personality. And some feel success all the time." (Teacher C FIN)*

Teachers could observe that especially (some) boys that, in the normal school work are more quiet and staying on the background, **improve their self-confidence and courage** when they actively took responsibility in working with electronics. Thus, some changes in the student behavior could be noticed during the project.

"He was taking the responsibility of his team's work progress. During the school year I could notice that he was somewhat secluding himself in the class but in this project he was the leading light in his team." (Teachers D and E FIN)

"Other students were looking that 'ok he knows that' and I think that for the more quiet boys that increased their self-confidence." (Teacher A FIN)

"When they have the courage to take responsibility of the work and they want to do it well. Taking the leader's role in the team. That is something students do not get anywhere else in the school work." (Teacher C FIN)

Not only did the project have impact on the individual behavior of students, it also **affected the group dynamics**. Teachers agreed that all students were actively working in the project in order to fulfill their plans and goals.

"It was great to see that all students were working. And could find their role in the group." (Teacher E FIN)

"There is a risk in this kind of a [project based] learning that there are free riders. But in this project there was nothing like that." (Teacher D FIN)

"I think they [students] worked very well in the beginning, before that and after that, well after that maybe even better. Here in a class I have seen a few girls who - well in my opinion - don't do anything, just sitting and doing something else [than the project] but they were very interested in making the flower." (Teacher A FIN)

- Related to the impact on learning lies the question whether the students are in the position to drive their own learning. I.e. in choosing their own topics/projects, their own materials they would like to use, determine their own timing, finding own ways to solve their problems or choose if and with whom they would like to do their project.

As the eCraft2Learn project had a bigger degree of freedom than students have been used to in the school work, **students were self-driven throughout the work**. Students were discussing their choices and justifying different decisions made while solving different problems.

"In the end I didn't interfere with the work in any way. Everyone could choose their own way of doing the work. -- And I didn't solve any problem to them [students]. That was the purpose that nothing will be given ready." (Teacher D FIN)

"I didn't want to restrict students' working too much." (Teacher E FIN)

"I remember the girls who were making this tiny flower with play-dough, they were very interested, they were all doing it. One of them was making the leaves and saying oh no, no, no, don't put it this way, put it that way. And it's better that way and we should have done it in different way." (Teacher A FIN)

"I would also say taking the responsibly is something this project fostered and that we don't have so much in the normal school work." (Teacher GroupsEF Teachers C, FIN)

Usually when creating a project, students have a specific problem and predefined materials and tools where they can choose from. Often the teacher delimits the amount of possibilities. In the eCraft2Learn projects **students could set the problem they want to find solutions for**, determine their team members and use any material they consider are important.

> *"Usually there are two options; iPad or a pen. Now everything possible could be used." (Teacher E FIN)*

> *"Well usually we just sit on our own desks and when they [students] do something, then they can do it in pairs or in groups of three or maybe sometimes of four. Well, the groups worked well because they could make their own choices, they could choose a way they want to work." (Teacher A FIN)*

Time-management during the project work was experienced **problematic**. Students were spending a lot of time for the project creation and teachers felt the need to start supporting students to finish their work towards the end of the project. Teachers proposed two possible ways to develop the time-management skills: teaching students to set clear goals and deadlines for the goals and teachers setting some time limits for the students.

> *"On the other hand, students tried everything. We have to reserve time for the creative work. Too much hurry is not good at this type of a project as creativity requires timeless and pressure less environment." (Teacher D FIN)*

> *"Maybe in the next round we have to give some deadlines because the biggest problems we had with the time management." (Teachers D and E FIN)*

Although the work in the eCraft2Learn projects allowed students to be in the position of driving their learning, **not all students could develop their self-regulatory skills**. Teachers felt that these students that were not in charge of their own learning could experience fear or hesitation towards new technologies and for that reason did not feel comfortable or competent to participate in the work.

> *"Maybe we say word technology and then there are students - well adults as well - who cannot pronounce it or don't want to do anything with technology. Maybe that's the reason why some of them [students] were just doing nothing." (Teacher A FIN)*

- Most important was the question on how the workshop influenced the ecosystem including the way of teaching or the own perception of your role as a teacher and coach, their perception of learning, skills and soft skills, possible hesitation/acceptance/fear towards technology, their view on future needs and abilities that students need to gain, the self-esteem of the students and the students individual developments.

For some teachers, working as a coach in the classroom is a familiar concept for the. During the eCraft2Learn project teachers were working even **more as observers and guiders than before** in their normal teaching.

> *"Teaching chemistry is somewhat similar, laboratory work, where the teacher is observing and advising. But instructions are more detailed and I give one carefully defined task at a time." (Teacher D FIN)*

Teachers were unanimously mentioning that they felt comfortable having a facilitator's role in the classroom and passing more responsibility on the students. This shift **allowed students to be more self-driven**. Thus, an impact on the teacher's and student's roles could be seen.

> *"It was great to see in the beginning how great things the students came up with. Many times I've given precise instructions on how to proceed and work." (Teacher E FIN)*
>
> *"Actually it was very wonderful to admit that I don't know, I actually have no idea how to. So we have to ask or check from the Internet if we want to find some [answers]…" (Teacher A FIN)*
>
> *"Teacher does not need to control everything that is happening in the classroom." (Teacher D FIN)*
>
> *"I could position myself better to the students' role [when I didn't know everything possible from the topic or the way we will work]. That gave possibilities for the students." (Teachers D & E FIN)*

Other teachers, not familiar with the concept of coaching rather than teaching reported:

> *"It was a shock to the education professional that some children did things much more easily than he could. In addition to that, he could not believe that the children would be involved because coaches tried to raise the students' interest without using threats …" (teacher A GR)*

The project did **not change teachers basic attitude towards technology for ICT advanced teachers** as they were familiar with using ICT in their teaching and held a positive attitude towards it already before starting the projects. However, it was a good experience for teachers to teach technological skills to a student group in their own subject area, not in a specific ICT class.

"During my teaching years I've learnt multiple things in ICT. But maybe what is different, I haven't brought ICT this strongly to other groups. So this was a great experience to teach ICT for a 'normal' group." (Teacher E FIN)

Specially those teachers that were not familiar with the concept of coaching reported positive **impacts** in relation to the **potential of their students, own perception of technology** as well as on **learning concepts of children**:

> *"As his perceptions were close to the educational methodology of the project, his way of teaching did not change. But his confidence in his students' abilities definitely did. Also, because of the need for preparation and the fear that a question may be asked by a student, he was forced to overcome his phobias regarding technology." (teacher A GR)*
>
> *"The teacher said she was influenced; the fear of electronics dropped. At the beginning, it all seemed terrifying. When faced with the children's ease, she got scared. Her attitude as to how children learn, changed because it was tangible for the children." (teacher B GR)*

Teachers found multiple benefits of this type of a project-based learning that eCraft2Learn projects represent and observed that this process is a graduate development (teacher A, GR). Especially **impacts on students' abilities in collaboration skills, methodological skills, creativity, programming and robotics** were mentioned as this project provided a small glimpse to technology. Teachers saw the value of having these skills in the future. They also found eCraft2Learn projects as a great way to **open a new perspective to real world**; where technology actually is and how it helps us everyday.

"Everything else that the students learn on top of biology, such as programming and robotics. Students learnt a lot and this project opened students' eyes. If we think in the future many professions will be based on it [technology]." (Teacher E FIN)

"I think those were skills that in the normal school work are not developed. They [students] got a touch for programming and robotics." (Teacher D FIN)

"It [technology] is quite strange thing for many [students] at this phase. So for them to realize that it is actually not so difficult, even I can build these myself." (Teacher E FIN)

"The future possibilities because if the students are now at least a little familiar with this kind of technology and they're 14 so when they are 20 or 25… So if they start now, what happens in future? Well this is just a little glimpse." (Teacher A FIN)

"They [students] start to understand what is in the world and around us, there are many devices, for example automatic doors. In a way it opens the door to how this world and technology works. And then you can take the skills further if you want to go to study this field. The basic principles came quite nicely in this project. Programming, electricity, sensors, and all these." (Teacher C FIN)

When viewing the project impacts on **students' self-esteem and self confidence, positive changes** could be observed by most of the teachers. The feedback that students gained during their work from both the environment (LED lights up in a correct way according to the programmed code), peers and teachers, helped students **gain confidence and increasing their motivation** towards the project.

"Most of the students strengthened their self-confidence. Especially you could notice that with girls." (Teacher D FIN)

"In the teams that had only boys I could see that the roles were so strong that maybe not everyone had the courage to try programming." (Teacher E FIN)

"This was something so new that if students noticed that they can manage this like anything else they have done, then they can be confident on an idea that 'I can learn anything if I get enthusiastic'." (Teacher B FIN)

Students were highly proud of what they had created and asked other peers and teachers to see their creations. Students also **enjoyed presenting and sharing their work** in different dissemination events such as science fairs and the special NASA astronaut meeting. Some students were even sharing posts in social media.

"Well I saw the girls' faces when they did the presentation and they were very happy with their project. They came to me and Susan saying 'look at what a beautiful flower we have'. And it was amazing the flower." (Teacher A FIN)

"That was great when students got to present their work, that increased their courage as well." (Teacher E FIN)

"In the end of the project everyone were happy to present their work, even the ones who had not put so much effort on the work, and they wanted to tell what they had done. They were proud of the outcome together." (Teacher B FIN)

Building on the previous examples on how teachers described their observations on students' self-confidence and self-esteem, **positive impacts on students' individual development** could be found on the kind of knowledge and skills students gained and how.

> *"In terms of technology usage and learning, for sure [there was positive impact]. For most of the students completely new skills and then they got courage when they saw that we can do this. Maybe even [impacts] on general working and teamwork skills." (Teacher D FIN)*
>
> *"I've seen with most of the students that they have got learning experiences and they've found new features about themselves and learnt to start working open-mindedly. I'm sure that type of an experience of success is important, everyone made their ideas to work." (Teachers D & E FIN)*
>
> *"Yes, maybe to see that you don't need to quit when something fails, instead you can come up with a new solution. That is also an important skill to learn." (Teacher E FIN)*
>
> *"There was one girl that I haven't seen in two years working so hard and engaging in the work as she did during this project. Especially that she took it seriously." (Teacher C FIN)*

As mentioned in the increased self-confidence, feedback from students' own work was important throughout the project. This feedback from teachers, peers and the technical ecosystem was continuous and teachers argued that students **gained much more feedback on their work during the eCraft2Learn project than during the normal school lessons**.

> *"In the eCraft2Learn projects students go one component at a time and test first one, then second and after that the whole. For sure it provides feedback." (Teacher D FIN)*
>
> *"You get a lot of feedback on your working." (Teacher E FIN)*
>
> *"Definitely, when you work something and when you get positive feedback, it's always good. And this was a very good project to give positive feedback to students, even from a small thing, because I honestly, I could go and say 'your light is flashing'. Your light is flashing!" (Teacher A FIN)*
>
> *"I felt that it gave them [students] a reward when they managed to do something and they managed to make it work so the prize came immediately. And that was rewarding in such an extent that it was enough." (Teacher B FIN)*

Other influences teachers mentioned were regarding the long-lasting work that eCraft2Learn projects offered. Even though project-based learning is used in the normal classrooms, projects are much shorter than in the eCraft2Learn projects. eCraft2Learn projects allowed students to **develop many skills that are characteristic for long-lasting work** and necessary in the future work life. For example students needed to **take more responsibility of their learning** and it was concretized in a new way for the students during the project work.

> *"They [students] have worked very long in the same team, that has improved their patience, perseverance and teamwork skills. And that is completely different when working only one lesson with something. Longer term planning. When you think about the future work life, projects are long there, so these are good skills." (Teacher E FIN)*
>
> *"Maybe the conception of taking responsibility of their work was strengthened, that was something students didn't have before." (Teacher C FIN)*

Several teachers **struggle with the amount of hours** needed to complete a project.

> *"There is no phenomenon worth 10 hours that you can find from the general studies (NOTE: this means the academic subjects, not related to arts/music/crafts/sports). But then again you learn so many other things, the skills learnt in this project serves for that subject area and for others as well." (Teacher C Groups EF Teachers A&C, FIN)*

The integration into the curriculum did not seemed to be a huge issue in terms of topic (due to the free choice of topic). But the amount of hours spend is very high compared to other teaching/learning methods when it comes to the topic (Math, Physics, a.s.o.). Consequently for the learning ecosystem it has to be said that teachers and coaches need to plan very well the hours dedicated to these type of projects or narrowing the topic down (like proposed from a Finnish (Teacher C Groups EF).

Also the framework setting is an issue when integrating it into the curriculum as well as the lack of a concrete learning goal (Teacher A, GR):

> *"Children like free frameworks but the coach has to know how to support that because it is difficult to combine it with conventional classes."* (Teacher C, GR)

- A major point (that is especially of importance for funding these types of projects) is the question if students learned something and if yes, what exactly did they learn?

Teachers pointed out that students had limited learning on the **subject matter itself** during the eCraft2Learn project but, unlike in other school work, **students improved their programming and technological skills as well as creative thinking.** Therefore, the knowledge gain developed during the eCraft2Learn project is much different than during normal lessons and rather teaches students skills that they can use and apply later than focuses on small details of the subject matter.

> *"I have to say that this photosynthesis wasn't the main thing, not definitely. It was just an idea how to use technology and combine it to something else than just technology. -- That's the main reason why this project was, I think it was a success eventually. The main point was to show students how to use technology; what is behind something, something is moving, some light is flashing, what is behind that." (Teacher A FIN)*

> *"If you have a wider topic, students will just grab something that they feel 'cool' but not actually learn the topic itself almost at all. You just have to choose a very narrow piece of the subject matter. " (Teacher C FIN)*

It can be said that eCraft2Learn projects **increased students' level of digital competency in multiple areas**. In the normal school work school subjects are mostly theory-oriented and there is not much space to make or craft. In the eCraft2Learn projects students enjoyed making the outcomes based on their own, individual ideas. Teachers felt that programming and electronics were integrated to the projects in a meaningful way as they were part of the whole. All students **got at least familiar with these technological skills, some of them acquiring deeper skills than others**. Teachers were combining programming to problem solving while explaining the effects and benefits of programming during the eCraft2Learn project.

"There was plenty of time for own ideation and crafting. In the normal school work there is not so much time, possibilities, for it. But students enjoy it. In that sense it was great that there was something else. -- Making in some way motivates much more than only theory itself. " (Teacher B FIN)

"This was maybe the best way to motivate students to program as programming was part of the project. When we look at the curriculum, programming is mentioned there, but we cannot just suddenly come up with a task that do this or do that, it has to be a part of something relevant." (Teacher B FIN)

"Surprisingly well students learnt programming." (Teacher D FIN)

"Well getting familiar. And it's possible to do something, it's possible to cover the light and then something happens, it's possible to put water and something happens." (Teacher A FIN)

"When we think about problem solving in programming, one from each team had the biggest responsibility with it, at least it was so in the team of only boys. But with girls' teams I think all girls improved their skills in it. Of course problem solving was necessary in many other parts of the work so maybe those [who did not program] solved problems in some other phase." (Teachers D & E FIN)

Engineering skills were also mentioned by one participant teacher as having a big role during the whole project work which in normal school work aren't really introduced to students in more than few subjects. The teacher explained a common situation where students have their initial idea and plan but need support in making the overall decisions on how to make something work. These engineering issues provided a great way for the students and the teacher to work together, see how these issues have been solved in the real world and understanding the principles, of for example physics, better.

"They have that idea so how to make it work. - - For example how does a latch on the door work? How do we get it to move and which way would be the best to make it work? So we studied different solutions how to make it work. - - It is not so easy to get a lateral motion from a rotation. Those were something we looked together, how a train works for example." (Teacher C FIN)

In addition to the digital competencies, many teachers identified **improved skills in social and collaboration skills**.

"Working together, one is doing something else than the other is doing and they combine it." (Teacher A FIN)

Teachers also saw the **value of self-regulated learning** that the project fostered.

"The concept of self-regulated learning, which is also mentioned in the curriculum, was realized nicely during this project. But I could have estimated already before the project the level of participation based on how I have seen them [students] working during the normal lessons." (Teacher B FIN)

"When the teacher has kind of a coach role, that means that the responsibility will be shifted to the learner. So I think in that sense students also needed to use their self-regulation skills." (Teacher B FIN)

Summarizing, it can be advised that a more focused **teaching/learning on the topics by traditional ways, combined with projects like eCraft2Learn** offers might be an ideal combination since … *"Basic principles come very nicely in this project from programming and electricity. And the side stuff like teamwork skills, making, self-regulation, time management, project work in general, etc., are skills that are very valuable and students will need in the future." (Teachers A and C, GroupsEF Teachers A&C, FIN).*

- Several students and teachers had hesitation towards technology. But were the pilots decreasing the students hesitation/fear towards technology?

Several teachers agreed that the project **decreased students hesitations and fear towards technology and provided a new way to see technology**, while others were the opinion that student do not fear technology at all (i.e. Teacher B GR). Technology was introduced in a way that was motivating and meaningful. Technology brought in this way to schools suited for both students with a lot of technological skills and also with no previous experience.

> *"I believe yes. I would think it did not go worse at least." (Teacher E FIN)*
>
> *"I think that is the best [in the project] that it showed technology from the grass-roots level. That is good." (Teacher B FIN)*
>
> *"If somebody thinks that they want to go and study computers or study technology now they know that there are very different kinds of projects so you can be interested. Here for example in biology and in technology and you can use them both, you can study them both." (Teacher A FIN)*
>
> *"If we just talk about technology that may be a vague concept that what does it even mean. 14-year-old may think of technology that 'oh, i need to create my iPhone'. So talking only about technology is not so meaningful or understanding that it consists of and starts from small parts. I hope students would see technology now in a more everyday way, how to utilize technology in the everyday life." (Teacher B FIN)*
>
> *"There was someone from the students who asked me that 'would it be possible to really invent something' and I said yes, of course our resources are limited but yes you could create something 'real'." (Teacher C FIN)*

This project was also a **good way to engage girls** looking into technology.

> *"Yes definitely because I think most of the girls were very interested in combining things and making and asking questions 'why this doesn't work and what do I have to do, what is wrong here'. Boys didn't have the same engagement because there was one guy who knew how to make these 3-D models and the rest of them didn't know anything. So it was mainly that one boy that was doing because he knew what he was doing and the others were doing nothing." (Teacher A FIN)*
>
> *"I think for girls working with new technologies was even more new. I was talking to the boys and they had done something in the school earlier. Some boys even said 'oh no, I hope we don't need to do any lighthouses'. They have done those LED lighthouses enough in primary school." (Teacher D FIN)*

- Also we asked if the projects allow the students to be creative and developing own solutions.

Teachers saw the value of eCraft2Learn projects in **fostering students creativity** throughout the projects. The importance of improving creativity skills is highly valued and making was seen a great way to boost creativity.

> *"If there is any project where students can do things with their hands, that's very good. Because when they are at the school in the first grade until sixth grade they are always making something. And when they come to this building, well there is only drawing, one subject where they actually build something and are very creative." (Teacher A FIN)*

The eCraft2Learn project provided **multiple opportunities for students to ideate, plan and find their own solutions for problems** they faced during the work. Teachers deployed the role of a coach well and let students to find these solutions on their own without interfering into the work much.

> *"In the end they [students] did try, test and figure out themselves which is the best of course. I instructed very little the problem solving processes, much, much less than during a normal lesson. It was more about just observing." (Teacher D FIN)*

Some participant teachers mentioned that they **saw new sides of their students** during the project work. These differences compared to normal school work were in regards to student behavior, level of self-confidence, skill acquisition or some other features teachers could not define. However, there were some teachers who saw students working in a similar way during the project as they work during the normal lessons. So, if a student was usually engaged in the school work, he would also show it in the eCraf2Learn projects by working eagerly and carefully.

> *"In a classroom we teachers can go and say 'you wrote this nicely and you've doing a good work' but that's all. So they actually can't surprise us in the classroom but many of the students surprised me in this project. [They were] doing something different, something they enjoy." (Teacher A FIN)*

3.1.3. LEARNING ECOSYSTEM

Having performed (at least) one pilot, we were asking the teachers for their ideal ecosystem to embed these type of learning. By ecosystems we included specific items that were included the school environment (rooms, facilities, ...), regulations and rules (ie. school curricula), support from other teachers or headmasters or parents or local community, and Financial support.

The idea of having a project based learning method in high schools is not very easy to implement if there is only one teacher and one subject area as the project work takes a lot of time from this one specific subject matter. Though, teachers understand the benefits of **project based learning** which fosters multiple skills, not only the subject matter knowledge in particular.

> *"It's because we're very busy with our subjects and our times and our lessons. So nine hours you just have to give something else away and you can get something else back in return." (Teacher A FIN)*

1. Teachers experienced great **support** from the headmasters who encouraged teachers to develop their professional development and update the teaching to stay up to date with the future of teaching and learning.

> *"Because our principal was blinking green light all the time so you could use whatever you need and you could go." (Teacher A FIN)*

Collaboration between different teachers was seen important in these kind of long-term project work that fosters multidisciplinary teaching and learning.

> *"Other teachers are collaborating with each other, students can go to the wood craft or arts classroom and there the teacher helps and supports, and wants to help. That is quite important. To do it together, it is like a project for the whole school so everyone helps if needed." (Teacher C FIN)*

> *"What had a very positive impact in the implementation is that the coaches were from different specialties. It was suggested that it would be equally good to apply a similar approach of mixed groups of disciplines with children." (Teacher A GR)*

Teachers have also understood that the **voluntary participation** of students is important, thus to find topics that attract the individual student and at the same time is compatible with the curriculum and the ecosystem of the school.

> *"It is also important that, if a student does not want to participate, s/he would not be forced to. Children like free frameworks but the coach has to know how to support that because it is difficult to combine it with conventional classes." (Teacher A GR)*

2. Also we asked if interdisciplinary learning was facilitated.

The project has **facilitated interdisciplinary learning**. The topic should have a connection with the curriculum. Thus, it is easier for the teacher to integrate this type of learning ecosystem, the eCraft2Learn pedagogical approach and technological approach into the curriculum.

> *"I think totally it was worth to use these nine hours. I think this was a very good project to do something with biology and math and technology, combine these things. Do something else what is a little bit of math, a little bit of biology and little bit of something else. " (Teacher A FIN)*

3. Included in the ecosystem, it has been asked if the pilot recognized by other teacher colleagues, the headmaster or the parents and if the reaction was on this.

The project pilots were causing a lot of inquiry when both teachers and students were interested in the project work. Few teachers got encouraged to come to learn and try themselves how to wire the electronics or program. Teachers reported that most of the reactions were positive and amazed, yet some other teachers were concerned of the time spent on one subject area only during the project work.

> *"There were actually few students asking what is this what are you doing. And a few teachers. They were amazed. And of course we faced - well it's everyday problem here - 'ah you're using nine hours for photosynthesis *shocked sigh*, that's too much'. But we all know that there's plenty of more. " (Teacher A FIN)*

Reading this comment from a teacher, it seems that also the self confidence of the teachers has risen and that the teachers can very well justify the time spend by seeing the additional value.

At the same time it raises the existing concerns of teachers. Thus, a lot of communication work shall be done in order to make teachers understand what exactly they gain from '*9 invested*' hours.

3.1.4. THE UNIFIED USER INTERFACE (UUI)

Teachers were also asked to give feedback to the UUI, in specific if they see advantages to use it, possible issues that were observed and if there are improvements that they would suggest. One has to mention at this point, that the UUI is under constant development, thus not all teachers were asked at the same level of UUI development. Therefore answers might be restricted in validity.

Teachers saw advantages in the UUI and the Open Educational Resources (OERs) especially when programming.

> *"There was the instruction book with the Arduino in the package but that has not been done for Snap4Arduino but for the own text editor. If they [students] would have had something like that - well now they have that brilliant [OERs] - from the beginning they would have gone into the programming maybe even more." (Teacher D FIN)*

Teachers mentioned the following advantages when using the UUI.

> *"It guides students to be more self-regulated. And it has everything needed. It is a very complete package for Arduino and 3D printing." (Teacher D FIN)*
>
> *"This platform makes it easy to search and find information." (Teacher D FIN)*

One teacher (teacher B GR) sees an advantage in the fact that everything is gathered at one spot and the coach can choose what serves or suits him/her best. She expressed the view that it would be good to record the children' actions so as to have some statistics, feedback; so **learning analytics is seen as something necessary and useful**.

One participant teacher also found a national wide benefit for the use of the UUI everywhere in the Finnish schools.

> *"Now when programming is mentioned in the Finnish curriculum, this what UUI provides is a very good help for both teachers and students to start exploring and testing. It is a great base where to start programming and making robots." (Teacher D FIN)*

As teachers identified the ideation as one of the most challenging stages in the project, they appreciated the Inspiratorium tool. They wanted something fun where students get enthusiastic and inspired and a tool that boosts creativity.

"It was fun and interesting, somehow a novel tool. The balls changed colour and were moving a little bit. I wanted to try what happens and how does this work." (Teachers A and C FIN)

During the second pilot round teachers got the opportunity to test the learning analytics tool for teachers in the real school setting during the projects. Teachers saw the value in fostering teacher's actions when guiding students. One participant teacher noticed a difference in the way he could observe students' actions in programming when using the learning analytics. Also, through the learning analytics teachers could see if students are interacting with the platform outside class hours as well.

"One boy had done so many rows of the code and it was quite complex and some more advanced programming. My own knowledge was not enough to notice that he had created a very interesting solution that requires deeper understanding. He had found a new way of solving the problem. That is also relevant to know if a student knew this beforehand or if he or she has studied and learnt it now." (Teacher C FIN)

3.1.5. GENDER ISSUES

Next to the impact, we were asking if teachers observed any differences between male and female students (i.e. in the interacting, the learning with the UUI or the project itself).

Teachers noticed that some boys were ambitious and were working with a high risk having a big plan and trying to implement something that may have required too much work considering their skill level and the resources available. In addition, teachers observed that some boys got very engaged in the project, some very little. In the boys' teams teachers also saw that other boys were working very little if only one boy in the team was familiar with technology and did all the work. A question of how the participation of all students could be encouraged and fostered even when some students would not have a lot of skills was being discussed during the interviews.

"Boys are trying something, maybe they're doing more than their capabilities are. Well isn't that what the boys are always doing? Want to reach the sky and find something. They might success, maybe, and they will eventually. But then if it fails, they don't have anything." (Teacher A FIN)

Teachers saw eCraft2Learn projects as a **great way to encourage girls in science and technology**.

"Yes, definitely. Well I think making the flower was the girl thing and then putting the technology and the beautiful flower together." (Teacher A FIN)

Consequently we were asking teachers if they would launch different projects for male or female study groups and arguing why.

Teachers could identify some **gender differences in preferences**. However, even though there may be some small differences, teachers would not launch different project for male and female students. Teachers did not feel comfortable to limit the work based on students gender or to set students in some specific gender groups. Rather, teachers would propose different topics and give the possibility for the students to choose what they prefer.

"This tiny and beautiful flower could be a big tree for the boys. Maybe, but I don't know. In age fourteen I think there still are some girls stuff and boys stuff." (Teacher A FIN)

"Basically we don't want to separate the boys are doing this and the girls are doing this because whoever wants to make a flower can make a flower. And maybe whoever wants to build a car or something can build a car you don't have to be a boy or a girl. That doesn't matter. No, I don't want to put different jobs for boys and for girls." (Teacher A FIN)

"It would be a pity if a girl would be interested in some different kind of a project that I would offer her. That would already categorize the liking because how do i know that? Like, is it me how decides that this is a girls' thing?" (Teacher B FIN)

3.2. SEMI-STRUCTURED INTERVIEWS WITH STUDENTS

During the two pilots, Greek and Finish Students replied to several interview questions. Also, we used opportunities to ask them during their participation in eCraft2Learn Events like the SciFest 2018 in Joensuu or the Athens Science Festival (see also Part III, Section 3). In general, the students were asked:

3.2.1. IMPACT ON PRESENTATION SKILLS AND INTERACTION

Some of the Finnish students who participated in the project pilots took part in the eCraft2Learn workshop in SciFest 2018 Science Festival in Joensuu, Finland. Students presented their project outcomes and guided visitors through simple hands-on electronics and programming activities. Three participant students from the formal pilot site were requested to provide their insights on both the workshop and the project as a whole.

All students mentioned that one of the best and most meaningful experiences during the workshop was to have **discussions with the visitors**. Students were happy to present the outcomes of their work and introduce the project in general. Although it was not directly pointed out, we can assume that the emphasized social aspect had a positive impact on the students' learning experience.

'I enjoyed meeting new people and talking with them. I would like to present much more in the future as well.' (student A from formal pilot site, Joensuu, FIN)

3.2.2. IMPACT ON COGNITIVE KNOWLEDGE

Students agreed that knowledge of electronics and programming was also a key skill that was fostered during the pilots. Students had diverse knowledge of these skills prior to the project pilots, though they all felt the project benefits in developing the programming and electronics skills which can be seen as an **impact on the cognitive side**.

'Participating in this workshop gave me more knowledge about programming. Somehow I feel I learnt it even more now than during the project in the classroom.' (student A from formal pilot site, Joensuu, FIN)

The students valued also the fact that they learned more advanced technologies thus they saw also some impact on cognitive knowledge:

"*[...] we have learned some more sophisticated things like Arduino, things that robots do, other constructions that we used as servo, sensors that we have not met before programming and*

programming tools related to Arduino. It was all new and I think that the implementation of technology was useful for me [...] " (student B from formal pilot site, Athens, GR)

Especially students interviewed after the second round emphasized that they felt much more able to handle the projects *"It turned out that it was easier. In the beginning we needed to recall a little bit of what we had done during the first round but it was much easier on this round." (Students GroupD_Students C&D, FIN)*

At some point, also visitors of the eCraft2Learn workshop in Joensuu (Finland) were involved. They had a chance to choose from two different tasks; to develop a drum machine or a painting robot. Both tasks were planned so that they get gradually more challenging and the completion of one task would take approximately one hour and a half. Two visitors that participated in the workshop had no previous experience on programming or electronics but in just 1.5 hours they created a robot with a brush holder that paints according to their program code. Thus, there can be found some **cognitive impact** that the workshop had on the visitors:

'I felt that programming was easier than the building itself. We had to ideate, plan and test a lot before we came up with the final and workable solution for the brush holder. From this workshop, I learnt how to program robots.' (visitor participating in the eCraft2Learn workshop, Joensuu, FIN)

3.2.3. IMPACT ON QUALITY OF LEARNING

Some students referred also to the way of learning emphasizing a more concrete understanding by the haptic experience they made:

> *"I think even though we needed to search the information from the internet, it got more concretized when you saw for example the differences in the dimensions of the Earth and the Sun. Seeing it in real life made it easier to perceive it. If you are reading from the book you cannot always imagine it in your head."* (Student Group D_Student E, FI)

And also:

" I think we learn like this more effectively when we are not forced to do something specific and we can choose ourselves what we want, it's more interesting." (Students Group D_Students A&B)

3.2.4. IMPACT ON SELF-CONFIDENCE AND SELF-ESTEEM

Not only did the project promote students' technological skills but it also gave **more confidence** for the students when working with electronics and programming activities. One participant student noted that he feels now more certain in a **skill level as well as in the self-esteem and self-confidence level**.

The novelty of the eCraft2Learn ideology was mentioned by all students. Learning with the eCraft2Learn technological and pedagogical innovations was experienced as 'different' in comparison with the usual work in schools. Students stated that activities during the pilot projects were engaging. Like the Greek students, one Finnish student felt that the project gave her also different perspectives. Therefore, the project provided an alternative way and new perspective of seeing what learning is and how each student can enjoy learning. That is to say, the project had an impact on the students' view of learning.

'Compared to what we usually do in the school, this project was more interesting and more comprehensive way of learning.' (student B from formal pilot site, Joensuu, FIN)

'Learning in the eCraft2Learn way with making and hands-on activities is more fun than learning from reading books. I liked when we got to make different, tangible things.' (student A from formal pilot site, Joensuu, FIN)

For once, the aspect of doing things independently, enabling students to make their ideas becoming a finalized product contributes to their self-esteem and self-confidence by being proud of their own product. This might also be in relation to the role of the teacher: two of the students explicitly mentioned also the **changed role of the teacher**

'The teacher of our team was closer to us and made us feel him as our assistant and not as someone older and thus he was very helpful.' (student B from formal pilot site, Athens, GR)

The students felt this changed role as helpful for their relationship with the teacher.

Consequently we can assume that eCraft2Learn contributed to a different approach of teachers towards their role, **moving from the classical teaching towards coaching** and supporting.

'*What we liked the most is that we made things with our own hands and we could support it as our own construction, our own work. You do something for several weeks and at the end you have the pleasure to support it as your own work... You did all by yourself. From the moment that we had the opportunity to use whatever material and program from the platform we want and do that autonomously ... we liked it! We didn't have someone to tell us how to do things...*' (student C from formal pilot site, Athens, GR)

Students also enjoyed the fact that teachers were able to dedicate more time for the students.

"In this workshop she found a good ratio of pupils and trainers, so it was more interesting compared to what she had tried before, both in terms of learning and content." (Student AP GR)

Thus, it has to be emphasized that the pedagogical concept of the 5 step model shall specifically foster the teachers' role as guiding coach that support only where needed or requested. By doing so, the **impact on increasing self-confidence and self-esteem is enabled**. Also presenting to other audiences strengthens the self-confidence: *"I managed to overcome one of my biggest fears, meaning to speak to an audience that I have not met before. Usually I feel nervous and I don't feel ready to talk. Today I managed to get over these feelings through my interaction with the audience - with kids, with adults, and by responding to difficult questions on technology and robotics"* (student C from formal pilot site, Athens, GR)

3.2.5. IMPACT ON COMPETENCE IN SOLVING PROBLEMS AND CO-WORKING

While some students seemed to be rather fine with being challenged to find own solutions ("*I prefer this kind of a learning over the traditional one."* (GroupD_StudentsA&B), other students commented that the fact that they had to solve problems was rather 'uncomfortable' for them. This is again in line with the observations of the coaches that mentioned that students need time to adapt this teaching/learning method.

However, many students mentioned also an **impact as of an increased competence in solving problems and co-working**:

"For me it was definitely a groundbreaking experience, funny and I liked very much the fact that it was a workshop about STEM in which skills like solving problems and co-working were developed [...]" Participant student (student from formal pilot site, Athens, GR)

"*[...] The workshops were an extremely valuable experience due to the fact that I learned to be part of a team and co-operate with other persons [...] " (student from formal pilot site, Athens, GR) and 'Working in teams was the major difference*

The student mentioned explicitly interpersonal and social skills that were developed. This is very much in line with the interviews with teachers, that were several times referring to the social aspect of learning in terms of teamwork:

"[...] but after a while a team of the three of us was. I think we immediately matched. We comprehend each other and we help each other with the robots." (student from formal pilot site, Athens, GR)

Considered the decreased request of pure knowledge and the increased demand of new skills (like teamwork, communication, problem-solving a.s.o.,) this impact mentioned by the students and teachers is considered as highly important and reassures the initial assumption of the eCraft2Learn project to have a positive influence in this respect.

Many students mentioned, that they most enjoyed was the team spirit and the lack of pressure of succeeding:

"The team spirit. There was no competition among them as to who is best." (Student ICK GR)

However, many students mentioned that they needed the support when they had issues. It has to be clearly outlined that every project had challenges the students need to handle thus support is needed.

"Teachers didn't need to know everything in this project, because we knew we were almost better than them. But if they're teaching something specific they should know quite much about what they're talking about. But it was nice in this project that you from the project were there [the coach from eCraft2Learn] *too so we could ask you because you knew a little bit more at least." (Students GroupD_Students C&D FIN)*

Giving the students **support in time when needed** is absolutely necessary to avoid frustration. It seems to be unavoidable to have at least some very good basic knowledge to support the students. Consequently it needs to be said, that in order for the teacher to be able to act as coach they need to make him/herself comfortable with the tools the students can/should use to be able to provide assistance in case is needed. Thus a teacher does not need to become an expert but should be in the position to know basic principles and/ or at least should know how possible help and solutions can be gained from. A teacher quoted at this point:

"*Basic information is something that teacher has to search and collect anyways whenever teaching and teacher has to always make preparations. Somehow the lesson is never ready, everything can be done in so many ways. But I know many teachers that could be afraid taking the step to the new and unknown and it would feel difficult to acquire that knowledge when it is so new and unfamiliar..." (Teacher, GroupsEF A&C, FIN).*

3.2.6. IMPACT ON (FUTURE) PERSPECTIVES

One interviewee of the pilot even mentioned that this type of learning opens new perspectives:

'Personally I liked the workshops very much. It was the first time that I got in touch with the branch of robotics and programming, and it gave me new perspectives for my Future.' (student from formal pilot site, Athens, GR)

This mentioned impact on considerations on future perspectives was unfortunately not specified. However, all the informal students in Greece that were interviewed (n=6) saw different options as to follow up on this field and even some considering such a career path. his indicates that these type of learning can open up for considering additional options to students. Thus we conclude that the pilots had an **impact on options, perspectives and/or interest** of some students.

4 IMPACT – QUANTITATIVE ANALYSIS

4.1. DATA ANALYSIS – GREECE AND FINLAND

The data from the student questionnaires was analyzed by statistical methods in order to see whether there was any difference in the student answers that was statistically significant in terms of students' overall liking of the project and their learning experience. The quantitative analysis was conducted by using IBM SPSS Statistics 23 software. When handling the data, additional variables were created for the class ID, context, country and pilot round as shown in table 2. The class ID was generated as the pilots were partially carried out in different classes by different teachers and the class or teacher effect was important to investigate in the analysis.

Table 2. class ID, context, country and pilot round

Class ID Formal Round 1 (class ID 1-3) Formal Round 2 (class ID 4-6) Informal Round 1 (class ID 7-8) Informal Round 2 (class ID 9-10)	1 = Finland: Photosynthesis task, teachers A&B 2 = Finland: Security system task, class 1, teacher C 3 = Greece: Formal class round 1 4 = Finland: Cold War task, teacher C 5 = Finland: Solar system task, teachers D&E 6 = Greece: Formal class round 2 7 = Finland: Informal round 1 8 = Greece: Informal round 1 9 = Finland: Informal round 2 10 = Greece: Informal round 2
Context	0 = Informal 1 = Formal
Country	0 = Finland 1 = Greece
Pilot round	1 = Pilot round 1 2 = Pilot round 2

There were in total of 151 student answers from both informal and formal contexts, both countries and both pilot rounds. From the total answers 58 were from the informal pilot site and 93 from the formal pilot site. The data analysis had the following structure. First, all data (N=151) was handled together and a principal component analysis (PCA) was used to identify the different clusters of variables which correlate highly together and therefore measure the same phenomena. Moreover, the purpose was to find underlying dimensions or components from the data. The rule of thumb for running a PCA is usually to have at least 10 samples per variable or to have the total sample size 20 times larger than the amount of extracted components in order to have reliable results. In our data the sample sizes for both informal and formal contexts would be relatively small (N=58, N=93) if analyzed independently, and therefore the PCA was run by pooling all the data together. The results of the PCA were used to aid in grouping the different individual variables for further analyses. In addition, based on the found components, sums of variables were created. Thus, more meaningful values were generated as the data was originally collected with the 3-class-values 'not at all, a bit, yes'. After all components were identified, individual variables that loaded onto the same component were

grouped and sums of variables created and named more descriptively to run further analysis with more meaningful scale of values.

After the PCA, informal and formal data were handled separately for the correlation coefficient test and for the independent samples T-tests by using the new "combined" sums of variables. The Pearson's correlation coefficient was conducted in order to investigate the correlations between the found factors and created sums of variables. As only few same students participated for the first and second round of pilots and no student was tracked with individual student ID in the first and second round student questionnaires, the data could not be treated as repeated measures and a Paired-Samples T-Test could not be reliably used to investigate the possible change in the answers from first to second round. Therefore, the independent samples T-tests were conducted. These T-tests were run separately for the two pilot rounds and the two countries, and they indicated whether there were some differences between the pilot rounds or countries.

Finally, as in the pilots the data was collected from two contexts (informal and formal), two countries and from different classes with different teachers, it was important to examine the possible context and class effects on the data for those sums of variables that showed significant differences between the countries or pilot rounds in the independent samples T-tests. A linear mixed effect model (LME) was conducted to investigate this random context and class effect.

Before the actual data analysis, the distribution of answers with histograms and the modes of each variable were explored to generally describe the data. The modes can be seen in table 3. The range of values for the variable "How did you like the project" was coded on a scale from 1 to 4 *(1 = not at all, 2 = not a lot, 3 = I liked it, 4 = I liked it a lot)*. Values for all the other variables ranged from 1 to 3 (1 = not at all, 2 = a bit, 3 = yes). Note that these values are only representing a category given out of the four or three used and the coding should not be understood as a scale. As the original values were categorical and coding created arbitrarily to enable the statistical analysis, direct means and averages would not provide meaningful information. Therefore, modes were calculated to describe the collected data the best.

Table 3. Variables and Mode

Variable	**Mode**	
	Informal site	Formal site
How did you like the project?	4	3
During the project I was able to: be innovative	3	3
During the project I was able to: be creative	3	3
During the project I was able to: do the things the way I preferred	3	3
During the project I was able to: test and try out	3	3
During the project I was able to: to plan and coordinate with others	3	3
During the project I was able to: to share with others	3	3
I feel more comfortable than before to: programme	3	3

I feel more comfortable than before to: make and craft things	3	3
I feel more comfortable than before to: work with electronics	3	3
I feel more comfortable than before to: tackle problems	3	2
I feel more comfortable than before to: find solutions for issues that we faced	3	3

The data analysis started with the principal component analysis (PCA). PCA was used to identify underlying dimensions from the data and get an indication on how the variables can be grouped together. The rotation method was Direct Oblimin with Kaiser Normalization. As the Kaiser-Mayer-Olkin Measure of Sampling Adequacy was good (.80) and in the Bartlett's Test of Sphericity Sig. = .000, significant correlations between variables could be noticed. Thus, the PCA could be conducted. From the original variables all other variables except the "How did you like the project" was used in the factor analysis as it had a different range of values than the other variables. In the analysis all variables loaded onto some component, the loading values were all over .60 and the communalities ranged from .76 to .95. When forced onto six components, the PCA (with Direct Oblimin rotation) revealed a meaningful six component solution (see table 4). Only the variable "I feel more comfortable than before to: make and craft things" had loadings on multiple components but the highest loading indicated with which other variables this variable correlates the most and was taken into account under the first component. This six component solution explained in total of 81.9 % of the total variance which is very good as explanations over 60 % of the total variance can be seen as sufficient in social sciences and humanities. Based on the PCA, in total of four sums of variables were created and used in the further analyses: *Making, Creativity, Collaboration and Problem solving*.

Table 4. Principal component analysis (PCA)

TABLE 4 *Principal component analysis (PCA): Student questionnaire, informal and formal pilot sites, loadings with an absolute value over 0.30 (N=140)*						
Rotated pattern matrix						
	C1	C2	C3	C4	C5	C6
I feel more comfortable than before to: work with electronics	.88					
I feel more comfortable than before to: programme	.82					
I feel more comfortable than before to: make and craft things	.60		.32	-.38		
During the project I was able to: be creative		.81				

	C1	C2	C3	C4	C5	C6
During the project I was able to: test and try out		.91				
During the project I was able to: to share with others			.80			
During the project I was able to: to plan and coordinate with others			.81			
During the project I was able to: be innovative				.80		
During the project I was able to: do the things the way I preferred					.95	
I feel more comfortable than before to: find solutions for issues that we faced						-.91
I feel more comfortable than before to: tackle problems						-.82
Eigenvalues	4.08	1.61	.94	.88	.81	.69
% of Variance	37.06	14.60	8.57	8.03	7.35	6.29
Note. Extraction Method: Principal component analysis. Rotation Method: Oblimin with Kaiser Normalization. Rotation converged in 9 iterations. C1: Making, C2: Creativity, C3: Collaboration, C4: Innovativeness, C5: Own preferred way of working, C6: Problem solving.						

4.2. INFORMAL PILOTS' CONTEXTS (GREECE AND FINLAND)

Table 5 shows the correlation matrix between the created four sums of variables as well as the *Innovativeness* and *Preferred way* variables. Also, the *overall liking* variable ("How did you like the project?") was added to the analysis to investigate which dimensions from the data would correlate with the general student experience. The analysis demonstrate that there exists no multicollinearity as all correlations are less than .8.

From the informal site, collaboration, creativity, problem solving and innovativeness are correlating moderately ($r > .3$) with the overall liking of the project and these correlations are statistically significant ($p < .05$ and $p < .01$). In addition, **collaboration and making as well as collaboration and problem solving were correlating relatively strongly** ($r > .5$). Moderate correlations were also noticed between making and problem solving, creativity and collaboration, problem solving and creativity as well as innovativeness and problem solving ($r > .3$).

These results show that in the informal setting, the more students liked the project, the more they felt during the project that they could plan, coordinate and share with others, be creative and test and

try out things, and more comfortable they felt than before to tackle problems and find solutions for the issues. When students could collaborate with each other during the projects, they felt more comfortable than before to solve problems, work with electronics, program and make things. Consequently, **the support from other students and the teamwork encouraged students to make things and tackle problems and resulted students feeling more competent with these skills. Students who collaborated with each other also could be creative and test things.** In addition, **the more students experienced having gained confidence in making, electronics and programming, the more comfortable they were than before to tackle and solve problems.** Moreover, students who reported being **more confident in solving problems had been able to be innovative, creative and test and try out things.**

Table 5. Correlation matrix

TABLE 5 *Correlation matrix: Student questionnaire, informal pilot site (N=53)*

Variable	Overall liking	Making	Collaboration	Creativity	Problem solving	Innovativeness	Own preferred way of working
Overall liking	1.00	-	-	-	-	-	-
Making	.17	1.00	-	-	-	-	-
Collaboration	.29*	.57**	1.00	-	-	-	-
Creativity	.30*	.23	.27*	1.00	-	-	-
Problem solving	.32*	.31*	.48**	.33*	1.00	-	-
Innovativeness	.41**	.18	.25	.12	.32*	1.00	-
Own preferred way of working	.01	.03	-.04	.11	.20	-.02	1.00

Pearson r. **p <.01, *p < .05

Next, an independent samples t-test was conducted to further investigate possible differences between the two countries and pilot rounds. The purpose was to examine whether there was any statistically significant difference in the student answers within the created sums of variables. According to the t-test results, there **was no significant difference between the two pilot rounds** in any of the created sum of variables (*making, collaboration, creativity or problem solving*) when analyzing the Greek and Finnish answers together. However, the t-test run for the two countries indicated **differences between Greece and Finland in collaboration and problem solving.** The difference in the scores for collaboration between Finland (M=2.65, SD=0.37) and Greece (M=2.92, SD=0.18); t(24.21)=-3.760, was significant (p=.005). The practical significance of the difference (effect size d=0.93) was high. **Problem solving scores** between Finland (M=2.40, SD=0.45) and Greece (M=2.76, SD=0.48); t(56)=-2.820, **were also significantly different** (p=.007). This difference had a moderate practical significance as the effect size d was 0.77. These differences may be due to the **different duration of the informal pilots which may affect that Finnish students felt being able to collaborate less** with each other or feeling more comfortable to solve problems than before the project pilots. In Finland the first round of informal pilots took approximately 9 and the second round 8 hours, when in Greece the pilots were 30 and 20 hours each round.

When looking further into these differences and viewing the two pilot rounds separately it was noticed that only in the second pilot round answers the *collaboration* mean values were statistically significantly different. After the second pilot round, the Greek students (M= 2.92, SD=0.19) felt that they were able to share, plan and coordinate with others significantly more than the Finnish students (M= 2.65, SD=0.34); t(12.31)=-2.301, p=.04. The practical significance of the difference was high (d=0.98). **From the observation notes it was seen, that the Finnish students were interacting very little with other team members during the pilots,** although the mean value of 2.65 is relatively high. Though, this may explain the difference. The mean values with problem solving had a difference but this did not have statistical significance. There was also a slight difference between the pilot round 1 answers with collaboration and problem solving but these differences were not statistically significant.

A Linear Mixed-Effect model (LME) was conducted for the informal data to investigate further the differences in the student answers identified in the t-tests (see Annex II). As found in the t-tests, the results of the LME suggest (Table 5) that in **Finland both the collaboration and problem solving had somewhat smaller values than Greek answers**. Both differences were statistically significant ($p_{collaboration}$=.000, $p_{problem\ solving}$=.007). There were no differences when comparing the two pilot rounds together (p>.05). The results showed no random class effect as the variances were zero and the covariance parameters were redundant in the model including the pilot round, country and class effects. This validates that the data can be treated as independent and the independent samples t-test results being valid.

4.3. Formal Pilots' Contexts (Greece and Finland)

The correlation matrix between the created four sums of variables as well as the *Innovativeness*, *Preferred way* and *Overall liking* ("How did you like the project?") variables is shown in Table 6. No multicollinearity exists in the data as all correlations are less than .8.

It is noteworthy that all dimensions are correlating with the students' overall liking variable. Thus, all these variables have effect on the student's learning experience during the eCraft2Learn project. The correlations between the overall liking and innovativeness, problem solving and making were high and statistically strongly significant. Therefore, these dimensions explain student liking the most. **The more students felt they could be innovative and the more comfortable they were with solving problems and making, the more they liked the project.** Also, creativity, collaboration and own preferred way of working were correlating moderately with the overall liking of the project.

The correlation matrix indicates that Problem solving and Making are correlating relatively strongly (r >.5) and the correlation is statistically significant (p=.000). Consequently, **students who after the project pilots felt more comfortable than before to tackle problems and find solutions for issues that they faced, also felt more comfortable than before working with electronics, programming and making things.**

It is important to notice that the innovativeness variable loaded to its own factor in the factor analysis and couldn't be placed with any other variables on the same factor. However, the correlations demonstrate that innovativeness correlates moderately with all four sums of variables (r >.3) statistically significantly (p<.01). Therefore, we can suggest that all the variables include the innovativeness dimension. Consequently, the **more the student reported being able to innovate during the project, the more he/she felt being able to collaborate and be creative during the project, and the more comfortable than before he was to make things and solve problems.**

Moderate correlations could also be found between creativity and collaboration (r = .40), preferred way of working (r = .36) and making (r = .32). All correlations were statistically significant (p<.01). **The more the student felt that he/she could be creative and test and try out during the project, the more he could share, plan and coordinate with others but also do things the way he preferred.** Thus, we can conclude that students were positively working creatively and testing and trying out. Additionally, **the more creative the student felt, the more comfortable he was to make things including electronics and programming.** Finally, collaboration and preferred way of working correlated moderately (r = .42, p=.000) which indicates that students willingly chose to work collaborating with others during the pilots and therefore preferred working in teams.

Table 6. correlation matrix - student questionnaire

TABLE 6 *Correlation matrix: Student questionnaire, formal pilot site (N=87)*

Variable	Overall liking	Making	Collaboration	Creativity	Problem solving	Innovativeness	Own preferred way of working
Overall liking	1.00	-	-	-	-	-	-
Making	.49**	1.00	-	-	-	-	-
Collaboration	.26*	.24*	1.00	-	-	-	-
Creativity	.38**	.32**	.40**	1.00	-	-	-
Problem solving	.51**	.68**	.25*	.23*	1.00	-	-
Innovativeness	.53**	.39**	.35**	.44**	.36**	1.00	-
Own preferred way of working	.26*	.10	.42**	.36**	.13	.27*	1.00

Pearson r. **p <.01, *p < .05

Next, an independent samples t-test was conducted to further investigate the differences between countries and pilot rounds. The results showed that there was no significant difference between collaboration or creativity, thus the mean values were very similar in Finland and in Greece. When analyzing the countries separately, there was no statistically significant difference between the pilot round 1 and round 2 in any of the variables in Finland nor in Greece. However, **significant difference was found between the countries in problem solving and making.** There difference in the scores for problem solving between Finland (M=2.21, SD=0.63) and Greece (M=2.57, SD=0.47); t(86.05)=-3.076, was significant (p=.003). The practical significance of the difference (effect size d=0.67) was moderate. Also, significant difference was found from the scores for making between Finland (M=2.32, SD=0.58) and Greece (M=2.63, SD=0.52); t(91)=-2.642, p=.010. The result was moderately significant as the effect size d was 0.57.

When analyzing the different pilot rounds separately between countries, it was found that the statistical differences were resulting from the **first round student answers only in both problem solving and making.** After the first pilot round, the Greek students (M=2.61, SD=0.39) felt significantly more comfortable to solve problems than the Finnish students (M=2.14, SD=0.56); t(45)=-3.116, p=.003. The practical difference of the result was high as the Cohen's d was 0.97. Likewise, the Greek

students (M=2.75, SD=0.32) felt more comfortable than before to make than the Finnish students (M=2.26, SD=0.53); t(45)=-3.947, and the difference was statistically significant (p=.000). As the effect size d was 1.12, the difference between the two means is larger than one standard deviation, thus, the practical significance of the difference is high. In both variables the mean values in Finnish student answers slightly increased and in Greek ones decreased from first round to second which evened the difference and resulted the difference not being significant in the second round. Possible reasons for this phenomena were identified. The **Greek students had already participated in the first pilot round and therefore the feeling of being more comfortable with problem solving and making after the second round was probably not so different compared to the first round when the eCraft2Learn** way of working was new for them. In other words, the change in the feeling with problem solving and making did not increase as much from the first to second round as from the normal school work to the first round. Furthermore, the **use of UUI including the educational resources in the second pilots in Finland was bigger, which may have influenced students in the second round feeling more comfortable of solving problems** and making with electronics and programming than the students in the first round as the UUI provided support and encouraged students to be more self-regulated.

The results of the LME indicated that in Finland both the problem solving and making got slightly smaller values than the values from Greek students. This was statistically significant only with the problem solving variable (p=.005). The pilot round did not have any statistical significance with either variables (p>.05). The results validated that there was no random class effect as the variances got zero values and the covariance parameters were redundant in the model that included the pilot round, country and class effects. Therefore, all data can be treated as independent and the independent samples t-test results are valid.

4.4. GENERAL COMPARISON BETWEEN INFORMAL AND FORMAL SITES

When comparing the modes of each variable, it was noticed that all other variables except the “How did you like the project” and “I feel more comfortable than before to: tackle problems” had the same modes between informal and formal settings where the formal site had one value lower mode in both variables. In general terms in both settings, **students had a positive learning experience on the project as a majority of the students had liked the project** and reported “Yes” for the different dimensions of the project.

When investigating which dimensions had the biggest effect on the students’ overall liking of the project, the correlation matrix indicated these variables being innovativeness, problem solving, collaboration and creativity in both informal and formal contexts. Thus, **the more students experienced being able to be innovative, collaborative and creative, and the more comfortable they felt after the project to tackle and solve problems than before**, the more positive was their experience of the project.

In both sites, **the more students experienced having gained confidence in making, electronics and programming, the more comfortable they were than before to tackle and solve problems.** Moreover, the support from other students and the teamwork encouraged students to make things and tackle problems and resulted students feeling more competent with these skills. Students who reported being more confident in solving problems had also been able to be innovative, creative and test and try out things. Students who collaborated with each other by planning, coordinating and sharing things, felt being able to be creative and test things. One important finding was that the informal site answers had in general less correlations between variables than the formal site.

Innovativeness was included in all variables in the formal site but in the informal site only in overall liking and problem solving. The own preferred way of working did not correlate in the informal setting with any other variable but in the formal setting the correlations indicated that students willingly chose to work collaborating with others during the pilots and therefore preferred working in teams. In addition, **if students in the formal site could do things the way they preferred, they experienced being able to be creative and test things**.

The independent samples t-test indicated scientifically significant **differences between Greece and Finland in answers with collaboration and problem solving in the informal setting and with making and problem solving in the formal setting**. In the informal setting, the Finnish students reported having been slightly less able to plan, coordinate and share with others than the Greek students. These differences emerged in the second pilot round answers only. Moreover, the Finnish students felt in some extent less comfortable to tackle problems and find solutions for issues than the Greeks after the project. In the formal setting after the first pilot round, the Greek students felt significantly more comfortable to solve problems and to make, work with electronics and program than the Finnish students. These differences may not be due to the different cultures, especially when the differences are relatively small and only appearing with some studied dimensions. For the informal site, the difference in the **duration of pilots was significant** which may have had an effect on the view of the project and students' own capabilities. In the formal site, the **use of UUI** including the educational resources in the second pilots in Finland was bigger, which may have influenced students in the second round feeling more comfortable of solving problems and making with electronics and programming than the students in the first round as the UUI provided support and encouraged students to be more self-regulated.

Overall, these results suggest that within each country where the eCraft2Learn ecosystem was deployed, the students' experience in terms of creativity, collaboration, making, problem solving and innovativeness was similar regardless of the type of projects created or who the actors (teachers and students) were. Consequently, by providing guidelines for the teacher training, the eCraft2Learn pedagogical framework and the technical environment, the outcomes of the student learning can be gained anywhere by anyone.

PART III – DATA ANALYSIS BY COUNTRY

1 GREEK PILOT SITES ANALYSIS

1.1. THE BACKGROUND

The data collected by Greek pilot sites are based on the work done during two rounds at formal and informal sites. During the 1st round in Formal site there were 30 students (2 classes, 15-16 years old) with 3-4 teachers/coaches per session, working in groups of 3-4 over 2-3 school hours per week on 10 sessions and in total approximately 23 hours. During the 1st round in informal site there were 24 students (13-17 years old) with 6-8 teachers/coaches per session working in groups of 3-4 over 3 hours every Saturday on 10 sessions and in total approximately 30 hours. During the 2nd round in formal site there were 15 students (1 class, 15-16 years old) with 2-3 teachers/coaches per session, working in groups of 3 over 2-3 school hours per week on 5 sessions and in total approximately 15 hours. During the 2nd round in Informal site there were 24 students (13-17 years old) with 5 teachers/coaches per session working in groups of 3-4 over 3-4 hours the last week of June on 5 sessions and in total approximately 20 hours.

The project ideas came initially by the teachers (making selections from the indicative project scenarios in D5.1). As the sessions were progressing and the students were more familiar with the available tools and technologies they were notices to take initiatives and to either extend the project activity scenario or to work on their own ideas. During the 2nd pilot round the students directly worked on their own ideas for computer-supported artefact construction.

1st pilot (informal)
Lighthouse project
Shy Rabbit project
Sunflower project
Christmas artefacts (Christmas trees, Christmas boxes with music, Christmas figures and more)
DIY automobiles (simple to more complex implementations)

2nd pilot (informal)
The 3 level security control system
the Joypad for controlling a video game
Voice Driven Face project (AI)
Advanced DIY automobiles with remote control

1st pilot (formal)
Lighthouse project
The small village (extension of the lighthouse project)
Christmas artefacts
The Sunflower project
The solar panel (based on functionalities of the Sunflower project)
DIY automobiles (simple ones)

2nd pilot (formal)
DIY automobiles (advanced ones)

The 3D bridge

The projects are ideas came by teachers, extension of an idea, upon an earlier implemented or came from students.

Table 7. overview pilot projects concept design

Projects	**The project idea/topic was suggested by the teachers**	**The project idea was extended by the students resulting to a new project or an advance one**	**The project was building upon another project that had been earlier implemented**	**The project idea came from the students**
The Lighthouse project	√	√		
The Shy Rabbit project	√			
The Sunflower project	√	√		
Christmas artefacts				√
DIY automobiles	√	√		
The small village			√	
The 3 level security control system				√
The Joypad for controlling a video game				√
Voice Driven Face project (AI extensions)	√			
DIY automobiles with remote control			√	√
The solar panel			√	
The 3D bridge project			√	

The projects formation in Greek Pilot sites is according to the following image.

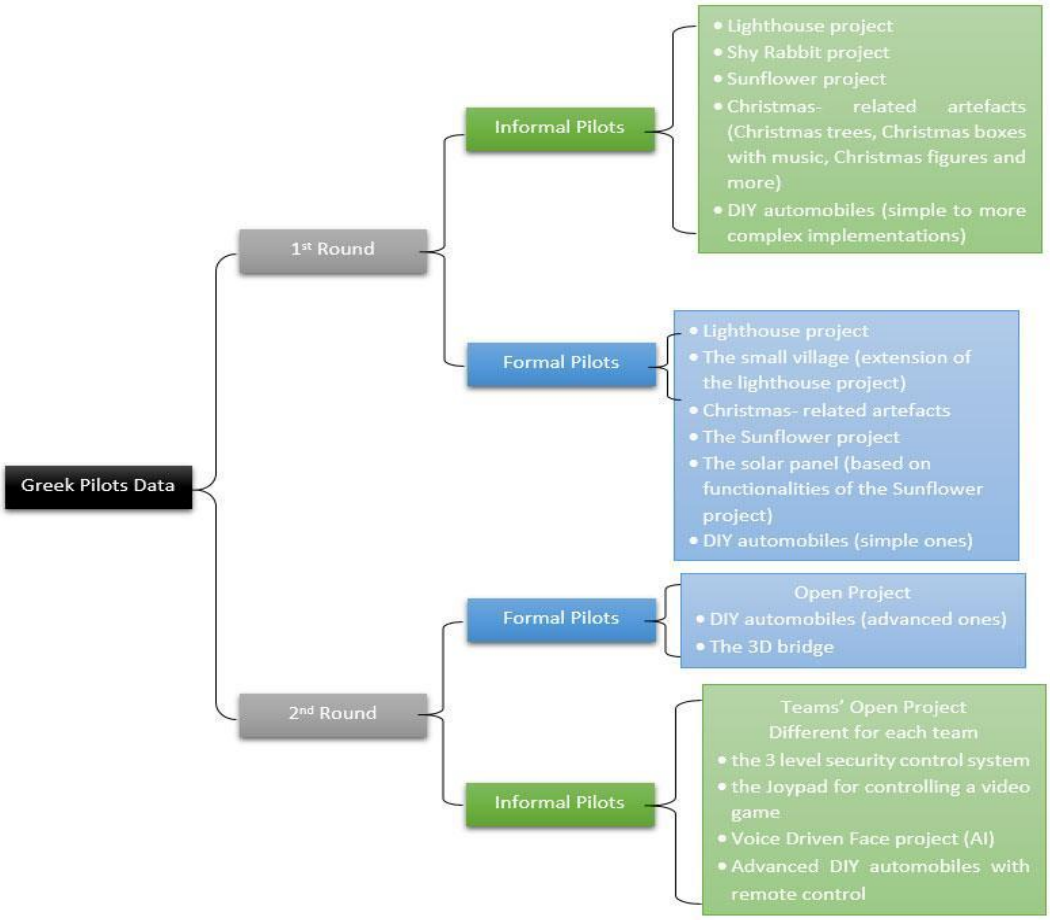

Figure 2. Projects overview per phase and pilot

The evaluation tools used for all projects developed at the formal pilots (8 projects) and informal pilots (9 projects) were jointly analyzed in order to reveal the impact of the rounds as a whole. The analysis of data from the Greek pilot sites is two-folded qualitative and quantitative, presenting the raw data in a very detailed and substantial manner using descriptive statistical methods supported by the qualitative analysis of the findings. The analysis was carried out and is presented in the sequence of Teacher Diaries from informal pilots (1st and 2nd round) and Teacher Diaries from formal pilots (1st and 2nd round), followed by Student Diaries from informal pilots (1st and 2nd round) and Student Diaries from formal pilots (1st and 2nd round). After this Observation Forms from informal pilots (1st and 2nd round) and formal pilots (1st and 2nd round) were analyzed, finishing off with Student Final Questionnaires from informal pilots (1st and 2nd round) and formal pilots (1st and 2nd round).

1.2. Greek Teacher Diaries

1.2.1. Greek Informal Pilot Site

The tables below show the data collected during both 1st and 2nd pilot rounds through seven closed questions using the teacher diary evaluation tool. Six out of these have a connected open question, which helped us to further analyze the results. In addition to that, there are single open questions that were analyzed in a separate section of this report. It is important to note that within the two sessions the teams have approximately the same number of students, though not exactly. The analysis is based on the answers to closed questions as well as the answers to the related open questions.

As for the first closed question of “Ideation/ Imagine. Did the students go through this stage today?”, according to teachers most of the time they did (Table 8), and only two times for two teams there was a negative answer to this question (see Annex III) - once during the first round and once in the second round. Further investigation of the related notes revealed that this was logical since the one “No” is about a session where a particular team did Ideation in the previous session. The other “No” answer is related to the final session of the second round from a team where there was no need for ideation.

Regarding the second closed question of “Planning. Did the students go through this stage today?”, according to teachers most of the time teams did, with 7 out of 37 teachers giving negative answers to this question in the first round and 1 out of 10 in the second round, which equates to 17% for both rounds. It is of great interest that five negative responses came from Team 5. Further investigation of the related notes revealed a logical explanation for this. The “No” response is from the last session of the second round which did not require any planning. Other comments from Team 5 reveal that planning was not necessary “There was a more spontaneous interaction, during this project.”, which is rather common for Greek students. Another “No” from other teams is about a session where this particular team did Ideation in the previous session and a further negative response is about the last session of the second round from a team where there was no need for ideation. The comment from Team 8 during the first round is of great importance: “I notice that – during the design phase - children are too eager to experiment with the tools and seem to think that they don’t need to draw their idea.”. This is a rather common approach for students that are not eager to plan (Table 8).

For the third closed question “Create. Did the students go through this stage today?”, teachers responded that most of the time teams went through creation and only 3 out of 47 times, in both round (6.3%) for three different teams the answer was negative. Further investigation of the related notes revealed that there is a logical explanation here too, in that in second round sessions, creation was not necessary and they followed other steps (Table 8).

Regarding the fourth closed question of “Program. Did the students go through this stage today?”, according to teachers most of the time teams went through the program stage and only 9 out of 47 times (19.14%), in both rounds, for five teams was the response to this question negative. Further investigation of the related notes revealed that the negative answers could be explained. Five of them were in second round sessions that did not require programming, but rather other steps in the educational framework. The other four, according to some comments, were due to the fact that teams did not spend time on programming in this particular session. This may be of interest since many students have the belief that STEAM is all about programming. For us, this is an indication that eCraft2Learn methodology may also provide them opportunities to concentrate on other aspects of project design (Table 8).

The aspect of sharing seems to have been problematic according to teacher diaries, as a rather high percentage of **25.5% of teams in all sessions did not include sharing** in their project steps. This needs further investigation especially since sharing is a very important part of eCraft2Learn educational methodology. In addition, difficulties in sharing appeared in student questionnaires as well. Investigating the open comments made by teachers in relation to sharing, telling comments were found, such as “To my surprise, the children did not want to expose themselves, even if they had the initiative during the implementation of the project.”, “They did not present their work as it was their first day and they did not manage to deliver the final result” and “Children hesitate to make a presentation maybe because they don't feel confident enough to explain all the construction phases.”.

This mainly means that students did not have the right mindset and courage to present, which **might reveal the need for knowledge and techniques on presentation**. Presentation is considered one of the most important skills nowadays, and essential for one's future. As students stated in their questionnaires, and in the analysis that appeared later in this deliverable, eCraft2Learn educational methodology helps students feel more comfortable presenting their work.

Table 8. 1st pilot round - total number of work sessions 10 - Tables for the five closed questions (the detail answers are included in Annex 1)

Students Group (Informal site)	**Ideation**		**Planning**		**Creation**		**Programming**		**Sharing**	
	Yes	**Limited**	**Yes**	**Limited**	**Yes**	**Limited**	**Yes**	**Limited**	**Yes**	**Limited**
Group 1	7	1	5	3	6	2	5	2	3	4
Group 2	5	1	2	3	6	0	2	2	6	0
Group 3	0	1	0	1	0	1	0	1	0	1
Group 4	1	1	2	0	2	0	0	2	2	0
Group 5	4	1	0	1	5	0	4	1	4	0
Group 6	4	0	3	1	3	1	3	1	2	2
Group 7	5	1	5	1	4	3	2	4	3	2
Group 8	3	1	2	1	4	0	0	4	0	2
8 Work Sessions in Total	29	7	19	11	30	7	16	17	20	11

Table 9 - 2nd pilot round - total number of work sessions 5 (the detail answers are included in Annex 1)

Students Group (Informal site)	**Ideation**		**Planning**		**Creation**		**Programming**		**Sharing**	
	Yes	**Limited**	**Yes**	**Limited**	**Yes**	**Limited**	**Yes**	**Limited**	**Yes**	**Limited**
Group 2	1	0	1	0	1	3	0	0	0	0
Group 4	2	2	1	3	0	0	1	2	0	3
Group 5	1	1	0	2	1	1	0	1	0	1
Group 7	0	1	0	1	0	0	0	0	0	0
Group 8	0	1	0	1	1	0	1	0	0	0
8 Work Sessions	4	5	2	7	3	4	2	3	0	4

As far as the sixth question (Table 10) related to collaboration is concerned, among team members during the 1st round, teachers answered mainly that team members showed "**Very Good" (40.42%) and "good" (25.5%) collaboration**. What is of most interest, however, are the 3 replies of "No collaboration", 2 of "poor" and 6 of "fair". Further investigation of the data revealed that those 3 answers of "No collaboration" came from teams where there was only one student per team in the session, so collaboration was not possible. The 2 "poor" responses came from teams that had problems with collaboration and we discovered this from other notes and answers to open questions such as "Two out of the three students stopped participating in the programming, from a specific point on". Nevertheless, the percentage of "good" and "very good" 43% (16 out of 37) is quite high.

Table 10. How was the collaboration among the group members?

1st round	**How was the collaboration among the group members?**					
Group	**No collaboration**	**Poor**	**Fair**	**Good**	**Very Good**	**Group Sum**
Group 1	0	0	3	5	0	8
Group 2	0	0	0	0	6	6
Group 3	0	0	0	1	0	1
Group 4	0	0	0	2	0	2
Group 5	1	0	1	1	2	5
Group 6	1	1	0	0	2	4
Group 7	0	0	0	0	7	7
Group 8	1	1	2	0	0	4
Total Sum	3	2	6	9	17	37

Regarding collaboration among team members during the 2nd round (Table 11), teachers responded mainly that team members displayed "very good" and "good" 50% collaboration. The 2 "poor" and 3 "fair" responses are of interests, although the total number of answers is quite small (10).

Table 11 How was the collaboration among the group members

2nd round	**How was the collaboration among the group members?**					
Group	**No collaboration**	**Poor**	**Fair**	**Good**	**Very Good**	**Group Sum**
Group 2	0	0	0	0	1	1
Group 4	0	0	1	1	1	3
Group 5	0	2	1	0	0	3
Group 7	0	0	0	1	0	1
Group 8	0	0	0	1	0	1
Total Sum	0	2	3	3	2	10

The tables and analysis of the final three closed questions are as follows. Since there was more than one teacher per session, each question was analyzed separately. The analysis is based on the answers to closed questions as well as to the related open questions. Most teachers, 25 out of 37 (67.5%), were **satisfied with the students' level of engagement in sessions during the first round**. (Table 12).

Table 12. To what extent are you satisfied with the level of students' engagement today

1st round	To what extent are you satisfied with the level of students' engagement today?					
Group	**No Answer**	**Not at all**	**Very little**	**Somewhat**	**To a great extent**	**Group Sum**
Group 1	0	0	1	4	3	8
Group 2	0	0	0	0	6	6
Group 3	0	0	0	0	1	1
Group 4	0	0	0	2	0	2
Group 5	0	0	0	1	4	5
Group 6	0	0	0	1	3	4
Group 7	0	0	0	0	7	7
Group 8	0	0	0	3	1	4
Total Sum	0	0	1	11	25	37

The same was true for the second round with 4 out of 10 (40%) teachers being satisfied with the students' level of engagement in sessions (Table 13).

*Table 13 level of engagement - t*o what extent are you satisfied with the level of students' engagement today

2nd round	To what extent are you satisfied with the level of students' engagement today?					
Group	**No Answer**	**Not at all**	**Very Little**	**Somewhat**	**To a Great Extent**	**Group Sum**
Group 2	0	0	0	0	1	1
Group 4	1	0	0	0	3	4
Group 5	0	1	0	2	0	3
Group 7	0	0	0	1	0	1
Group 8	0	0	0	1	0	1
Total Sum	1	1	0	4	4	10

The majority of teachers, 27 out of 37 (~73%), were also satisfied with the level of their team's progress during the first round of sessions (Table 14)

Table 14 level of engagement 2nd round - To what extent are you satisfied with the progress made by your team today

1st round	To what extent are you satisfied with the progress made by your team today?

Group	No Answer	Very little	Somewhat	To a Great Extent	Group Sum
Group 1	0	1	3	4	8
Group 2	0	0	0	6	6
Group 3	0	0	0	1	1
Group 4	0	0	1	1	2
Group 5	0	0	1	4	5
Group 6	0	0	1	3	4
Group 7	0	0	0	7	7
Group 8	1	0	2	1	4
Total Sum	1	1	8	27	37

During the second round, a greater proportion (50%) of teachers responded to the question "To what extent are you satisfied with the progress made by your team today?" that they were "Somewhat" satisfied. The extended content analysis of the related open question did not reveal anything particular apart from only one answer mentioning that "There was no agreement between them in what they would do.". So we cannot make any concrete conclusions at this stage and further analysis is required. (Table 15).

Table 15 – satisfaction with the progress made by your team today

2nd round	**To what extent are you satisfied with the progress made by your team today?**				
Group	**No Answer**	**Very little**	**Somewhat**	**To a great extent**	**Group Sum**
Group 2	0	0	1	0	1
Group 4	1	0	1	2	4
Group 5	0	2	1	0	3
Group 7	0	0	1	0	1
Group 8	0	0	1	0	1

Most teachers, 27 out of 37 (~73%), felt satisfied with the level of team creativity during the first round of sessions. (Table 16).

Table 16 progress 2nd round- Satisfaction with the creativity demonstrated by your team today

1st round	**To what extent are you satisfied with the creativity demonstrated by your team today?**					
Group	**No Answer**	**Not at all**	**Very little**	**Somewhat**	**To a Great Extent**	**Team Sum**
Group 1	0	0	0	6	2	8
Group 2	0	0	0	1	5	6
Group 3	0	0	0	0	1	1

Group 4	1	0	0	0	2	2
Group 5	0	0	1	1	3	5
Group 6	0	0	0	1	3	4
Group 7	0	0	0	2	5	7
Group 8	0	0	0	3	1	4
Total Sum	1	0	1	14	27	37

During the second round, a larger percentage (50%) of teachers responded to the question "To what extent are you satisfied with the creativity demonstrated by your team today?" that they were satisfied "To a great extent" (Table 17).

Table 17 Satisfaction with the creativity demonstrated by your team today

2nd round	**To what extent are you satisfied with the creativity demonstrated by your team today?**					
Group	**No Answer**	**Not at all**	**Very little**	**Somewhat**	**To a Great Extent**	**Team Sum**
Group 2	0	0	0	0	1	1
Group 4	0	0	0	1	2	4
Group 5	0	1	0	2	0	3
Group 7	0	0	0	0	1	1
Group 8	0	0	0	0	1	1
Total Sum	0	1	0	3	5	10

Regarding the question "On the following scale...(1 = traditional teacher/ 5 = coach) …where do you place your role in the workshop based on today's experience?", teachers during the first round mostly placed themselves on 3 (43.24%) and 4 (40.54%) and only 10.81% on 5 (*Table 18*).

Table 18 Traditional vs Coaching - 1st pilot

1st round Pilot session\scale	**1 = Traditional**	**2**	**3**	**4**	**5 = Coach**
Session 1	0	0	1	2	0
Session 2	0	0	1	4	0
Session 3	0	0	2	3	0
Session 4	0	1	5	1	0
Session 5	1	0	4	1	0
Session 6	0	0	2	2	1
Session 7	0	0	1	0	2

Session 8	0	0	0	2	1
Total Sum	1	1	16	15	4

As far as the second round regarding the question "In the following scale...(1 = traditional teacher/ 5 = coach) …where do you place your role in the workshop based on today's experience?" is concerned, most teachers placed themselves on 4 (77.78%), and only 11.11% on 5 (Table 19).

Table 19. Traditional vs Coaching - 2nd pilot

2nd round Pilot session\scale	**1 = Traditional**	**2**	**3**	**4**	**5 = Coach**
Session 1	0	0	0	1	0
Session 2	0	0	0	3	1
Session 3	0	0	0	1	0
Session 4	0	1	0	2	0
Total Sum	0	1	0	7	1

In the teacher diaries there is an open question related to Project Description. The teachers' answers showed that all teams took part in all 1st round projects and indicated which projects teams chose to do during the second round. The notes were short but quite descriptive of what was done as a project. Through this question we have a clear view about the context of the open project that teams carried out during the second round. More specifically, Team 2 created a security alarm system with three zones using a distance sensor and LED lights for the alarm notification. They used Ardublock. Team 4 constructed a control system with photoelectric sensors. They made the construction as well as the connections. They used Arduino IDE and Snap4Arduino. Team 5 built a robot with a distance sensor and used Ardublock. Team 6 built a robot that follows light and they added an ultrasound sensor for distance detection. They used Ardublock. Team 7 constructed an autonomous robot using Raspberry Pi, without Arduino. They used AppInventor and controlled the robot remotely. Team 8 built a car with a distance detector and they used Ardublock.

A very useful open question in the teacher diaries turned out to be "Describe briefly your role today:". There were various interesting answers like those referring to the fact that they acted as "Coach", saying that "*I supported the students to work on the project.*" or "*Helping*" or even "*Adequate guidance of the team for the implementation of the circuit and the preparation of the program.*". The more detailed notes mentioned that children hesitated to work on their projects, such as "*Our role as trainers was to help. But we noticed that the children were expecting us to tell them the next step, what was an obstacle to the development of the project. So, after the initial guidelines, we let the team work autonomously and take initiatives*". **Teachers believed that they responded appropriately and allowed students to work autonomously**. Some teachers provided some help with equipment: "*To bring H/W and S/W up…..*" and "*Provide the necessary tools and help with the implementation of children's ideas.*". On the other hand, there were instances where teachers were more actively involved in the construction: "*In the creation phase I participated only in the stabilization of the sunflower. In the programming and (mainly) the circuits, I offered a lot of guidance so as to simplify the artifact and ensure the right use of the Arduino entry/exits.*" and "*I participated as a member of*

the team in the programming so that some problems can be fixed. As a teacher, I helped with the new electronic material that were used.", which is not in accordance with the project aims.

In addition, in some cases teacher said that they reverted to a more traditional way of teaching: "*Teaching code using snap4arduino, explain code's logic…..*" and "*I had to answer a lot of questions, explain to them why many of their ideas would not work the way they thought*.". However, there were some instances where teachers had no choice but to be more active, as in the case of a new team formation "*I was completely involved since the students of my team were absent and I created a new team with two new students*".

Concerning the open question about tools used during the first and second round of sessions, the most frequently mentioned teacher tools are shown in the table below. The most frequently mentioned tools are Arduino Uno and Raspberry Pi which were the key tools used by teams, followed by Snap4Arduino, Breadboard, Arduino IDE and cardboard. There are also some tools that, although widely used by the teams, were not often referred to by the teachers in diaries, such as silicone, silicone guns, photo resistors, ruler and ultrasonic sensors.

Table 20. tools used during pilots in Greece

Tool	**Times mentioned by teachers**
Arduino Uno	24
Raspberry PI	20
Snap4Arduino	18
Breadboard	8
Arduino IDE	7
Cables	7
Cardboard	7
Glue	7
Led	7
Scissors	7
Ardublock	6
Paper	4
Resistors	4
Tinkercad	4

As for the question "Did you **learn something new** from your interaction with the students today?", teachers mentioned various aspects of a number of different fields in their diaries, **mainly related to teaching issues but also some knowledge and creativity issues**. In terms of training issues, teachers found that "*Yes, the children enjoyed to create workable projects and prefer more to listen to their instructor instead of reading!*" as well as "*Also, I learned that students' total satisfaction is strictly related to the teachers' creativity and coaching capability*". In addition, some teachers understood through the course of the sessions that team collaboration and teamwork could be applicable to teaching and they commented that "*Children can easily cooperate together on a project even if they briefly known each other.*", as well as that children preferred a more practical teaching approach, with

greater freedom to experiment and to try to relying on their own abilities and capabilities, as illustrated by these teacher comments: "*Children are more keen in trying from the moment they realize that there might be more than one solution to a problem*.", "*They managed to complete the previous project, believing in themselves, even though all the other teams were moving faster ….*" and "*They love to be taught, coached and treated with enthusiasm and motivation…*". Furthermore, there were some interesting diary entries about teamwork like these ones about self-regulation: "*That the team has to auto-regulate, even is this is time consuming*", "T*he importance of a good team*", "*Disagreement sometimes can be creative. A combination of ideas could be chosen, but next day, unfortunately there was a change in the members of the team.*", and also about the importance of creativity and the level of collaboration: "*Creativity gives results. And harmonic cooperation*".

Furthermore there were some comments about knowledge that teachers gained through these sessions, such as "I *was actually not good in the "art*" part of the project.", "*I am improving and the artifacts' level.*", which are mainly about the artistic side of the project. This seems to be something new that the eCraft2Learn educational framework offers teachers at the informal site in Greece, and in a fairly new way. These type of comments were found not only in teacher diaries but also in other evaluation tools. Additionally, teachers mentioned that they gained some knowledge in creativity: "*I had to make available some alternative implementations of the joystick or talk about extending their idea (smartphone as a controller, Makey Makey as a controller, 4 button controller).*" and "*Problems about lack of materials or time (in order to make usual buttons from scratch) drives to innovation*".

1.2.2. GREEK FORMAL PILOT SITE (KORYDALLOS 1ST EPAL)

The tables below show the data collected during both the 1st and 2nd pilot rounds through seven closed questions from formal pilot site teacher diaries. Six of the closed questions have a closely connected open question to help further analyze the results. In addition, there is a single open question which was analyzed in a separate section of this report. It is important to note that within the two sessions the teams have approximately the same number of students, though not exactly. The analysis is based on the answers to closed questions as well as the answers to the related open questions.

As for the first closed question of "**Ideation/ Imagine. Did the students go through this stage today?", teachers overwhelmingly answered "Yes" (98%)**. Regarding the second closed question of **"Planning.** Did the students go through this stage today?", teachers once again overwhelmingly answered "**Yes" (98%)**. Furthermore, to the third closed question of "Create. Did the students go through this stage today?", teachers answered "Yes" (45%) and "Yes but to a limited extent" (55%). This illustrates a rather positive teacher attitude to this question. In addition, answers to the fourth closed question of "Program. Did the students go through this stage today?", indicated that most of the time teams did programming, with 55% answering "Yes" and 24.4% answering "Yes but to a limited extent". However, there is a rather concerning proportion of 20.4% that answered "No". As there were no comments related to this question, we were unable to shed light on the reasons for this. We would like to mention that teachers who answered "No" to this question in the first session, also answered "No" in the next closed question of sharing.

The **aspect of sharing seems to have been problematic according to teacher diaries, with the majority of teachers (65.31%) responding with "No"**. Unfortunately, we do not have any diary notes to further investigate the reasons behind this. Since limited time in each session at the formal site had been referred to in interviews, it can be concluded that this might be at least part of the problem. Furthermore, this may have been due to the students not having the courage to present in front of

others. Presentation is considered one of the most important skills nowadays and also essential for one's future. In student questionnaires that were analyzed later in this deliverable, it was noticed that the eCraft2Learn educational methodology help students to feel more comfortable to present (Table 21).

Table 21. total number of work sessions

Students Group (Formal site)	Ideation		Planning		Creation		Programming		Sharing	
	Yes	Limited	Yes	Limited	Yes	Limited	Yes	Limited	Yes	Limited
Group 1	9	0	9	0	5	4	3	4	0	4
Group 2	6	0	2	0	4	2	2	2	1	1
Group 3	6	0	6	0	4	2	3	1	0	2
Group 4	7	0	6	0	3	4	1	4	1	1
Group 5	7	0	6	0	3	4	4	1	1	2
Group 6	3	0	7	0	1	2	3	0	0	1
Group 7	3	0	3	0	1	2	3	0	0	1
Group 8	2	0	3	1	1	2	3	0	0	1
Group 9	3	0	3	0	0	3	3	0	1	0
Group 10	2	1	3	0	0	2	2	0	0	0
10 Work Sessions	48	1	48	1	22	27	27	12	4	13

Regarding the sixth question, which is about collaboration among team members during the 1st and 2nd round at the formal pilot site, teachers answered mainly that team members displayed "good" (39.2%), "fair" (35.3%) and "poor" (15.56%) collaboration. Unfortunately there were no dairy entries or teacher comments to further investigate the responses, but according to teacher and student interviews we know that there were some problems within the teams, with some students not showing any interest, and others feeling dominated by some team members (Table 22).

Table 22. collaboration among the group members

	How was the collaboration among the group members?					
Group	**No collaboration**	**poor**	**fair**	**good**	**very good**	**Group Sum**
Group 1	0	2	5	2	0	9
Group 2	0	0	2	3	1	6
Group 3	0	0	1	4	1	6
Group 4	0	1	4	2	0	7

Group 5	1	3	1	2	0	7
Group 6	0	0	2	1	0	3
Group 7	0	0	1	2	0	3
Group 8	0	0	1	2	0	3
Group 9	0	1	1	1	0	3
Group 10	1	0	0	1	0	2
Total Sum	2	7	18	20	2	49

The tables and analysis of the remaining three questions are as follows. Since there was more than one teacher per session, we analyzed each question separately. The analysis is based on the answers to closed questions as well as to the related open question. Most teachers (89.8%) at the formal site during the first and second round were satisfied "To a great extent" (44.9%) and "Somewhat" (44.9%) with the level of student engagement in sessions. This indicates that teachers had a rather positive view of student engagement during the sessions (Table 23).

Table 23. satisfied with the level of students' engagement today

	To what extent are you satisfied with the level of students' engagement today?					
Group	**No Answer**	**Not at all**	**Very little**	**Somewhat**	**To a great extent**	**Group Sum**
Group 1	0	0	1	4	4	9
Group 2	0	0	0	0	6	2
Group 3	0	0	0	2	4	6
Group 4	0	0	0	4	3	6
Group 5	0	0	0	3	4	7
Group 6	0	0	1	2	0	7
Group 7	0	0	0	3	0	3
Group 8	0	0	1	1	1	3
Group 9	0	0	1	2	0	3
Group 10	0	0	1	1	0	3
Total Sum	0	0	5	22	22	49

Most teachers (85.7%) at the formal site during the first and second rounds were satisfied "To a great extent" (40.82%) and "Somewhat" (44.9%) **with the level of student progress in sessions**. This is shows that teachers had a rather positive view of student progress during the sessions (Table 24).

Table 24. Satisfied with the progress made by your team today

	To what extent are you satisfied with the progress made by your team today?				
Group	**No Answer**	**Very little**	**Somewhat**	**To a Great Extent**	**Group Sum**
Group 1	0	1	4	3	9
Group 2	0	0	1	5	2
Group 3	0	0	3	3	6
Group 4	0	0	4	3	6
Group 5	0	0	2	5	7
Group 6	0	1	2	0	7
Group 7	0	2	1	0	7
Group 8	0	1	1	1	3
Group 9	0	1	2	0	3
Group 10	0	0	2	0	3
Total Sum	0	7	22	20	49

Most teachers (85.11%) at the formal site during the first and second rounds were satisfied "To a great extent" (29.79%) and "Somewhat" (55.32%) with the level of student creativity in sessions. This is shows that teachers had a rather positive view of student creativity during the sessions (Table 25).

Table 25. Satisfied with the creativity demonstrated by your team today

Group	**No Answer**	**Not at all**	**Very little**	**Somewhat**	**To a Great Extent**	**Team Sum**
Group 1	0	0	2	4	3	9
Group 2	0	0	0	3	3	2
Group 3	0	0	0	4	2	6
Group 4	0	0	1	5	1	6
Group 5	0	0	1	2	4	7
Group 6	0	0	0	3	0	7
Group 7	0	1	2	0	0	3
Group 8	0	0	1	2	0	3
Group 9	0	0	1	1	1	3
Group 10	0	0	0	2	0	3

Total Sum	0	1	8	26	14	49

Regarding the question "In the following scale…(1 = traditional teacher/5 = coach) …where do you place your role in the workshop based on today's experience?", teachers at the formal site placed themselves on 2 (8.16%), 3 (12.24%), 4 (65.31%) and 5 (14.29%) (Table 26).

Table 26. Role of teacher vs. coach

Pilot session\scale	**1 = Traditional**	**2**	**3**	**4**	**5 = Coach**
Session 1	0	0	0	0	0
Session 2	0	0	0	0	0
Session 3	0	0	0	0	0
Session 4	0	0	0	0	0
Session 5	0	1	2	3	2
Session 6	0	2	1	3	0
Session 7	0	0	0	7	2
Session 8	0	0	1	6	3
Session 9	0	0	0	4	0
Session 10	0	0	1	4	0
Session 11	0	0	0	5	0
Session 12	0	0	0	0	0
Session 13	0	0	1	0	0
Session 14	0	1	0	0	0
Total Sum	0	4	6	32	7

In the teacher diaries, there is an open question about Project Description. The teachers' answers revealed that all teams took part in all 1st and 2nd round projects. The diary entries are short but quite descriptive of what was done in each project. It is worth mentioning that the special project of the fully functional bridge, combining electronics and 3D printing, which was created by school students from the formal site were referred to in the diaries.

A very useful open question in teacher diaries was "Describe briefly your role today:". There were various interesting answers, such as the ones mentioning that they acted as instructor, coordinator and problem-solver most of the times, which is rather different from what eCraft2Learn wishes to inspire. On the contrary, it was also mentioned that they acted as an assistant (quite a few times),

supporter, helper, guide, sponsor, mentor and even observer, which are more in alignment with eCraft2Learn teaching methodology.

The most commonly mentioned tools employed during the first and second sessions by teachers in response to the open questions can be found in the table below. The most frequently mentioned tools are Snap4Arduino, Electrician materials and paper materials followed by glue cables, pairs of scissors, welding tools, wheels, Arduino boards, Arduino IDE, Cura, Tinkercad and servo motors. It is worth pointing out that no teacher mentioned Raspberry Pi (Table 27).

Table 27. tools used during formal pilots in Greece

Tool	Times Referred by teachers
Snap4Arduino	21
Electrician materials	16
Paper materials	16
Glue cables	9
Pair of scissors	9
Welding tools	8
Motor	6
Wheels	6
Paper cartridges	6
Arduino board	5
Arduino IDE	3
Cura	2
Tinkercad	2
Servo motor	1

As for the question “Did you learn something new from your interaction with the students today?”, teachers at the formal pilot site did not make many comments. They mentioned only aspects of knowledge, especially regarding handcrafting, for instance “Construction with paper and straws”, “Construction with papers, leds”, “How to make a paper house” and some other issues regarding motors like “Understanding servo’s function”.

1.3. GREEK STUDENT’S DIARIES

1.3.1. GREEK INFORMAL PILOT SITE

At informal pilots that took place at Technopolis during the 1st pilot round, 24 students participated - 9 female and 15 male. During the 2nd pilot round once again 24 students participated - 9 female and 15 male. The analysis of diaries from informal pilots is two-folded - quantitative and qualitative. In student diaries there is only one quantitative question regarding “The **collaboration** among the team members was today”. The responses to this question obtained from informal pilot dairies at Technopolis during the 1st round are summarized in the following table. It is worth noticing that during

all 1st round sessions only one answer was “poor” (0.6%). **The vast majority of answers were “very good” (79.64%**) (Table 28).

Table 28. Collaboration among the team members 1st pilot phase

Technopolis (Informal) 1st round		
The collaboration among the team members was today	Sum	Percentage
Very Poor	0	0%
Poor	1	0,6%
Fair	9	5,49%
Good	24	14,47%
Very Good	133	79,64%
Total Sum	167	

The following table 29 summarizes the answers regarding collaboration within the teams in the 1st round. Only Team 1 responded with “poor”, with 3 additional responses of “fair”. In the qualitative analysis of the answers it was found that the student that considered collaboration to have been “poor”, responded to the question “What did you like the least today?” along the same lines: “We did not work as much as a team”. In addition, one more student that rated collaboration as “poor”, responded to the question “What did you like the least today?” with the following: “That we did not collaborate very well and that the microphone did not work”. These pieces of evidence indicate that there was an issue with collaboration in the team. On the other hand, the students from Team 7 all felt that collaboration was “very good” and, furthermore, did not make any negative comments about collaboration in response to open questions.

Table 29. collaboration among the team members

Informal pilot site 1st round						
The collaboration among the team members was today						
Group	Very Poor	Poor	Fair	Good	Very Good	Sum Per Group
Group 1	0	1	3	7	19	30
Group 2	0	0	1	1	21	23
Group 3	0	0	1	1	5	7
Group 4	0	0	2	5	18	25
Group 5	0	0	1	2	19	22
Group 6	0	0	1	6	12	19
Group 7	0	0	0	0	23	23
TGroup eam 8	0	0	0	2	16	18
Sum Collaboration	0	0	9	24	133	167

During the 2nd round, there was only one answer of "very poor" (1.54%) but at the same time a decrease in the number of "very good" ratings for collaboration during the 2nd round compared to the 1st round (61.54% vs 79.64%).

Table 30. Collaboration among the team members 2nd pilot phase

Technopolis (Informal) 2nd round		
The collaboration among the team members was today	Sum	Percentage
Very Poor	1	1,54%
Poor	0	0,00%
Fair	7	10,77%
Good	17	26,15%
Very Good	40	61,54%
Total Sum	65	

The following table summarizes the answers regarding collaboration within the teams in the 2nd round. It is important to mention that the second round teams are different from those in the first round. It is also worth mentioning that only Team 5 in the second round had the one answer of "very poor", with none of the teams responding with "poor". In the qualitative analysis of the answers we found that the student that rated collaboration as "very poor", responded to the question "What did you like the least today?" with: "My team". We did not identify any other problems in the team diaries, something that is in fact mentioned in the diaries. Since this team worked on a rather innovative project involving remote control, this negative comment about collaboration might be due to the very first session when the team met for the first time.

Table 31. Collaboration among the team members 2nd pilot phase

Technopolis (Informal) 2nd round						
The collaboration among the team members was today						
Group	Very Poor	Poor	Fair	Good	Very Good	Sum Per Group
Group 2	0	0	1	2	10	13
Group 4	0	0	0	1	8	9
Group 5	1	0	2	4	2	9
Group 6	0	0	1	3	11	15
Group 7	0	0	3	7	5	15
Group 8	0	0	0	0	4	4
Sum Per Collaboration Level	1	0	7	17	40	65

The second part of the analysis relates to the open questions in student diaries. The open questions are:

1. What did you like the most today?
2. What did you like the least today?
3. Do you think that you learnt something new? If yes, could you please refer to what you learnt?
4. Do you have a project idea that you would like to have implemented by the end of the pilots?

The replies to the question "What did you like the most today" revealed a variety of points. Many students commented that they liked everything and a significant number that they gained knowledge. There are notes regarding knowledge of circuits and especially about Breadboard use, including: *"Breadboard use", "Connecting the components", "Circuit construction", "I learned how to connect lots of parts on breadboard".* In addition, special mention is made of electronics and specific types of electronics such as LEDs: "*I learned how to turn on a led using raspberry and Arduino", "I like that I learned about how to make a circuit on the board and various new to me components, such as the resistor", "I liked that I learning about the infrared sensor"* and *"We learned a lot about servo motors"*. Comments were made about Arduino and Raspberry Pi, which was to be expected since they were the basic and essential tools in the projects. Students stated that: "I liked that they showed us how to connect several cables with Arduino and Raspberry and how to make a LED light work, with these materials". Knowledge of robots and artefacts were the most popular constructions that students remembered: *"I like the most the construction of robot ring", "I liked a lot when we made another robot in half a hour", "I liked the artefact/construction that we made, I learnt new things…."* and "*That I can build an autonomous artifact*". Apart from this, 3D printing was frequently referred to by the students since for most of them it was their first attempt. Comments such as "*How 3D printer draws*", *"I liked a lot that we print something in 3D printer"* and others illustrates the strong interest in 3D printing.

Another aspect that the students liked was some of their achievements. Students mentioned that: *"I liked that we finally managed to make the sunflower after a lot of trouble", "I liked that we made an interesting construction and made it very complicated", "I liked that we managed to make the sunflower after lot of effort"*, which means that they recognized and confronted the difficulties they faced, dealing with them efficiently - something they enjoyed.

They were also pleased with the fact the they materialized some 3D printing constructions: *"I liked that we were manage to print 3D", robots with artificial intelligence "I liked the idea of making the robot move with voice commands", "That we made the program for Artificial Intelligence with Snap4Arduino humanoid",* but also general constructions: "*the construction", "The construction of the rabbit", "The construction of the rabbit and the voice command…", "it was fascinating when we were making noise over the threshold the rabbit was hiding.".* In addition, achievements in programming were not insignificant either to students, as they referred to robot programming: *"Today I liked more that we managed to make our robot turn", "Today I liked more the robot programming"* and "*Today what I liked the most was that I managed to turn on the led".* They also enjoyed achievements related to things that they had never tried before *"Today, I like it that I tried to program, because I have never done something like this in my life.", "We combine our artefact with 3D printing*".

Students also liked programming and they referred to it in various ways. Comments include: *"App Inventor"* by many, *"Arduino programming", "How we programmed with Snap4Arduino, by quite a few students, "I enjoyed setting up the commands that made the led flash."* and more generally *"The*

programming".

A significant portion of students' comments about what they **liked** focused on the way they worked, in other words **collaboration, teachers' methods,** and so on. More specifically, a large number of positive comments were made regarding collaboration: *"Collaboration and teamwork", "team discussion about all team project and their idea", "I liked it that we worked well all together and we made something as a team", "The collaboration to find nice ideas"* as well as about the method used: *"I liked it today when we planned and made everything we needed today", "I liked that we all worked together and we had a great result".* There are some very interesting comments about the way teachers worked with students: *"I liked that we were left by our teacher to explore ourselves the solutions of some problems that emerged.", "I really enjoyed the collaboration we had with my team and teachers...".* The whole environment seemed to have played a positive role since there are comments such as: *"The nice atmosphere within the team".* Finally, it is worth mentioning that some teams really liked being part of the same team in the first and second rounds: "*Reuniting with my team's friends as well as sharing and presenting ideas with the others".*

The second open question in the diary was "What did you like the least today?". The most common response was "Nothing", mentioned in 85 diaries in both rounds. Combined with "Everything is ok", "I liked everything", "I liked all" and other similar comments made more than 15 times, it can be safely concluded that from around 95 to 100 diaries out of the 232 completed in both rounds, the students were pleased with everything. And in combination with the many positive aspects that students referred to in the previous question, it can be concluded that students had a very positive attitude about the implementation of both rounds. Taking into account the positive comments during student interviews, there is convincing evidence of the overall positive opinion of the project application at the informal site.

In terms of what they liked least, some students referred to the teaching methods. The most noteworthy comments are: "*A very theoretical part that made the lesson slow, in my opinion"* and *"Continuous repetition of recycling of ideas",* which differ from the target of the project. In addition, the comment "*That at the begin I did not understand what to do (connections, breadboard, Arduino etc.)*", indicates that the eCraft2Learn framework needs improvements in order to be understandable to all possible users.

Furthermore, **students noted down some achievements that they believed were not attained**, such as: "*All went well, we simply did not manage to complete the program so as to deal with the construction the next time", "I liked less that we did not manage 100% to make the led blink every few seconds", "We did not manage to implement the project with the camera and the microphone"* and *"We did not manage to make the robot to move"* and also related to some technical issues that they faced: *"I did not like the fact that the microphone did not work with the programming", "Programming"* and *"I did not like that we could not connect to Tinkercad".* **Sometimes technical issues disappointed students**: "*That nothing worked".* There are several comments and concerns about Raspberry Pi in some tests that they had to perform, which caused frustration: "*That raspberry was crashing too much and made programming too slow because we had to"* or *"That the PC crashed".* Special reference was made to AI: "*The fact that Snap4Ardunio could not respond to the program. Also, Raspberry could not recognize the camera, so we never get this done"* which seemed to have a problematic application in the first attempt. Nevertheless, the problems related to achievements compared to the positive experiences are very small.

Another issue that was brought to light is **cooperation.** Once again, there were **only a few negative issue** in the diaries and those took place during the initial sessions. One student noted: *"I did not like*

that at first we could not concentrate and coordinate". On the contrary, we had notes asking for a particular team that they have a very good collaboration "*I wanted us to be all in the same team"* or they sought for collaboration "*That I was a bit alone"*, which means that they wished to collaborate in some way.

The final issue that was referred to in student diaries, in response to what they liked least is about methodology and the way they worked. There are some comments indicating how they felt: "*The boring introduction*", "*The delay at the beginning", "The long presentation", "game we played at the beginning of the session", "The game with the balls was what we liked the least.", "to much talk".* Apart from the introductory game, the other comments are not in alignment with eCraft2Learn educational methodology. Although there were only a few comments, attention to this issue is needed. In addition, some students said "*That I confused*" might be connected to another comment "*That we did many things*". Furthermore, a noteworthy comment is this one about the artistic aspect of the project: "*The construction piece. Not the circuit, just the artistic design, lighthouse design*" which stood out from the rest.

The third question in the diary was "Do you think that you learnt something new? If yes, could you please refer to what you learnt?". Apart from "Nothing" being the most common response, possibly due to the lack of difficulty of the project, there are plenty of examples of new knowledge that students mentioned gaining, for instance: "*A lot of things about raspberry and for programming generally",* about robots, sensors, microphones, Arduino: *"Draw 3D and print 3D*" and *"I learnt about Cura", "connection on a breadboard"*, photoresistors: *"How to program a car"*, and knowledge about programming: *"I gained a lot of knowledge about programming*", as well as about electronics: *"I learned about speakers connection and motion sensor", "I learned about the L293D amplifier and for mini bread board"* and *"Use of App Inventor, Raspberry".*

Concerning the last question of the diary, "Do you have a project idea that you would like to have implemented by the end of the pilots?", apart from the most common response of "No" mainly due to a lack of difficulty, there are several references to various robots: "*A bodyguard for a figure; when it feels motion it raises his hand", "A robot remote control", "Create a robot that is capable of answering questions."* as well as **many comments about different types of car**: "*Electric car", "A car that moved using sensors", "A car that will change color by means of an application", "...to build a wooden small car that I can control".* Some responses refer to animals: *"A rabbit that hops", security systems: "Achievement of the door mechanism", "Alarm system" as well as a flying object: "Something that flies, anything", "something, like a drone, a helicopter".* Also, there were comments about simply making a 3D printed object: *"Create and print something on the 3D printer and keep it, if I can.", "I want something more specific with 3D printing eg key ring printing".* Finally, quite a few students mentioned that they were content with the kind of objects that they created during the pilot sessions, "I am fully satisfied", "I think that I am totally covered".

1.3.2. GREEK FORMAL PILOT SITE

At formal pilots that took place at the 1st EPAL of Korydallos during the 1st pilot round, 30 students participated - 2 female and 28 male. During the 2nd pilot round 15 students participated - 2 female and 13 male. The analysis of diaries from formal pilots is two-folded - quantitative and qualitative. In student diaries there was only one quantitative question regarding "The collaboration among the team members was today". The responses to this question from diaries at the formal pilot site of 1st EPAL of Korydallos during the 1st round are summarized in the table below. It is worth noting that during all 1st round sessions, the majority of answers were "good" (36.21%) and "very good" (33.63%), although there was also a significant percentage of "No Answer" (14.66%) (table 32).

Table 32. collaboration among the team members

Korydallos (Formal) 1st round		
The collaboration among the team members was today	Sum	Percentage
No Answer	17	14,66%
Very Poor	5	4,31%
Poor	3	2,59%
Fair	10	8,62%
Good	42	36,21%
Very Good	39	33,62%
Total Sum	116	

The following table 33 summarizes the responses regarding collaboration within the team. Teams 1, 2, 5, 6, 10 responded with "very poor", "poor" and "fair", with Team 5 in particular providing 7 answers of "poor" and "fair" (39%). No negative comments were discovered in the qualitative analysis of the answers.

Table 33. collaboration among the team members

Korydallos (Formal) 1st round							
The collaboration among the team members was today							
Group	No Answer	Very Poor	Poor	Fair	Good	Very Good	Sum Per Group
Group 1	4	1	0	2	5	2	14
Group 2	6	1	0	1	1	6	15
Group 3	3	0	0	0	8	2	13
Group 4	1	0	0	1	3	6	11
Group 5	2	0	1	6	7	2	18
Group 6	0	1	2	0	10	6	19
Group 7	0	0	0	0	1	5	6
Group 8	0	0	0	0	2	5	7
Group 9	0	0	0	0	2	5	7
Group 10	1	2	0	0	3	0	6
Sum Per Collaboration Level	17	5	3	10	42	39	116

The responses to the questions in the diaries at the formal pilot site of the 1st EPAL of Korydallos during the 2nd round are summarized in the table below. For all 2nd round sessions, the majority of

answers were “good” (41.67%) and “very good” (20.83%), but with there was a significant percentage of “No Answer” (16.67%). There were no responses of “very poor” or “poor” (table 34).

Table 34. collaboration among the team members - formal 2nd round

Korydallos (Formal) 2nd round		
The collaboration among the team members was today	Sum	Percentage
No Answer	4	16,67%
Very Poor	0	0.00%
Poor	0	0.00%
fair	5	20,83%
good	10	41,67%
very good	5	20,83%
Total Sum	24	

The following table summarizes the answers related to collaboration within the teams. Teams 4 and 5 responded with “fair”. No negative comments were discovered in the qualitative analysis of the answers - in fact, only positive comments were made about the sessions (table 35).

Table 35. collaboration among the team members per team

Korydallos (Formal) 2nd round							
	The collaboration among the team members was today...						
Group	No Answer	Very Poor	Poor	Fair	Good	Very Good	Sum Per Group
Group 1	1	0	0	0	5	0	6
Group 2	0	0	0	0	1	2	3
Group 3	1	0	0	0	1	2	4
Group 4	1	0	0	3	1	0	5
Group 5	1	0	0	2	2	1	6
Sum Per Collaboration Level	4	0	0	5	10	5	24

The second part of the analysis relates to the open questions in student diaries. The open questions are:

1. What did you like the most today?
2. What did you like the least today?
3. Do you think that you learnt something new? If yes, could you please refer to what you learnt?
4. Do you have a project idea that you would like to have implemented by the end of the pilots?

The replies to the question “What did you like the most today” revealed a variety of points. Apart from the most common answer of “All” and “everything”, mention was made of electronics that students worked with: “controlling the leds from the program”, “How to put LEDs” and particularly about Arduino: “I liked the idea with the arduino”. There were several comments about various constructions, including: “Building lighthouses“, “I like the rc car”, “I liked a lot the construction”, “I liked that we made the bridge”, “I liked the fact that we made something related to Christmas”. Students also enjoyed the coding: “That we used programming to control the leds”, and they were proud of their achievements: “The functional final outcome”, “the hands on constructions!”, “...Also I liked how in the end we brought all the parts together.”, “We put the solar panel into operation with the photoresist”. Finally, they positively commented on the distinct lesson format: “The freedom that we had in making our designs and constructions”.

As for the second open question “What did you like the least today?”, apart from the very common response of “I like Everything” or similar, there were other answers about electronics, such as: “few hour lessons about arduino”. Some students commented on the availability of materials and time: “Not enough material for the construction”, “That it was only three hours; I would have wanted more.”. A very important issue that was referred to is collaboration within the teams. There were some negative remarks: “The bad collaboration with my classmates”, “the communication among students”. Students also mentioned the serious problem of limited time: “The fact that we only had 2 hours available for the workshop”, which is of particular concern in any formal classroom setting.

To the third question, “Do you think that you learnt something new? If yes, could you please refer to what you learnt?”, the majority of students answered that they had not learnt anything. Some mentioned electronics: “About photoresistors”, “How to put LEDs”, “I learned how to connect many parts with arduino like Leds, buttons and monitors”, “I learned how to melt zink and combine a led to a cable.”, “The servomotor” and also programming: “I learned programming at Snap4Arduino” and “I learnt to control the blinking rate/rhythm in the led”. A few students wrote that they had learnt general skills: “How to combine my designs better.”, “I improved my skills” and “I just improved my capabilities”.

Regarding the fourth open question of “Do you have a project idea that you would like to have implemented by the end of the pilots?”, most of the answers were “No” or “I don't know”, except for one: “We could automate the lights of one classroom to light when motion is detected.”, which is actually a very good idea for a project.

1.4. GREEK STUDENTS’ QUESTIONNAIRE

1.4.1. GREEK STUDENTS’ INFORMAL SITE QUESTIONNAIRES

A total of 41 questionnaires were completed by students from the informal pilot site at Technopolis during the 1st and 2nd pilot rounds. The following tables provide information about the quantitative part of the questionnaire, showing how many students chose each answer. For each question, the results of which are in different tables, a brief comment can be found above each table.

Table 36. Number of questionnaires per round -How did you like the workshop

Pilot round	**Final Questionnaires per round**
1st	23
2nd	18
Total Sum	41

In the question "*How did you like the workshop?*" it is worth noticeable that we have only answers of "*I like it*" and "*I like it a lot*" and three students that did not answer.

Table 37. How did you like the workshop

How did you like the workshop?						
Pilot round	No Answer	Not at all	Not a lot	I liked it	I liked it a lot	Total Sum
1st	3	0	0	4	16	23
2nd	0	0	0	3	15	18
Total Sum	3	0	0	7	31	41

To the question "During the workshop I was able to be innovative" the majority of the students answered "Yes", with three students answering "A bit". (table 38)

Table 38. During the workshop I was able to be innovative

During the workshop I was able to be innovative					
Pilot round	No answer	Not at all	A bit	Yes	Total Sum
1st	0	0	1	22	23
2nd	0	0	2	16	18
Total Sum	0	0	3	38	41

To the question "During the workshop I was able to be creative", the only answers were "A bit" and "Yes".

Table 39. During the workshop I was able to be creative

During the workshop I was able to be creative					
Pilot round	No answer	Not at all	A bit	Yes	Total Sum
1st	0	0	2	21	23
2nd	0	0	5	13	18
Total Sum	0	0	7	34	41

To the question "During the workshop I was able to do the things the way I preferred", the only answers were "A bit" and "Yes".

Table 40. I was able to do the things the way I preferred

During the workshop I was able to do the things the way I preferred					
Pilot round	No answer	Not at al	A bit	Yes	Total Sum
1st	0	0	8	15	23
2nd	0	0	6	12	18
Total Sum	0	0	14	27	41

To the question “During the workshop I was able to test and try out”, the only answers were “A bit” and “Yes” (table 41).

Table 41. During the workshop I was able to test and try out

During the workshop I was able to test and try out					
Pilot round	No answer	Not at all	A bit	Yes	Total Sum
1st	0	0	2	21	23
2nd	0	0	2	16	18
Total Sum	0	0	4	37	41

To the question “During the workshop I was able to plan and coordinate with others”, the only answers were “A bit” and “Yes” (table 42).

Table 42. I was able to plan and coordinate with others

During the workshop I was able to plan and coordinate with others					
Pilot round	No answer	Not at all	A bit	Yes	Total Sum
1st	0	0	0	23	23
2nd	0	0	1	17	18
Total Sum	0	0	1	40	41

To the question “During the workshop I was able to share with others”, the only answers were “A bit” and “Yes” (table 43).

Table 43. I was able to share with others

During the workshop I was able to share with others					
Pilot round	No answer	Not at all	A bit	Yes	Total Sum
1st	0	0	3	20	23
2nd	0	0	2	16	18
Total Sum	0	0	5	36	41

To the question “I feel more comfortable than before to program”, there was one response of “not at all”, but the majority of answers were “A bit” and “Yes”. This may be due to some students already having had significant programming experience (Table 44).

Table 44. I feel more comfortable than before to program

I feel more comfortable than before to program					
Pilot round	No answer	Not at all	A bit	Yes	Total Sum
1st	0	0	7	16	23
2nd	0	1	3	14	18
Total Sum	0	1	10	30	41

To the question "I feel more comfortable than before to make and craft things", the only answers were "A bit" and "Yes" (table 45).

Table 45. I feel more comfortable than before to make and craft things

I feel more comfortable than before to make and craft things					
Pilot round	No answer	Not at all	A bit	Yes	Total Sum
1st	0	0	6	17	23
2nd	0	0	5	13	18
Total Sum	0	0	11	30	41

To the question "I feel more comfortable than before to work with electronics", there was one response of "not at all", but the majority of answers were "A bit" and "Yes". This may be due to some students already having had significant experience working with electronics (table 46).

Table 46. I feel more comfortable than before to work with electronics

I feel more comfortable than before to work with electronics					
Pilot round	No answer	Not at all	A bit	Yes	Total Sum
1st	0	0	4	19	23
2nd	0	1	2	15	18
Total Sum	0	1	6	34	41

To the question "I feel more comfortable than before to tackle problems" ", there was one response of "not at all", but the majority of answers were "A bit" and "Yes". This may be due to some students already having had significant experience working on STEAM projects. (table 47).

Table 47. feeling more comfortable to tackle problems

I feel more comfortable than before to tackle problems					
Pilot round	No answer	Not at all	A bit	Yes	Total Sum
1st	0	0	3	20	23
2nd	0	1	3	14	18
Total Sum	0	1	6	34	41

To the question “I feel more comfortable than before to find solutions for issues that we faced”, there were two responses of “not at all”, but the majority of answers were “A bit” and “Yes”. This may be due to some students already having had significant experience working on STEAM projects (table 48).

Table 48. more comfortable - solutions

I feel more comfortable than before to find solutions for issues that we faced					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	0	0	6	17	23
2nd	1	2	1	14	18
Total Sum	1	2	7	31	41

During further investigation of the five answers of “not at all”, it was found that in all five cases the responses were made in the 2nd round. Only two of these were in response to the same question: “I feel more comfortable than before to find solutions for issues that we faced”, meaning they were made by two different students. Two other students answered “not at all” to two different questions; one student to the questions: “I feel more comfortable than before to program” and “I feel more comfortable than before to work with electronics” and the other student to: “I feel more comfortable than before to tackle problems” and “I feel more comfortable than before to find solutions for issues that we faced”.

The second part of our analysis concerns the open questions. The most noteworthy aspects of this part are detailed in the following paragraphs. Regarding the question "Any other thing that you feel more comfortable to do than before? If so, which:", it was found that students felt comfortable with finding ideas in both sessions, mentioning: “Finding more ideas” (1st session) and “Find new ideas for the project” (2nd session). A very important issue is that students referred to feeling comfortable with aspects not related to technology, such as social interaction. In particular, they mentioned that they felt comfortable “Being an active member of a team” (1st session), “to meet my team” and “Never give up”. There are also references to “the robot”, “Nothing”, “To use 3D printing”.

The second open question “During the workshop I liked most:” drew the most responses from students; in fact, every student answered and there are very interesting findings among them. It seems that students particularly liked robotics, since five referred to robot construction and some to the whole construction “Robotic with sensor and 3D printer” and “The construction of robots and other artifacts and adding light bulbs, motion sensors etc, to the construction the last one with robot and 3D printing”. A significant number of answers referred to programming and programming capabilities. The answers came from the 1st and 2nd pilots and one in particular mentioned AppInventor: “Programming with AppInventor”. There were some positive comments about Arduino: “More I liked the use of the Arduino microprocessor...”., and also positive comments about 3D printing, both separately: “3D printing”, “The 3D pen” and combined with another aspect: “Programming and 3D printing”.

We should mention that during the 1st pilot session one student said that “I liked the fact that the realization of each project was done with simple daily materials and the pleasant atmosphere that prevailed as we were all guided, helped and inspired by the other teams….”, another one that “Firstly, I really enjoyed working with the team and the trainers….”, and a third that “I liked that we slowly became somehow bonded as a team and that we could all deal with the difficulties we eventually had to face…”. These comments reveal the artistic side of the sessions as well as the social aspect of the

project.

On the other hand, the purpose of the question “During the workshop I liked least:” was to identify issues that the majority of students may not have liked, and in one way or another, they mostly said “Nothing” (33 out of 41). However, a few problems arose due to technical issues such as “The PC was rather slow” (two of these), “Sometimes electronics would crash and I was tired of making a reset.”, “At some of our meetings I did not like the fact that we had problems with the microphone or that the Raspberry crashed" and “Sometimes we encountered difficulties that made us nervous, like the slow internet connection”. Another set of answers had to do with projects like the flower, which was not popular, and the demanding nature of projects that one student mentioned: “Constructions because they were demanding” and “I did not like the fact that the attempt for the artificial intelligence project was not completed”. A final issue worth mentioning, since we had come across this before, was one student’s desire to use AppInventor: "I did not like the fact that we made specific software packages and I think we should have had several programs like MIT Inventor”.

1.4.2. GREEK FORMAL PILOT SITE QUESTIONNAIRES

In total, 37 questionnaires were completed by students from the formal pilot site at the 1st EPAL of Korydallos during the 1st and 2nd pilot rounds. The following tables provide information about the quantitative part of the questionnaire, showing how many students chose each answer. For each question, the results of which are in different tables, a brief comment can be found above each table.

Table 49. Pilots /questionnaires

Pilot round	**Final Questionnaires per round**
1st	31
2nd	6
Total Sum	37

To the question “How did you like the workshop?”, answers were mainly “I like it” and “I like it a lot”, apart from one student that answered “Not a lot” and another one that did not answer at all. This student did not make any negative comments in response to the open question, apart from not liking the lighthouse construction, which may be reasonable. Additionally, to the question “During the workshop I was able to test and try out”, this student answered “not at all”. Often, especially in a workshop setting such as this, not being able to try out and test leads to disappointment and discourages students (table 50).

Table 50. like the workshop

How did you like the workshop?						
Pilot round	No Answer	Not at all	Not a lot	I liked it	I liked it a lot	Total Sum
1st	0	0	1	16	14	31
2nd	1	0	0	2	3	6
Total Sum	1	0	1	18	17	37

To the question "During the workshop I was able to be innovative" (table 51), the only responses were "a bit" and "Yes", though 3 students that did not answer at all. There is no obvious explanation for this, but two possible assumptions are that they did not remember at all or did not understand the meaning of innovation, with the second being much more important and needing further investigation.

Table 51. able to be innovative

During the workshop I was able to be innovative					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	1	0	7	23	31
2nd	2	0	0	4	6
Total Sum	3	0	7	27	37

To the question "During the workshop I was able to be creative", the only answers were "a bit" and "Yes", though one student failed to answer (table 52).

Table 52. being creative

During the workshop I was able to be creative					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	1	0	8	22	31
2nd	0	0	1	5	6
Total Sum	1	0	9	27	37

To the question "During the workshop I was able to do the things the way I preferred", the answers were mainly "a bit" and "Yes", with 3 students not answering and one student answering "Not at all" in the first round. For this particular student we noticed that there were no negative answer to the open questions; on the contrary, they responded with positive answers to all other questions and expressed the desire to do more, possibly to do more things that they simply did not have the time to do the way he/she preferred (table 53).

Table 53 - preferences

During the workshop I was able to do the things the way I preferred					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	2	1	12	16	31
2nd	1	0	0	5	6
Total Sum	3	1	12	21	37

To the question “During the workshop I was able to test and try out”, responses were mostly “A bit” and “Yes”, with one student not answering one student answering “Not at all”. This is the same student that answered “Not at all” to the question “How did you like the workshop?”. As mentioned above, this particular student did not respond negatively to the open questions, apart from not liking the lighthouse construction, which seem reasonable. Often, especially in a workshop setting such as this, not being able to try out and test leads to disappointment and discourages students (table 54).

Table 54. testing and trying out

During the workshop I was able to test and try out					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	0	1	9	21	31
2nd	1	0	0	5	6
Total Sum	1	1	9	26	37

To the question “During the workshop I was able to plan and coordinate with others”, the majority of answers were “A bit” and “Yes”, though one student did not answer and two students answered “Not at all”. For these students we noticed no negative responses to the open questions, apart from one student explained that they did not like the way the team was formed. This is closely related to the question of planning and collaboration and explains the answer of “Not at all” (table 55).

Table 55. planning

During the workshop I was able to plan and coordinate with others					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	1	2	9	19	31
2nd	1	0	0	5	6
Total Sum	2	2	9	24	37

To the question “During the workshop I was able to share with others”, the answers were mainly “A bit” and “Yes”, though two students did not answer and two students answered “Not at all”. In the open question, there was one mention of poor team work, possibly indicating a somewhat problematic sharing stage in the first round (table 56).

Table 56. sharing

During the workshop I was able to share with others					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	1	2	9	19	31
2nd	1	0	0	5	6
Total Sum	2	2	9	24	37

To the question “I feel more comfortable than before to program”, the answers were mainly “A bit” and “Yes”, though one student did not answer and two students answered “Not at all”. This may be due to some students already having had significant programming experience (table 57).

Table 57. comfortable than before

I feel more comfortable than before to program					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	1	1	8	21	31
2nd	1	0	0	5	6
Total Sum	2	1	8	26	37

To the question “I feel more comfortable than before to make and craft things”, the answers were mainly “A bit” and “Yes”, though four students did not answer and three students answered “Not at all”. These three students only made positive responses to the other open questions. An explanation might be that crafting was simply not their thing (table 58).

Table 58. - crafting

I feel more comfortable than before to make and craft things					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	3	3	8	17	31
2nd	1	0	0	5	6
Total Sum	4	3	8	22	37

To the question “I feel more comfortable than before to work with electronics”, the answers were mainly “A bit” and “Yes”, though three students did not answer and one student answered “Not at all”. This may be due to some students already having had significant experience working with electronics (Table 59).

Table 59. working with electronics

I feel more comfortable than before to work with electronics					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	3	0	9	19	31
2nd	0	1	0	5	6
Total Sum	3	1	9	24	37

To the question “I feel more comfortable than before to tackle problems”, the answers were mainly “A bit” and “Yes”, though one student did not answer and three student answered “Not at all”. This may be due to some students already having had significant experience working with electronics or with working on STEAM projects (table 60).

Table 60. tackling problems

I feel more comfortable than before to tackle problems					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	1	3	12	15	31
2nd	1	0	0	5	6
Total Sum	2	3	12	20	37

To the question "I feel more comfortable than before to find solutions for issues that we faced", most answers were "A bit" and "Yes", though one student did not answer (table 61).

Table 61. solutions for issues

I feel more comfortable than before to find solutions for issues that we faced					
Pilot round	No Answer	Not at all	A bit	Yes	Total Sum
1st	1	0	12	18	31
2nd	1	0	0	5	6
Total Sum	2	0	12	23	37

The second part of our analysis concerns the open questions. The most noteworthy results of our analysis is detailed in the following paragraphs. Regarding the question "Any other thing that you feel more comfortable to do than before?", students mentioned "To program", "I can handle Arduino Ide and Ardublock now" and "to present publicly". This indicates a wide range of impacts of the pilots on the students regarding knowledge, confidence and capabilities.

Regarding the second question "During the workshop I liked most:", apart from the main answer of "Everything" provided by 5 students, other mentioned "the creativity" (two of them), "The concept", "That we i got to use some of my knowledge on robots and electronics" and programming. On the other hand, the question "During the workshop I liked least:", some students responded with "Nothing", while others were more specific about particular projects, for instance "The lighthouse creation". Some mentioned the end of the program: "that the project was over" and "I don't like the fact that now the project is over.". Others mentioned the team formation: "The way the teams were formed" and collaboration: "I didn't like at all the cooperation with some persons" which had been mentioned in relation to other closed answers also. One student mentioned the fatigue of such a time consuming session.

1.5. Greek Pilot Sites Observation Sheets

1.5.1. Greek Informal Pilot Site

The aim of the observation tool was to evaluate how the teams managed in each of the five stages of the eCraft2Learn educational model as well as the final accomplishment of each project. The observer had to respond to related open and closed questions (categorical), together with any additional comments. There was one closed question per each stage and each followed the format of the first one: "Ideation, Did the students go through this stage today? Please use the text box to add any interesting comments/quotes:"

The table 62 below contains the number of answers of “Yes”, “Yes, but to a limited extent”, “No” to each of the questions about Ideation, Planning, Creation, Program, Share, Project/Artefact construction for Technopolis (informal pilot site). The analysis of the observation sheets revealed various interesting findings. From the 1st round, there are observations for 8 sessions with around 8 teams per session and from the 2nd round there are observations for 4 sessions with around 6 teams per session. This explains the smaller number of responses in the second round. In general, it was found that in each session, more than half the teams did Ideation (only 18.57% “No” responses), Planning (only 16.67% “No” responses), Creation (81.08% “Yes” responses), and Program (80.56% “Yes” responses). The most significant result of the analysis concerns Sharing. It was determined that 53.97% did this stage, 19.05% did it to some extent and a worrying 26.98% did not share at all. Finally, regarding the last question about “Project/Artefact construction”, in all sessions the majority accomplished this goal fully (57.33%) or to a limited extent (34.67%). The 6 answers of not accomplished (8.00%) in only the second session does not reflect reality and there is an explanation. These six responses were from the very first two sessions of the second round, which was an open project for students where it was reasonable to complete Ideation and possibly Planning, but impossible to accomplish Construction.

Table 62. informal pilot site observation sheets

Greek Informal pilot site (Technopolis)	**1st round**	**2nd round**	**Total**	**Percentage of SubTotal**
IDEATION				
Yes	31	7	38	54,29%
Yes, but to a limited extent	14	5	19	27,14%
No	10	3	13	18,57%
SubTotal	55	15	70	
PLANNING				
Yes	28	7	35	48,61%
Yes, but to a limited extent	19	6	25	34,72%
No	8	4	12	16,67%
SubTotal	45	17	72	
CREATION				
Yes	49	11	60	81,08%
Yes, but to a limited extent	2	5	7	9,46%
No	4	3	7	9,46%
SubTotal	55	19	74	
PROGRAM				
Yes	50	8	58	80,56%
Yes, but to a limited extent	2	3	5	6,94%
No	0	9	9	12,50%

SubTotal	52	20	72	
SHARE				
Yes	31	3	34	53,97%
Yes, but to a limited extent	10	2	12	19,05%
No	5	12	17	26,98%
SubTotal	46	17	63	
Project/Artefact construction				
Yes	42	1	43	57,33%
Yes, but to a limited extent	13	13	26	34,67%
No	0	6	6	8,00%
SubTotal	55	20	75	

The open comments proved to be of great interest and are outlined in the following paragraphs.

In relation to question of "Educational resources used by the teachers/coaches (i.e. videos, web-links, print-outs, etc.…):", observers noted the following: YouTube videos, online images, online information, paper-based sketches, worksheets, printouts, paper, pairs of scissors, glue, silicon, LEDs, resistors, Arduino, Raspberry Pi, servo motors, sound sensors, Arduino, raspberry, motion sensors, handcraft, Arduino, raspberry, working sheet, speakers, led, wires, pictures of L293 chip, video Sparkfun with motors, distance Sensor, Snap4Arduino, Ardublock, Tinkercad, Cura, Snap4A web version, AI blocks, microphone, videos, web search, UUI.

As for as the overall workshop impressions, we observed a positive working atmosphere. The teams were working on their projects without any problems. The teachers considered the stage of sharing very important and they tried hard to allow time for this. The students were also enjoying this stage and spent the necessary time on deciding together how to present their work and talk about their construction. We also observed that that for every piece of equipment provided during the session, the teams assumed it was for immediate use but when they had problems with tools students invented new tools. In addition, cross-team collaboration took place among the teachers of different teams as well as among students of different teams, with no intervention from the research team in this regard.

Regarding needs emerged (if any), the students and the teachers were taking pictures of their artefact constructions. They kept asking how they could share these videos and photos. "Where can we upload them?" "How can we share our work and the progress that was made?". It was mentioned that Snap4Arduino and Arduino IDE were very slow, as well as that microphones did not work. The teachers and students had ideas for new materials for crafting (i.e. playdough). It was difficult to observe what exactly was going on in each team as each team progressed at a different rate.

1.5.2. GREEK FORMAL PILOT SITE

Regarding the formal pilot site, the table 63 below contains the number of "Yes", "Yes, but to a limited extent" and "No" responses to each of the questions concerning Ideation, Planning, Creation, Program, Share and Project/Artefact construction for the sessions helped at the 1st EPAL of

Korydallos. The analysis of the observation sheets revealed various interesting findings. From the 1st round, there are observations for 8 sessions with 10 teams per session (two classes - electricians and informatics) and from the 2nd round there are observations for 2 sessions with around 5 teams per session (one class of informatics). It was unexpectedly difficult to manually collect observation forms and other evaluation tools during the sessions at the formal site in Greece, since available teachers are limited in number. This lead to the need for an automated data collection system for evaluation. In general, in each session the majority of teams did Ideation (91.67%), Planning (88.14%), some form of Creation (45% "Yes" and 53.33% "Yes but to a limited extent" responses), and some form of Program (46.67% "Yes" and 30% "Yes but to a limited extent" responses). The most significant result of the analysis concerns Sharing. It was determined that only 5.56% did this stage, 11.11% did it to some extent and a very worrying 88.33% did not share at all. This needs further investigation of the open comments by observers. The most likely explanation is that the school class duration is less than the informal sessions (45 minutes), and school classes need more time to adapt and get into the mood of the lesson, meaning it was much more difficult to reach the last stage of eCraft2Learn methodology.

Finally, regarding the last question about "Project/Artefact construction", in all sessions the majority accomplished this goal fully (57.33%) or to a limited extent (34.67%). The 6 answers of not accomplished (5.00%) in only the second session does not reflect reality and there is an explanation. These six responses were from the very first two sessions of the second round, which was an open project for students where it was reasonable to complete Ideation and Planning, and possibly some Creation and Programming, but impossible to accomplish Construction.

Table 63. overview formal pilots

Greek Formal pilot site (1st EPAL of Korydallos)	**1st round**	**2nd round**	**Total**	**Percentage of SubTotal**
IDEATION				
Yes	48	7	55	91,67%
Yes, but to a limited extent	4	1	5	8,33%
No	0	0	0	0,00%
SubTotal	52	8	60	
PLANNING				
Yes	46	6	52	88,14%
Yes, but to a limited extent	5	2	7	11,86%
No	0	0	0	0,00%
SubTotal	51	8	59	
CREATION				
Yes	23	4	27	45,00%
Yes, but to a limited extent	28	4	32	53,33%
No	1	0	1	1,67%
SubTotal	52	8	60	
PROGRAM				
Yes	23	5	28	46,67%

Yes, but to a limited extent	15	3	18	30,00%
No	14	0	14	23,33%
SubTotal	52	8	60	
SHARE				
Yes	3	0	3	5,56%
Yes, but to a limited extent	4	2	6	11,11%
No	43	2	45	83,33%
SubTotal	50	4	54	
Project/Artefact construction				
Yes	9	2	11	18,33%
Yes, but to a limited extent	46	0	46	76,67%
No	3	0	3	5,00%
SubTotal	58	2	60	

The observation forms in relation to the question of "Educational resources used by the teachers/coaches (i.e. videos, web-links, print-outs, etc….)" the observers noted mainly web links and whiteboard.

Regarding the overall workshop impressions, observer comments convey "*Very positive impressions*". students were very creative working in a real Making environment. The pleasant environment included instances such as when students listened to music while working productively. Some students asked to extend the workshop or even to skip the Math class in order to continue working on the project. The teachers were surprised to see how much the students were into crafting. Furthermore, there were role allocation and intense trial and error practices. Some students were more into programming than others, while other preferred soldering, wiring and crafting. It was observed that some students got very excited when they received compliments for their work. This seemed to be a strong motivation for them to continue and to communicate their ideas to other teams. The teaching method helped to reduce the noise in the classroom.

In general, students seemed to have been enjoying the hands-on constructions and the fact that teachers were not acting as traditional teachers: the students were many and thus teachers took on a supportive role; they were looking for solutions together with the students, for resources online (e.g. wiring diagrams) and they were also explaining to the students that they do not have ready-made solutions, but that they could explore any emerging problems together. The resources/guidelines provided during training were considered very useful, as they could be adapted to different variations of problems. It seems that the completion of diaries was problematic due to lack of time. Time appears to be a critical factor, as referred to in diaries. It was encouraging that the atmosphere was good, pleasurable and creative, as the project got progressively more complex, with the team observation becoming more difficult. The students require more workshops like these and seem to have new ideas for projects (e.g. a robot that recognizes colours, rooms that lock and unlock, and many more). Some students have some ideas for more optimal solutions (referring to the car project). In terms of the

preparatory session for 3D printing, we are satisfied with the students' engagement even though they initially had some problems in 3D printing.

As far as any needs are concerned (if any), at times more materials, particularly electronic components, were required for the construction stage. Some problems arose with a microphone sensor as well as some Raspberry Pi crashes.

1.6. General discussion and Conclusions - Comparing both Greek Settings

Some differences, observed in the response to closed questions in the observation forms between the formal and informal pilot site, are worth mentioning. The **formal site appears to be more concentrated on Ideation and Planning** compared to the informal site. At the formal site, there were 91.67% “Yes” responses to Ideation, compared to the lower, but still over half, 54.29% “Yes” responses at the informal site. For Planning, there were 88.14% “Yes” responses at the formal site compared to the lower 48.61% at the informal site. In contrast, the proportions of “Yes” responses for Creation, Program and Share are at the informal site. More specifically, for Creation there were 81.08% “Yes” responses at the informal site in comparison to the 45% responses at the formal site; 80.56% “Yes” at the informal site in comparison to the 46.67% responses at the formal site for Planning; 53.97% "Yes" responses at the informal site in comparison to the 5.56% responses at the formal site for Share. Thus there are **significant differences of creation, planning and sharing in formal and informal Greek** sites. Moreover, teams at the **informal site had a higher project construction success rate (57.33% vs 18.33%)**, although almost the same percentage of teams at both sites did not reach the project construction stage (8% vs 5%). The former is due to the limited time of each session at the formal pilot site and the latter is due to the fact that, at the formal pilot site, the students have the time to work as a team after school, since they belong to the same community. The above mentioned differences between the formal and informal sites in a way reflects the differences between the two eCraft2Learn methodology environments.

2 FINNISH PILOT SITES ANALYSIS

The qualitative data analysis from the pilots in Finland follows the structure below (Figure 3).

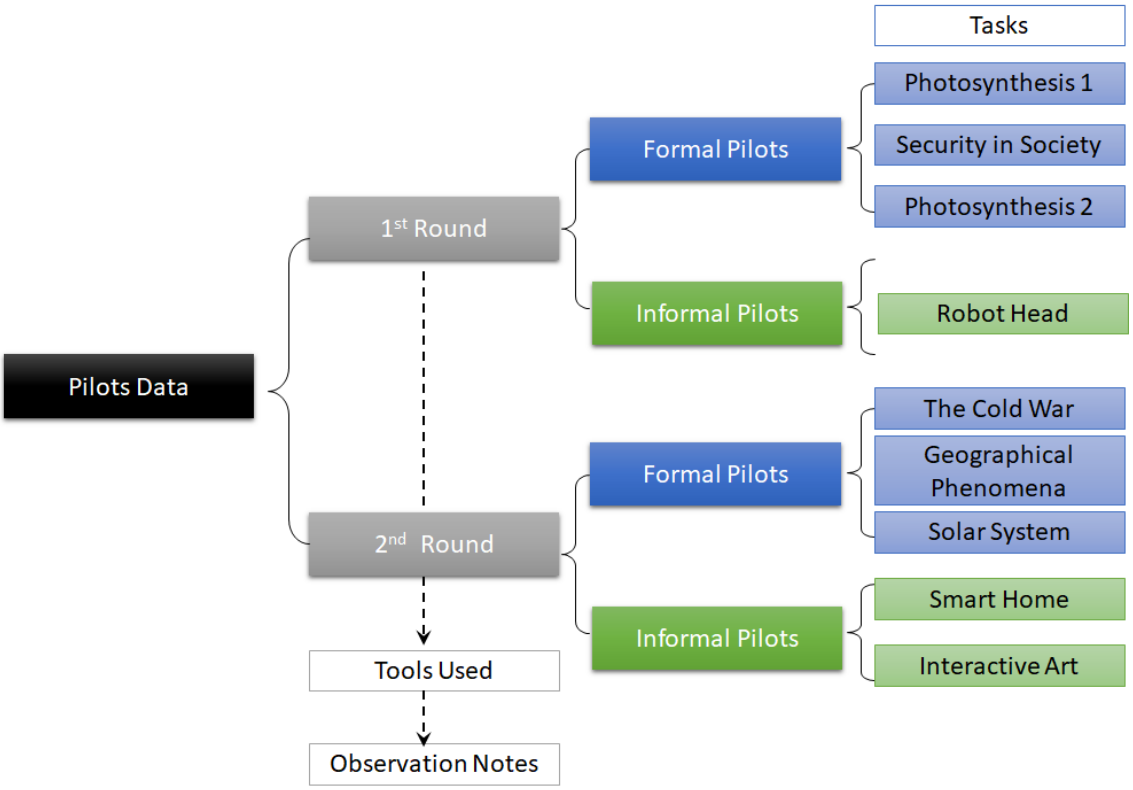

Figure 3. Finnish pilots qualitative data analysis structure

Each task developed within the formal (6 tasks) and informal (3 tasks) contexts and rounds of the pilots have been qualitatively analyzed, separately, to present the **teachers' perspectives as well as students' perspectives, according to teacher's and student's diaries** respectively, whenever possible. The open questions responses from the final student questionnaire are presented at the end of each formal and informal setting. The tools used in each context (formal and informal) as well as the researchers' observation notes are also presented.

2.1. FIRST ROUND OF PILOTS - FINLAND

2.1.1. FORMAL SETTINGS

In order to contextualize the work, the following section describes the learning environment of the workshops in Finland. However, a detailed description of all pilots and projects are captured in D5.5.

A. PHOTOSYNTHESIS TASK (SCHOOL 1)

1 class of 16 students, 2 teachers. Total number of work sessions - 3 (7 school hours of 45 mins each)

Brief description of the subject from the curriculum

In the Finnish curriculum photosynthesis is under the biology subject matter as students are guided to understand the basic structure and physiology of plants and organisms. This builds on to

understanding of different ecosystems and further the students' environmental awareness and biodiversity appreciation. (The Finnish National Board of Education 2016.[1]) Instruction aims at developing students' knowledge of nature and guiding understanding of basic natural phenomena, including the following 4 themes: nature and ecosystems; life and evolution; the human being; and the common environment. Within these themes the students get familiar, among other topics, with the ecosystem, its structure and operation, the structure and activity of the cell, the structure and major vital functions of the human body and with ecologically sustainable development and objectives of environmental protection, respectively. (Mullis et al. 2016). During the pilots, the photosynthesis topic from the nature and ecosystem theme was chosen by the teachers to be developed through the eCraft2Learn learning ecosystem. The photosynthesis task helped students to understand what are the main factors needed for photosynthesis and how this phenomenon supports life and the functioning of ecosystems. According to the curriculum, biology teaching should foster students' 21st century skills by utilizing different technologies, collaborative work and problem solving activities, and the eCraft2Learn method covers all these aspects in great extent.

Teachers' perspective - Teachers' diaries

In here we present a summary of the teachers diaries starting from their reported observations on the pedagogical processes of the eCraft2Learn pedagogical core including team collaboration, and level of engagement of the students on the learning activities. The teachers also reported their perceived level on their role as coach in their classroom. A biology teacher and a math teacher carried out the task together.

Table 64. Pedagogical processes - reported occurrences of ideation, planning, creation, programming and sharing activities for each group. The 'Limited' column indicates that the activity was observed only to a limited extend

Students Group	Ideation		planning		creation		programming		sharing	
	Yes	Limited	Yes	Limited	yes	limited	yes	limited	yes	limited
Group 1	2		2		3		2	1	1	1
Group 2	1		1		3		1			
Group 3	1		1		3		2	1	1	
Group 4	1		1		3		3		1	
3 sessions total	5	0	5	0	12	0	8	2	3	1

How was the collaboration among the team members?

No collaboration	poor	fair	good	Very good
0	0	0	1	2

[1] https://www.ellibs.com/fi/book/9789521362590/national-core-curriculum-for-basic-education-2014

The following Table 65 indicates the extent that teachers perceived their students engaged in the learning experience

Table 65. Perceived engagement of students

To what extent are you satisfied with:	Not at all	Very little	Somewhat	To a great extend
a. level of students' engagement			2 (boys especially)	1 (girls especially)
b. progress made by teams			1	2
c. creativity demonstrated by the teams				2

Did you learn something new from your interaction with the students (today)?

To this question, one teacher answered in their diary: *"... actually they can't surprise us in the (everyday) classroom but many of the students surprised me in this project." (Teacher A)*

Teacher role as a coach

When asked: In the following scale (1 = traditional teacher | 5 = coach) where do you place your role in the workshop based on today's experience? These teachers saw themselves as closer to being a coach than to a traditional teacher in two out of three sections with their students. Furthermore, one teacher commented: *"It was a good way to exercise and go to the same level with the students." (Teacher A)*

Table 66. traditional vs coaching

	1=traditional	**2**	**3**	**4**	**5=coach**
session2				**x**	
session3				**x**	

Students' perspectives - Students' diaries

The analysis in Table 67 here summarizes the emergent themes found in the data and gives examples of the students' comments. In many cases several themes appeared together in the same comment (48 responses).

Table 68. students perspectives

Theme	**What did you like the most?**	
	No. Occurrences	Examples
Ideation, Planning & Collaboration	16	*"Today I liked the most planning the team work and we were happy with the result!"* *"That we tried"* *"[Student X] because she kept me company when we couldn't do anything"*
Programming, circuits	16	*"Working together, programming, planning"* *"Turning on the lights (LEDs)"* *"Editing/modifying"* *"Planning, turning on the lights (LEDs)"* *"When we got three LEDs to work at the same time."* *"When you got it how it works."*
Crafting & Making	14	*"Crafting is fun! Everything was fun. It was nice that we got our plan done."* *"Combining lights and crafts"* *"I liked the most making the flower and when everyone were molding the flower."*
3D printing	3	*"Making flower with 3D printer"* *"A model of a palm tree that we made for 3D printing with a computer"*
Plan completion	8	*"It was nice that we got the flower to work"* *"I liked the most today when we managed to finish our work and the result is excellent and unique in our opinion."*
Theme	**What did you like the least?**	
	No. Occurrences	Example
Work processes & difficulties	9	*"Not knowing how the work will proceed."* *"Choosing the electronics (what we need)"* *"If I didn't understand"* *"That I couldn't do anything"* *"Recording the video was the most challenging"* *"When I didn't know what to do. XD"* *"That everything went wrong."* *"When there were some small problems at times."*
Collaboration, programming	6	*"When my group didn't focus. Difficulties came when we tried to program the sensor."* *"Programming was difficult"* *"[Student x]"*
Listening	4	*"Listening (too long speech). Difficulties came when I*

		couldn't get lights turning on at the same time." *"When we had to listen so long the info about arduinos. I had difficulties in the beginning when we needed to start programming."* *"When doing nothing but listening"*
Time and space	3	*"That we only had 2 hours"* *"Lack of space"* *"I liked the least that we couldn't finish the project."*
Circuitry	2	*"Putting up the flower"* *"Pushing the wires into the tube"*

From here it is noticeable that the students enjoyed the collaborative aspects of the project which could perhaps helped them navigate the new work processes and difficulties that they encountered. Several students reported, nevertheless, that they liked everything about the project (e.g., "*I liked everything we did because this is interesting and I've learnt a lot of new things."; "There wasn't anything I wouldn't like").*

Collaboration

The students also reported their perceived collaboration among the team members as shown in Table 69.

Table 69. The collaboration among the team members was today

None	poor	fair	good	Very good
0	0	0	2	6

Future projects ideas

The students did not put forward any other project ideas of their own.

B. SECURITY IN SOCIETY TASK (SCHOOL 1)

2 classes, 20 students each, 1 teacher. 20 work sessions each class, 45 mins each session

Brief description of the subject from the curriculum

In Finland, social studies is described as the key subject for citizenship education. In 9th grade (junior high school) the focus on is on the institutions and functions of society. The key themes include individuals as members of a community, welfare, citizens' security, among others. (Niemi et al. 2016). As part of their social studies subject matter students were tasked to reflect on issues of security in society and institutions and how technology is applied. The pedagogical objectives were therefore interdisciplinary, fostering students' social awareness as well as their digital literacy.

Teachers' perspective - Teachers' diaries

Table 70 indicates the observations of the teacher related to the pedagogical core processes for each class and their groups. A social studies teacher carried out the task together. The collaboration of the

students from the teachers perspective as well as the perceived students' engagement in this task are also presented here

Table 70. Reported occurrences of ideation, planning, creation, programming and sharing activities for each class and group. The 'Limited' column indicates that the activity was observed only to a limited extend

Students Group (class1)	**Ideation**		**planning**		**creation**		**programming**		**sharing**	
	Yes	Limited	Yes	Limited	yes	limited	yes	limited	yes	limited
Group 1	4		4	1	6	2	7	1	10	2
Group 2	4		7	1	7	2	8	1	2	2
Group 3	4	1	4	2	3	7	3	2	1	3
20 sessions	12	1	15	4	16	11	18	4	13	7
Students Groups (class2)	**ideation**		**planning**		**creation**		**programming**		**sharing**	
	Yes	Limited	Yes	Limited	yes	limited	yes	limited	yes	limited
Group1	1		6		8		5		1	2
Group2	2	1	3	1	8		4			1
Group3	3		4		8		4	1	1	1
Group4 *(fused with Group2 after session 15)*	1		3		6		1			
20 sessions	7	1	16	1	30		14	1	2	4

How was the collaboration among the team members?

No collaboration	poor	fair	good	Very good
				2

The following table indicates the extent that teachers perceived their students engaged in the learning experience.

Perceived engagement of students

To what extent are you satisfied with:	Not at all	Very little	somewhat	To a great extend
a. level of students' engagement				2

b. progress made by teams				2
c. creativity demonstrated by the teams				2

Did you learn something new from your interaction with the students (today)?

"I was surprised that two students were really against this project. They just could not understand any good sides, why we do this." (Session 1)

"I am getting more comfortable in instructing easy wiring and programming." (Session 2)

Teacher role as a coach

When asked: In the following scale (1 = traditional teacher | 5 = coach) **where do you place your role in the workshop based on today's experience?** The teacher saw himself as closer as a coach in the classroom. This was due to the fact that the teacher was familiar with the idea of being a coach previous using the eCraft2Learn learning ecosystem (as he pointed out during the interview). The use of technology alongside a craft- and project-based pedagogical approach was something new to this teacher, nevertheless.

	1=traditional	**2**	**3**	**4**	**5=coach**
session1					**x**
session2					**x**
session5					**x**

This teacher was familiar with the idea of a teacher as a coach before starting the eCraft2Learn projects. As he had acquired this role already previously, not much difference could be found from the way he instructs and guides students in his normal class and in the eCraft2Learn pilots. Consequently, he saw himself as a coach (value 5) throughout the project. In the open question "*Describe briefly your role today:*" he described that he was instructing, helping and guiding the students in their learning processes. He mentioned his active role in the ideation phase and engineering problems in particular. As the teacher was giving students a lot of responsibility in their work and letting them be the main actors in the classroom, he focused on encouraging students and giving them support on how to start solving problems. He described his activities in the classroom as follows:

"Mostly my task was to give support to students "wow, you did it!" And then encourage them to go to next level (a little bit more difficult connection)." During the fourth pilot session he mentioned that the basics of electronics and programming are relatively easy to acquire but the more complicated the ideas and plans get, the more difficult it really gets which refers to the needed knowledge level of the teacher in these technological areas so that the teacher can effectively guide students if needed.

Students' perspectives - Students' diaries

The analysis here summarizes the emergent themes found in the data and gives examples of the students' comments from both classes: class 1, 12 responses; class 2, 19 responses (Table 71).

Table 71. Student perspectives Security in Society Task

Themes (Class1)	**What did you like the most**	
	No. Occurrences	Examples
Ideation, Planning, Design	5	*"Planning the vault"* *"Designing the red diamond"* *"Created a blog - Planned what tools we need"*
Programming	2	*"When we got 2 LEDs to light up on our own"*
Making & Crafting	3	*"We could wire an LED light, and make with our own hands"*
Themes (Class1)	**What did you like the least?**	
	No Occurrences	Examples
Work processes & difficulties	6	*"In the beginning it was hard to understand what we should do"* *"We didn't get help so the work progressed little"* *"Wiring"*
Time	2	*"The amount of time was too little"* *"The lesson was short"*
Themes (Class2)	**What did you like the most?**	
	No Occurrences	Examples
Ideating, Planning & Designing	6	*"Planning/designing the room"* *"When we got a good idea"* *"Today I liked the most planning/designing my house."*
Collaboration	1	*"Our awesome team spirit."*
3D modelling	1	*"Trying Tinkercad. Getting the voice thing* (NOTE: piezoelectric sensor) *to work"*
Circuitry & Programming	5	*"I learnt that the rolling thing* (NOTE: a servo motor) *can turn 360 degrees and -360 degrees"* *"LED lights when they were shining"*
Making & Crafting	7	*"Crafting"* *"I liked that I could cut boxes."* *"Painting the floor"*
Themes (Class2)	**What did you like the least?**	

	No Occurrences	Examples
Work processes & difficulties	1	*"I didn't manage to do 'anything'"*
Collaboration & Teamwork	2	*"there was not anything for me to do, others were having fun :)"* *"Student x"*
Electronics, 3D modelling & 3D printing	3	*"3D printer info"* *"Choosing the electronics (what we need)"* *"Using Tinkercad application"*
Crafting difficulties	5	*"Getting the hot glue and hot glue dropping on my finger"* *"When the support broke apart"*

In these two classes the students ideation, planning and designing were the main activities that the students reported to enjoy. Making and crafting followed. There were however difficulties for students understanding what they needed to do. Crafting and making difficulties were also reported as with larger constructions more challenges would appear. Some of the students' groups needed to develop their collaboration skills, as students also reported poor teamwork during some sessions.

Collaboration

In general the students reported having *very good* collaboration among the team members

The collaboration among the team members was today

Class	None	poor	fair	good	Very good
Class 1		1		1	10
Class 2			1	3	12

A team in Class 1 was not so interested in carrying out a hands-on project through the eCraft2Learn learning ecosystem, which reflects on the poor collaboration reported. The team needed a lot of guidance from the teacher to help them advance.

Future projects ideas

One student from Class 1 was interested in building a *"safety system for a sports car"* whereas 2 students from Class 2 put forward as project ideas making a bank and a castle.

C. PHOTOSYNTHESIS TASK (SCHOOL 2)

1 class, 11 students, 2 teachers. The work was carried out in 14 work sessions of 45 mins each.

Teachers' perspective - Teachers' diaries

Table 72 indicates the observations of the teacher related to the pedagogical core processes for their class. A biology teacher and a physics teacher carried out the task together. The collaboration of the students from the teachers' perspective as well as the perceived students' engagement in this task are also presented here.

Table 72. Reported occurrences of ideation, planning, creation, programming and sharing activities for each class and group. The 'Limited' column indicates that the activity was observed only to a limited extend

Students Group (class1)	Ideation		planning		creation		programming		sharing	
	Yes	Limited	Yes	Limited	yes	limited	yes	limited	yes	limited
Group 1	2	1	3	2	8	3	9	1	1	
Group 2	1	2	2	2	9	1	6	2	1	
Group 3	1	1	2	1	9	1	5		1	1
Group 4	3		1	1	8		4		1	
14 sessions	7	4	8	6	34	5	24	3	4	1

How was the collaboration among the team members?

No collaboration	poor	fair	good	Very good
		1	1	2

The following Table 73 indicates the extent that teachers perceived their students engaged in the learning experience.

Table 73. Perceived engagement of students

To what extent are you satisfied with:	Not at all	Very little	somewhat	To a great extend
a. level of students' engagement				1
b. progress made by teams			1	1
c. creativity demonstrated by the teams				3

During the fourth pilot session the physics teacher raised a question on how could the girls be more engaged in the making as based on his observations it looked like boys were testing and trying out things without any doubts or fears but girls needed some encouragement as they were hesitating to try without knowing exactly how to proceed. He saw how girls also wanted to make creations visually beautiful and aesthetic and during the next lesson introduced a 3D pen for the students. One of the

teams with only girls as team members got interested in the 3D pen and used it willingly. Towards the end on the project both teachers noticed that also girls were also very engaged in the making and creation and could apply knowledge in great extent. This shows that in the end girls were as enthusiastic as boys in making with different materials and tools.

Teacher role as a coach

When asked: In the following scale (1 = traditional teacher | 5 = coach) **where do you place your role in the workshop based on today's experience?** The teacher saw himself as closer as a coach in the classroom.

	1=traditional	**2**	**3**	**4**	**5=coach**
session5					**x**

Students' perspectives - Students' diaries

We received 6 responses in the students' diaries. The students indicated the they enjoyed the most *planning and wiring*, circuitry ("*Assembling and disassembling the computer"*), making ("*Cutting pipettes"*) and programming ("*That the light was blinking"*). The students reported as well that they liked the least when having problems with making ("*Failing with super gluing"*), issues of collaboration among students or problems with circuitry ("*Wires when they were hard to connect"*).

Collaboration

The collaboration among the team members was today

None	poor	fair	good	Very good
	1		2	3

Future projects ideas

One group reported to be interested in building 'something that moves' as a future project idea.

FINAL STUDENTS' QUESTIONNAIRE - OPEN QUESTIONS

In the final students' questionnaire, the students reported that they enjoyed the most completing their projects, planning and collaborating, crafting and programming primarily. One student reported that *"Planning and expressing myself"* was the most enjoyable part. Also, the students were excited working within the eCraft2Learn learning ecosystem, finding solutions to problems and achieving their goals, i.e. *"The way we were working in this project", "Learning and facing new things. Also the opportunities we got!"*

However, issues of collaboration were also reported in the final questionnaire. For instance, one student said that they liked the least *"When I couldn't take part of our group when two people could do the project, and even though we were just trying to help, they excluded us from the group",* and another student said *"That I wasn't allowed to program"*. This indicates that teachers as coaches should assist the students to develop their teamwork and collaborative skills, particularly when

students are not used to work together as to avoid feelings of exclusion and frustration. Furthermore, teachers intervention would also be beneficial to assist students with understanding how to become independent learners (e.g., scaffolding their problem solving process, etc.) in order to deal with things when they don't work as expected.

2.1.2. INFORMAL SETTINGS

TASK – THE ROBOT HEAD ACTIVITY

4 sessions, 6 groups of students, 8 hours in total

The groups that participated in the task varied in size each session as the students from the after-school technology club of the university participated voluntarily during the sessions. A total of 15 kids joined the groups.

Instructors perspective - teacher's diary

The instructors reported their diaries for 2 groups of participant students. The results are shown below for their observation regarding the pedagogical core processes.

Table 74. teacher's diary

Students Group	Ideation		planning		creation		programming		sharing	
	Yes	Limited	Yes	Limited	yes	limited	yes	limited	yes	limited
Group 1	2		2		2		2			1
Group 2	2		2		2		1	1		1

How was the collaboration among the team members?

The collaboration among team members was perceived as good by the instructor, and the satisfaction with the students' engagement in the learning experience was very high, as indicated below.

No collaboration	poor	fair	good	Very good
			2	

The following Table 79 indicates the extent that teachers perceived their students engaged in the learning experience.

Table 75. Perceived engagement of students

To what extent are you satisfied with:	Not at all	Very little	somewhat	To a great extend
a. level of students' engagement				2

b. progress made by teams				2
c. creativity demonstrated by the teams				2

Teacher role as a coach

When asked: In the following scale (1 = traditional teacher | 5 = coach) **where do you place your role in the workshop based on today's experience?** The instructor saw himself as closer as a coach in the classroom during the 1st work session, and a bit more so during the 2nd session. This was perhaps due to the fact that the students were more independent in their work as their task developed.

	1=traditional	**2**	**3**	**4**	**5=coach**
session1			**x**		
session2				**x**	

Students perspective - Interviews with students

In Finland, student diaries were not analyzed from the informal settings pilots deployment as it was noticed that students were not providing rich feedback based on the used forms (i.e., students were answering the learning diaries' questions with single words or not at all). From this experience it is emphasized the role of interviews as a data collection method with young children.

From the interviews, students reported to like the most to design the 3D printed parts but they didn't like to wait. The group worked well together as they reported to work on the same tasks at the same time. The students reported to have planned their work at the beginning of the activity after coming up with the idea of what type of robot head they wanted to create. They didn't face too difficult challenges and reported receiving help from the instructors when they needed it. This could be due to the fact that the these students had been already exposed to electronic devices and technology for making in general as they are part of an after-school technology club.

Future project ideas

The interviewed students did not put forward any other project ideas to be developed.

FINAL STUDENTS' QUESTIONNAIRE - OPEN QUESTIONS

10 students returned the final questionnaire after the 1st round of informal pilots. The students identified working with 3D modelling, 3D circuit simulator and 3D printing as the most enjoyable activities during the pilots. This is perhaps because the participants were already familiar with using technology in the after-school technology club but 3D printing was something new to them. On the other hands, they reported liking the least when problems with the 3D printing process arouse. Waiting was also disliked.

2.2. SECOND ROUND OF PILOTS

2.2.1. FORMAL SETTINGS

A. THE COLD WAR TASK, 1 CLASS, 18 STUDENTS (SCHOOL 1)

This task was carried out in 4 sessions with a total of 14 school hours of 45 mins each.

Brief description of the subject from the curriculum

The aim of history teaching is to develop students' historical awareness and knowledge of cultures. By improving students' historical literacy skills, students develop their critical and analytical skills, and learn to make valid interpretations of the meaning of different historical information. Students are supported to identify the different values, tensions in the values, and changes in the society during different epochs. This will improve students skills to evaluate various reasons for historical events and understand the human actions in different historical situations. Moreover, students are encouraged to make interpretations and explain human actions. (The Finnish National Board of Education 2016 [2]) In more details, history subject should introduce students to some of the biggest Wars in the history such as the Cold War, which was being studied during this eCraft2Learn task. Students could find and focus on some specific phenomenon of the Cold War, which led to projects about the Cuban Missile Crisis, the Berlin wall, the Korean War and one project about a bomb shelter. In addition to the above-mentioned aspects, students could consider the human rights issues during the Cold War.

Teachers' perspective - teachers' diaries

Table 76. teachers' perspectives - 2nd round of pilots Cold War task

Students Group	Ideation		planning		creation		programming		sharing	
	Yes	Limited	Yes	Limited	Yes	limited	yes	limited	yes	limited
Group 1	3	1	3	1	4		3			1
Group 2	4		4		4		3	1	1	1
Group 3	2	2	3		3	1	4			
Group 4	3	1	3	1	4		4			1
Group 5	3	1	3	1	4		3	1		1
4 sessions	15	5	16	3	19	1	17	2	1	4

In the open notes, during the second pilot session, teacher felt that two teachers for a group of 15-20 students would be ideal for this type of an eCraft2Learn project work. Thereby teacher could provide enough support for all teams as time management would get easier. In addition, both teachers could use their own knowledge and skills, a physics teacher would have knowledge of many issues that emerged during the project work especially for engineering part and a history teacher for the subject

[2] https://www.ellibs.com/fi/book/9789521362590/national-core-curriculum-for-basic-education-2014

matter, for instance. When teacher is alone in the classroom, teacher needs very detailed planning and still the management of time for all teams will be difficult in the beginning. Though, when the projects start going, guiding students become much easier. The teacher also reported that it is challenging to define the topic so that it is wide enough but not excessively wide. One idea the teacher had was to pose a big topic and provide sub-topics with already existing materials to go through for each topic. Student teams would choose one sub-topic, explore it more and choose something smaller from the sub-topic to start working with. After completion, students could share their project in a presentation so not only talk what they created but also open up the theory behind the particular topic. During the fourth session teacher noted that too much time is still going to the crafting part of the artefact creations. He was thinking how to set some limits to this process.

How was the collaboration among the team members?

The teacher reported two observations on the collaboration of the students

No collaboration	poor	fair	good	Very good
			1	1

The following Table 77 indicates the extent that teacher perceived their students engaged in the learning experience.

Table 77. Perceived engagement of students (cold war task)

To what extent are you satisfied with:	Not at all	Very little	somewhat	To a great extend
a. level of students' engagement				1
b. progress made by teams			1	1
c. creativity demonstrated by the teams				1

Did you learn something new from your interaction with the students (today)?

To this question, the teacher reported the following:

"There was a surprise for me with one boy that is usually a little weaker in the class but now he was performing very well with the wiring the electronics and programming."

"One usually a silent girl in the classroom took a very responsible role in their team. That was for her a very good merit. Then there was one weak girl that I've never seen being so dedicated to her work. She really took it serious and that was great to see."

The teacher reported that he saw new sides of the students and felt that the experiences students get from eCraft2Learn projects give very valuable feedback for some students that they actually can. Thus, students can have feelings of accomplishment and achievement.

Teacher role as a coach

When asked: In the following scale (1 = traditional teacher | 5 = coach) **where do you place your role in the workshop based on today's experience?** The teacher saw himself as closer as a coach in the classroom.

	1=traditional	**2**	**3**	**4**	**5=coach**
session4					**x**

Students' perspective - student's questionnaires

During this class, due to time constraints, the students found themselves unable to fill in the students' diary and instead gave their opinions and views in the final student questionnaire. 18 responses were received, they are summarized by theme below:

Table 78. students perspective - the Cold War task (2nd pilot round)

Themes	**What did you like the most?**	
	No Occurrences	Examples
Crafting & Making	9	*"Building the project"* *"Crafting"*
Collaboration	3	*"Working together"*
Circuitry & Programming	6	*"Electronics and building"* *"Crafting and use electronics with the computer"*
Themes	**What did you like the least?**	
	No Occurrences	Examples
Circuitry issues	5	*"Working with electronics"* *"Servo motor when it broke"*
Waiting	3	*"When we had to wait"*

From this we can notice that the students enjoy the hands-on crafting activities the most followed by circuitry and programming as well as the social aspect of working together. Furthermore, 2 responses indicated that they liked 'everything' and one response stated that they enjoyed that *'You could work freely without a lot of rush'.* It is also noticeable that problems with the circuitry may cause a negative impression on the students that are not used to work with technology in the classroom. Also, the management of the classroom activities is important to orchestrate carefully as some students reported having to wait (e.g., to 3D print or to assembly their circuit with the needed sensors, etc.) as what they enjoyed the least.

Collaboration

The students reported having very good collaboration with their team members as indicated below

None	poor	fair	good	Very good
				3

Future projects ideas

The students did not put forward any other project ideas of their own.

B. MODELING A GEOGRAPHICAL PHENOMENA TASK (SCHOOL 2)

1 class, 15 students. This task was carried out within 3 work sessions, a total of 8 school hours of 45 min. each hour.

Brief description of the subject from the curriculum

In Finland, Geography is defined as a subject that built bridges between the natural and social sciences. According to the curriculum, the subject focuses on knowledge and understanding which are highlighted in the aims so that "instruction must support the students' growth as active citizens committed to a sustainable way of life'. (Tani, 2014). Since the focus is on 'learning and understanding' the pilot teacher decided to develop the topic of modeling a geographical phenomena (e.g., countries delimitations, volcanoes, rivers, etc.) through the eCraft2Learn learning ecosystem. It was expected that the students would gain understanding of technology and how it could be seen through a geographical lens application.

Teachers' perspective - teachers' diaries

Table 79. Teachers perspectives - geography phenomena task, 2nd pilot round

Students Group (class1)	Ideation		planning		creation		programming		sharing	
	Yes	Lim.	Yes	Lim.	yes	Lim.	yes	Lim.	yes	Lim.
Group 1	3		3		3		3			
Group 2	1	2	1	2	3		3			
Group 3	1	2	1	2	3		3			1
Group 4	2		1	1	2	1	2	1		1
3 sessions	7	4	6	5	11	1	11	1		2

How was the collaboration among the team members?

The teacher's reported observations on the collaboration of the students indicate that the team members worked well with each other.

No collaboration	poor	fair	good	Very good
			2	3

The following Table 80 indicates the extent that teacher perceived their students engaged in the learning experience.

Table 80. Perceived engagement of students (Geography task)

To what extent are you satisfied with:	Not at all	Very little	somewhat	To a great extend
a. level of students' engagement				3
b. progress made by teams			1	3
c. creativity demonstrated by the teams				1

Teacher role as a coach

When asked: In the following scale (1 = traditional teacher | 5 = coach) **where do you place your role in the workshop based on today's experience?** The teacher saw himself as closer as a coach in the classroom.

	1=traditional	**2**	**3**	**4**	**5=coach**
session3					**x**

Students' perspective - Student's diary

3 responses were returned from this class and task. The students reported to enjoy the most the making and programming process (*"Drawing, buying bananas (to work as sensors later during the session). We made it work!"; "Wiring multiple lamps and succeeding in what we did"*) as well as collaboration among group members. As with other reports, students did not like having issues with circuitry and programming (*"When the devices didn't always work and when we didn't succeed"*) and this was the main reported problem. The students reported to have learnt to use AI (e.g., voice commands) and wiring.

Collaboration

The students also reported a very good collaboration among team members, in agreement with the teacher, as indicated below

None	poor	fair	good	Very good
				3

Future projects ideas

The students were considering having as future projects *"a map where a light will turn on when some building's name will be said", "A map where a lamp of each city will turn on when its name is said"* and *"Everything for the government".*

C. SOLAR SYSTEM TASK (SCHOOL2)

1 class, 16 students. Total number of work sessions - 9 (45 min. each)

Brief description of the subject from the curriculum

Physics is a study of matter, energy and space, and interactions between them. Solar system forms part of the physics school subject in the Finnish curriculum. Teachers of this class chose solar system as the roof concept to create a joint project with physics and biology. Physics provides concepts for students to build their view of the world, explain their experiences in everyday life and understand the structures and dimensions of the universe. Modeling the different phenomena found in the nature and in the universe assists students to better comprehend the structures and principles of the phenomena and apply their knowledge to tangible projects. Using technologies increase students' 21st century skills and prepare students for the future work life. (The Finnish National Board of Education 2016 [3])

Teachers' perspective - teachers' diaries

Table 81. teachers perspective - 2nd round of pilots, solar system task

Students Group	Ideation		planning		creation		programming		sharing	
	Yes	Limited	Yes	Limited	yes	limited	yes	limited	yes	limited
Group 1	2	3	2	3	4		2		1	
Group 2	1	3		4	3	1	2			
Group 3	3		3		3	1	4		1	
Group 4	3	1	4		4		2			

[3] https://www.ellibs.com/fi/book/9789521362590/national-core-curriculum-for-basic-education-2014

Group 5	3	1	3	1	4		2		1	
9 sessions	12	8	12	8	18	2	12		3	

How was the collaboration among the team members?

The teachers reported that the collaboration of the students was very good as indicated below.

No collaboration	poor	fair	good	Very good
			2	3

To what extent are you satisfied with:	Not at all	Very little	somewhat	To a great extend
a. level of students' engagement				2
b. progress made by teams			1	2
c. creativity demonstrated by the teams				2

Teacher role as a coach

When asked: In the following scale (1 = traditional teacher | 5 = coach) **where do you place your role in the workshop based on today's experience?** The teachers saw themselves as closer as a coach in the classroom.

	1=traditional	**2**	**3**	**4**	**5=coach**
session5					**x**

Students' perspective - student's diaries

From this class, we receive 2 responses in the students' diaries. The students reported liking circuitry (*"Cutting the wires"*) and seeing the subject through a new light (*"Solving the mystery of the Sun, everything"*). Technical issues (*"I didn't like that there were problems with saving the projects"*) and *"sitting inside"* were the things least liked.

Collaboration

The collaboration among the team members was today

None	poor	fair	good	Very good
			1	1

Future projects ideas

The students did not put forward any other project ideas of their own.

FINAL STUDENTS' QUESTIONNAIRE - OPEN QUESTIONS

The final student questionnaire was answered by 28 students after the formal pilots. Their responses regarding what they liked the most pointed mainly at planning, crafting/making and programming activities. *"Working together"* and *"wiring"* were also mentioned by some students. One student said that *"Creating new"* was the most enjoyable aspect of the experience. Also sharing the results with a wider audience (e.g., SciFest 2018) was an experience that the students enjoyed. However, as also noted during the 1st pilot round, issues with dealing with electronic components or finding solutions to different problems as well as problems with coding/programming were aspects that the students liked the least. Time constraints and time management were also identified in this category.

2.2.2. INFORMAL SETTINGS

TASK - SMART HOME AND INTERACTIVE ART

15 students participated in the informal pilots. The pilots were carried out in 3 sessions with a total of 8 hours. 2 teachers and +1 special needs assistant participated in the pilots.

Teachers' perspective - teachers' diaries

Table 82. teachers perspective - 2nd round informal setting

Students Group	Ideation		planning		creation		programming		sharing	
	Yes	Limited	Yes	Limited	yes	limited	yes	limited	yes	limited
Group 1	2	1	3		2	1	3		1	2
Group 2	2	1	1	2	2	1	3		1	2
Group 3	1	1	2	1	2	1	2	1	1	1
Group 4	3		3		2	1	3		2	
Group 5	2		2		2	1	2	1	1	
3 sessions	10	3	11	3	10	5	13	2	6	5

How was the collaboration among the team members?

The collaboration among team members was perceived as good by the teachers, and the satisfaction with the students' engagement in the learning experience was high, as indicated below

No collaboration	poor	fair	good	Very good
			6	1

To what extent are you satisfied with:	Not at all	Very little	somewhat	To a great extend
a. level of students' engagement			4	3
b. progress made by teams			3	4
c. creativity demonstrated by the teams			4	2

Regarding the 'progress made by teams' one teacher observed that "*There were quite much difficulties with the sensors which maybe got students stuck. One team was just otherwise stuck. One team proceeded very nicely after the difficulties in the beginning. In general I was expecting teams to progress a little bit better/faster.*"

In terms of 'creativity demonstrated by the teams' one teacher noted that for one team *"There was a little bit lack of eagerness which was seen as lack of imagination and activity."*

The issues with technology seem to have affected the progress of the students as well as their motivation.

Did you learn something new from your interaction with the students (today)?

To this question, the teachers reported the following:

"Making the chicken wire stronger with cardboard was a good idea [that one team did]."

"I got maybe some new perspective on how to wire LEDs, how it can be done. I learnt a little bit more about programming servo motors."

Teacher role as a coach

When asked: In the following scale (1 = traditional teacher | 5 = coach) **where do you place your role in the workshop based on today's experience?** The teachers saw themselves as coaches to the students, mentoring and assisting them in the learning process to find solutions and self-regulate.

	1=traditional	**2**	**3**	**4**	**5=coach**
session1				**x**	
session2					**x**
session3					**x**

Additional perspective for the impact of the project

The special needs assistant gave her view of the project in a brief interview after the third pilot session. She is accompanying one student that has a flexible curriculum meaning that he is in a class that has smaller group size, differentiated hours for each subject and in some courses, such as this ICT course

joining the eCraft2Learn informal pilots, he is integrated with the ”normal curriculum students”. He has issues in working in bigger groups but the idea of the ICT teacher was to try to get him to attend the eCraft2Learn project. The special needs assistant’s thoughts were as follows.

“When students are in a different place, outside the school classroom, students feel freedom and they enjoy this. Also, often in the classroom students are sitting in their own chairs and the whole lesson you have to listen and concentrate, but there is no such a need here.”

”This boy that I’m accompanying is skillful and knows a lot but for him it is difficult to join a larger group.” ”It is a pity that he does not have courage to go into some team because now he does not get the teamwork aspect of the project. But anyway, he gets feelings of success. I think that he was pretty enthusiastic about the work as he noticed that he can do it. I think he was working with a positive attitude and enthusiasm about the fact that he was doing. He is a very skillful and smart boy, when you just can dig that out of him, but it just requires little work. I believe that this type of hands-on making is the right way to learn for him. Like reading things from books is not suitable for him, but the actual making yes.”

”I personally think that these kind of projects are super nice for students. One learns completely different things than at school classes. It is really awesome that students can take part in these kind of projects. I think it has been nice to notice how differently students understand the topic or what is being done here, although it is in general about the same thing. So it has been quite fun to notice how different approaches they have.”

”I feel that teaching technology in this way works the best for the younger students because they can think from their perspective how to implement it. Like when we think how teaching was in the past when I was in school, it was much more boring with the traditional way. In this project it is specifically that students can make and do in a tangible way. It is not just staring at the screen when a teacher is explaining, instead they can try and kind of fail. And then after that they can feel the success. That's probably the best thing in it. Many things will be better remembered when students are doing and experimenting themselves. So I do think this is a pretty good thing.”

”Now when I’ve been observing the students, I really think they’ve liked the project.”

Students’ perspective - Students’ diaries

The analysis here summarizes the emergent themes found in the data and gives examples of the students’ comments as found in 8 responses.

Table 83. students diaries, 2nd pilot round informal setting

Themes	**What did you like the most?**	
	No Occurrences	Examples
Collaboration, progress, success of the plan	3	*“When after a hard work we managed to turn on the lights and got our plan made”* *“We progressed with our work and skipped...classes”*
Social aspects	2	*“Group work and coffee”*
Programming, circuitry, crafting	3	*“Spray painting, we learnt to wire the LEDs correctly”*

Themes	**What did you like the least?**	
	No Occurrences	Examples
Progress difficulties	3	*"Some things were difficult and maybe we still didn't understand everything"* *"The movement detector broke and we faced problems."*

The students reported that they enjoyed the most the social aspect of the work as well as when they succeeded with their plans. Programing and making was another enjoyable aspect of the experience. On the other hand, reports on the difficulties of the work progress were also given. Furthermore, one student reported that ideation was what they liked least *"When we had to come up with the idea. It is always difficult and time consuming",* whereas another student said *"solving problems"* was something they didn't like. Nevertheless, 3 students reported that *'there was nothing bad'* and that they *'liked everything'* when asked what they liked the least.

Collaboration

The students reported to have good collaboration within their teams as indicated below.

The collaboration among the team members was today:

None	poor	fair	good	Very good
			4	4

Future projects ideas

Some students demonstrated interest in developing other project ideas through the eCraft2Learn learning ecosystem, including *"Some kind of a detector that is detecting movement", "Stars blinking in the space"* and a *"Future lamp system".*

FINAL STUDENTS' QUESTIONNAIRE - OPEN QUESTIONS

10 students provided their responses to the final student questionnaire. When asked what they liked the most, group work, making/crafting and planning were the main answers. Some also reported to enjoy programming and circuitry. One student enjoy the most having access to a variety of devices to put together into one project. In terms of the aspects that they liked the least, not surprisingly students were disappointed when they had troubles with the electronics or when they didn't know how to proceed or had to solve problems. Two students reported that they didn't like the programming part. Nevertheless, some students also said that they enjoyed the entire process, even when they had to face difficulties.

2.3. TOOLS USED

2.3.1. FORMAL SETTINGS

The Table 84 represents the tools used during the first and second round formal pilot projects referred by teachers in their diaries and in the interviews. In addition, the observation notes were used to complement these mentions. Electronics, such as LEDs, motors and different sensors, and paper or cardboard materials were mentioned the most. This is in line with the findings from the teacher and researcher observations as it was noticed that the creation stage, including the electronic circuit building and crafting, took the most time in the pilots. With the cardboard usage, the creation phase included creatively the use of different building materials such as wood and other natural materials, plastics, steel and fabric that teachers referred to. Students in all pilots used Tinkercad as the 3D modelling software and this was also widely mentioned. Arduino board and the programming environment used in all pilots, Snap4Arduino, got relatively many mentions and in many cases were mentioned together: the electronic circuit creation led to programming phase. It is worth noticing that although Snap4Arduino specifically was mentioned 13 times, many teachers described programming or the programming environment in general. From the technical environment, Raspberry Pi, tablets and laptops were also referred to. Mostly, RPis were used during the first round of pilots and laptops preferred by teachers during the second pilot round. The developed AI blocks were widely implemented in the student creations during the second pilot round and these were referred in the observation notes. Moreover, the second round brought emphasis on the UUI usage and therefore the eCraft native tools and learning analytics were mentioned.

Table 84. tools used - formal settings

Tool	Times Referred
Electronics (e.g., LEDs, resistors, sensors, etc.)	34
Paper/cardboard materials	25
Tinkercad/3D modelling	19
Arduino board	14
Snap4Arduino	13
Wood	7
Raspberry Pi	6
Tablet (eg. iPad)	6
Nature materials	5
Laptop	4
Plastics	4
AI Blocks	3
Fabric	3

Steel	3
Glue/hot glue	2
Play dough	2
Cura	1
eCraft native tools (eg. Search and Plan)	1
Foil	1
Learning Analytics	1
Tinkercad Circuit Designer	1

2.3.2. INFORMAL SETTINGS

All tools that were mentioned being used in the coach diaries during the first and second round informal pilot projects are represented in Table 85. Additionally, observation notes were used to complement the diary mentions. It has to be taken into account that the informal pilots' data was collected only from two different classes, whilst the formal pilots from seven student classes in total. The amount of sessions was also much less in the informal site which leads to having less mentions in the tools used and a smaller variety of different tools. However, likewise the formal site, electronics and paper or cardboard materials got the most mentions as they were mentioned in almost all session notes. Arduino board and other crafting materials were often mentioned as well. It is noteworthy that Snap4Arduino was not mentioned even one time in the informal site coach diary or observation notes. Though, the term 'programming' was used multiple times. One explanation for this is that teachers and instructors did not use any other programming environment with the students. Thus Snap4Arduino was seen as the natural and only programming tool, and instructors did not see the need to mention it specifically. 3D modelling did not get much usage in the second informal pilot round which presumably affected to the low occurrence of Tinkercad or 3D modelling mentions.

Table 85. tools used - informal pilots

Tool	Times Referred
Electronics	13
Paper/cardboard materials	9
Arduino board	7
Metal wire	4
Glue/hot glue, tape	3
eCraft native tools (eg. Search and Plan)	2
Laptop	2
Tinkercad/3D modelling	2

AI Blocks	1
Foil	1
Learning Analytics	1
Tinkercad Circuit Designer	1
Wallpaper paste	1

2.4. Observation Notes

2.4.1. Formal Settings

Table 86 presents the number of occurrences on each pedagogical stage from the researcher's observations in both rounds formal pilots in Finland. From the first pilot round, the data includes in total of 31 observation sheets, from 3 sessions of the photosynthesis task, from 10 and 9 sessions of the security system task class 1 and class 2 accordingly and from 9 sessions of the second photosynthesis task. Some observations have data from three and some from four student teams according to how many teams there were per student class. From the second round, there are in total of 12 observation sheets from which 4 from the cold war task, 3 from the map task and 5 from the solar system task. The number of teams per student class varied from four to five student teams.

The analysis demonstrates that student teams were ideating in more than half of the sessions (13,84% "*No*" as an answer). Planning was included in the project work sessions almost half of the time, although one third of the sessions did not have planning at all. The difference is big between the first and second round observations. This can be explained by the difference in the observations as during the first round pilots planning was considered only by plans that were recorded by drawings, calculations and role assignments. As there was only one observer per the whole student class, everything that happened in all teams in parallel could not observed and important student discussions were left unnoticed. Likewise in Greece, the demand for automated data collection system is high. From the student interviews and student diary notes the observer could complement the knowledge of the planning stage as students' reports showed that planning was in fact done in many of the sessions closely with ideation and creation. Therefore, during the second pilot round the observer had a wider view of the planning stage and the second round indicates more the reality in the classrooms. The second round data demonstrates that ideation, planning and creation have highly similar number of occurrences with "*yes*" and "*yes to a limited extent*" answers. In general the projects included creation most of all stages and only 11,39% of the sessions did not include creation. Over half of the sessions had programming (37,97% "*No*" as an answer) and programming was mostly included in the beginning and in the end of the artefact creations. The stage that teachers identified as being the one that had the least attention, sharing, was only identified in one third of the sessions (29,52% "*Yes*" and "*Yes to a limited extent*" answers). The subtotal of sharing stage was slightly larger as it included occurrences also from the dissemination events held both after the first and second pilot rounds.

The artifact construction was accomplished in the majority of the sessions as only 7,59% of the sessions did not include any work for teams' projects. The sessions where students did not work for their projects, were all in the beginning of the projects with a new student class. During these first introductory sessions students were getting familiar with the technological and pedagogical core of

the project and practicing easy wiring and programming. It has to be noted that also these tasks helped students later to create the needed electrical circuits and program codes for their projects but these sessions did not directly lead to artefact creation.

Table 86. Summary of observation notes - formal settings

Formal pilot sites Finland	1st round	2nd round	Total	Percentage to SubTotal
IDEATION				
Yes	58	34	92	57,86%
Yes, but to a limited extent	28	17	45	28,30%
No	16	6	22	13,84%
SubTotal			159	
PLANNING				
Yes	44	34	78	49,37%
Yes, but to a limited extent	15	16	31	19,62%
No	42	7	49	31,01%
SubTotal			158	
CREATION				
Yes	72	48	120	75,95%
Yes, but to a limited extent	16	4	20	12,66%
No	13	5	18	11,39%
SubTotal			158	
PROGRAM				
Yes	50	40	90	56,96%
Yes, but to a limited extent	5	3	8	5,06%
No	46	14	60	37,97%
SubTotal			158	
SHARE				
Yes	24	6	30	18,07%
Yes, but to a limited extent	10	9	19	11,45%
No	71	46	117	70,48%
SubTotal			166	
Project/Artefact construction				

Yes	76	50	126	79,75%
Yes, but to a limited extent	16	4	20	12,66%
No	8	4	12	7,59%
SubTotal			158	

For the first round of pilots teachers did not provide so many educational resources as for the second round. Thus, the first round experiences helped teachers to realize where students will especially need guidance and how they could provide support for students with different educational resources. In general, the resources were provided mostly in the beginning of the new projects and then the instructing and coaching was more tailored for each student team without using extra resources. As "Educational resources used by the teachers (i.e. videos, web-links, print-outs, etc….):" during both rounds, teachers were giving oral and written instructions on how to proceed during the lessons. For example one teacher wrote on the board three tasks (3D modeling, wiring the Arduino or programming) from which student teams could choose from the ones they saw important for their own project. This fostered their self-regulatory skills. Teachers also presented examples of other eCraft2Learn creations, provided a list (D2.2.4.) of possible sensors that students could use, showed pictures and gave key search words for finding Arduino circuits, provided web links for students where to find information and gave short introductory lessons or hints about 3D modelling and printing as well as Arduino wiring and Snap4Arduino programming. One teacher also brought his own 3D-pens from home for the students to use in their projects and showed videos of how to use these pens. Especially during the second pilot round these introductory lessons were made as slide show presentations that not only included basic instructions on Arduino wiring and programming, but also introduced the UUI and the topic to be studied during the projects. Teachers had also created few files to help students to plan their projects more carefully (which kind of materials and sensors to use, how to implement AI in the projects) as teachers noticed during the first pilot round that ideation and planning stages were slightly challenging for students. For the usage of AI blocks, two teachers had created an AI example in Snap4Arduino that student were following and learning to read and understand the code.

In terms of overall workshop impressions the students worked actively and with great motivation in all pilot projects by distributing roles and using each team members' strengths when working collaboratively towards the same vision and goal. Students had very little previous knowledge about electronics or programming but they quickly acquired new knowledge, were teaching other team members or even other teams, and created masterpieces. Students had ambitious plans and wanted to create visually beautiful artefacts striving to perfection. They were very proud of their creations and willingly presented their artefacts to other students and teachers in the school and visitors in different dissemination events. When students were programming their electronics, they got a lot of in-time feedback if they saw their code working or not, and the happiness was clearly seen when everything worked as students wanted after a long trial-and-error work. That joy and prize seemed to make all students' efforts and uncertainties worth it. It could be seen that some student teams were progressing fast and with a lot of self-regulation but some needed much more guidance. Likewise, in some teams all students participated actively but in some there were students who barely participated at all or interacted with the other students. It was noticed that the most effective teams where everyone had clear tasks were teams of 3-4 students. Moreover, it was noticed in the beginning of a project with new group that when students faced a problem with Arduinos or programming, they

easily asked help from the teachers. As students' skills improved, they gained more confidence and started finding out errors in the wirings or program codes themselves, and were very self-regulated learners. Theoretical knowledge gain takes time and it would be very good for students to try to go through what happened and why, after the programmed Arduino circuit works as they wanted. The observer noticed that every stage of the eCraft2Learn pedagogy was seamlessly connecting to each other, thus was iterative throughout the projects.

When it comes to teachers, in the beginning of the first round project pilots, teachers had difficulties in being confident enough to start running the projects and a lot of responsibility on carrying out the pilot sessions was given for the project researchers. This raises a question on how to support the teachers to trust their skills and abilities from the beginning of eCraft2Learn projects, although they would already have participated in the teacher training. What kind of background knowledge teachers still feel they would need and how can we provide this needed support for them. Slowly teachers gained confidence and increased their responsibility in the classroom. During the second pilot round sessions teachers were truly in charge of what happened in the classroom but also allowed students to have the main role as makers. Teachers acted entirely as coaches and were flexible to adjust to different student teams' needs. Teachers were encouraging students, providing them feedback for their effort, posing questions which help students to realize their plan even better and find out the missing or unclear parts in their plan, and giving them a gentle push to try out some other stage of the project. During the projects students also had a lot of engineering problems where teachers were guiding and coaching the students. One team for example was investigating with the teacher how to lift up a vault, and another team was pondering how to create a opening and closing system for a door with servo motor. When teachers were acting as coaches and provided guiding questions (scaffolding) for students, finding out answers for the respective problems took more time than teacher giving answers directly but shifting the responsibility for students to think brought plenty of learning results, such as problem solving and creativity skills, in the end. The observer had also noted that one 45-minute lesson was slightly too little for a project- and problem-based learning like eCraft2Learn work. The actual working time for 45-minute session was little because in the beginning students had to recall what they did last time and possibly in the end disassemble the equipment. However, for the teacher it is difficult to guide the student teams individually as they progress through acquiring the basics of electronics when teachers needed to spend a lot of time in one team at a time. Perhaps the solution could be teacher-led teaching for the beginning or encouraging students who know how to create circuits and program to help others.

There were some needs that emerged during the pilot sessions in both rounds. Students and teachers needed help and instructions on how to wire different sensors and actuators with the Arduino and especially on how to program the Arduino with using Snap4Arduino. It is relatively easy to find different Arduino circuit diagrams online but the program codes for Snap4Arduino are more tricky and here students could not proceed independently without teachers' help. Perhaps some library or repository of pictures about basic program codes would ease this part of the working for both students and teachers. This would assist students to catch up what was done during the previous sessions and foster their self-regulatory learning. In all pilot sites some technical difficulties with the Raspberry Pis and Tinkercad functionalities with iPads were confronted and this brought a need for the equipment to work and be robust. With Tinkercad, a common account was created as students would not need to remember new accounts and passwords. Also, for the 3D modelling itself, it could be noticed that lots of students were disappointed with their 3D printed items. Students are often supposing the item will be bigger and have all the details but it turns out the printer cannot actually print everything because of the model. When students are looking for the model from the ready-made models, the printer usually succeeds better. Perhaps students could use some other 3D modelling software than

to learn how the model should be designed and understanding how the printer actually can print. One question about organizing the sessions in the school-wide context is whether the equipment should be in some specific place or room all the time where there would be no need to carry the devices and tools from place to place and spend extra time on assembling the equipment, or is it better to have easy to assemble equipment that can be taken almost anywhere. Moreover, it was seen that each team needs their own Arduino so that the creations do not need to be taken apart every time. This brings another organizing issue if many classes inside the same school would make projects at the same time. It is important for the schools to think about resourcing and distributing the equipment and timetables of the projects.

2.4.2. INFORMAL SETTINGS

In the first round of informal pilots the observation data was collected from three sessions with 6 teams in each session. The second round observation sheets comprised data from three sessions with 5 teams each. The summary of the observations is found in Table 87. The findings indicate that student teams went through ideation in almost all sessions (only 6,06% "*No*" as an answer) and planning was seen in all sessions from all teams. Creation was also noticed in almost 90% of the sessions, though during the second round teams had creation in 95% of the sessions. Student teams did program in over half of the sessions, with approximately 30% of the session not involving programming. But again, during the second round only 7% of the sessions did not include programming. There is a big deficiency of sharing stage as it was not seen in 84,85% of the sessions. Student teams in both informal pilot rounds were very focused and engaged in their own work but did not interact with other teams. Although, one of the teachers in the second pilots argued that students are sharing constantly inside the teams and also when explaining their work for the teachers and instructors. However, sharing should be encouraged in the future projects. Students constructed their artefacts in some extent in almost all the sessions. Only during the first round in some sessions few student teams could not proceed with their work as the time went for off-time activities, especially with the younger students.

Table 87. Summary of observation notes - informal settings

Informal pilot sites Finland	**1st round**	**2nd round**	**Total**	**Percentage to SubTotal**
IDEATION				
Yes	7	13	20	60,61%
Yes, but to a limited extent	10	1	11	33,33%
No	1	1	2	6,06%
SubTotal			33	
PLANNING				
Yes	10	12	22	66,67%
Yes, but to a limited extent	8	3	11	33,33%
No	0	0	0	0,00%

SubTotal			33	
CREATION				
Yes	11	14	25	75,76%
Yes, but to a limited extent	4	0	4	12,12%
No	3	1	4	12,12%
SubTotal			33	
PROGRAM				
Yes	6	14	20	60,61%
Yes, but to a limited extent	2	0	2	6,06%
No	10	1	11	33,33%
SubTotal			33	
SHARE				
Yes	0	3	3	9,09%
Yes, but to a limited extent	1	1	2	6,06%
No	17	11	28	84,85%
SubTotal			33	
Project/Artefact construction				
Yes	15	13	28	84,85%
Yes, but to a limited extent	0	2	2	6,06%
No	3	0	3	9,09%
SubTotal			33	

As educational resources, teachers and coaches were using slideshows about possible topics and about Arduinos containing information on how to connect an LED and how to program it. Coaches were showing videos and pictures of some previous work done and to help students to grasp what is possible to do with the available equipment and support their ideation process. Students planning and ideation processes were also fostered with the leaflet of different sensors and how to use them. For students to understand the principles behind electricity and electric circuits, one coach drew a sketch of the electronic circuit explaining which way the LEDs come, where is the power source and how does

the closed circuit work. Moreover, coaches were using internet search to find pictures for different Arduino sensor wirings.

In the overall workshop impressions the observer noted in the first informal pilot round that the skill level of the students was very high despite of their young age as many of the students participating in this after school technology club had been making with different electronics and programming for many years. These skills and the knowledge was seen as having highly self-regulated, independent and patient learners who only needed few hints and instructions about how to proceed. Children were very keen on making tests and projects with electronics and they were not afraid of trying out and exploring. They also had ambitious plans such as creating a robot that shoots marshmallows. However, also during the second pilot round students got very interested and engaged in the project and got many creative ideas, although they did not have much previous experience on electronics or programming. The ideas shown by the teacher worked just as inspiration and demonstrated what might be possible to do, but students were considering very nicely the possibilities and created their own ideas. After testing and when acquired one skill, students started applying the knowledge for something else. For example when they knew how to wire one LED, students created their own solution for wiring three LEDs. The observer also noted that students did not hesitate to ask questions or help, and that showed they were really giving thoughts for what was happening and excited and innovative in their work. Although, it was noticed that questions did not go very deeply for the functioning of electronics or the theory behind programming. When explaining the principles of electronic circuits and programming, it could be seen that these were relatively difficult for many students to understand. It is relevant to ponder, how much time would it take to make students to comprehend these principles more deeply, or how much do students need to understand. Thus, what is the meaningful ratio of white and black box information?

As during the first pilot round, some of the students' 3D printed models did not turn out how they were supposed to, students developed their problem solving and creativity skills as they were trying to solve the issue by either making a new 3D model or trying to make the creation with other materials. In the first pilot round, the tasks had to be challenging enough and the tools had to offer enough opportunities for different creations to keep these students motivated throughout the whole project. Some of the younger students got distracted relatively easily and started shifting their focus away from the actual task, and thus needed guidelines on how to progress. Without instructing more in details, these children started having off-time by playing with their phones or causing other students to start fooling as well. The excess off-time was seen in the second round too as students did not like to sit and wait which raised a need to have some short instructions guiding students on what to do next. Although, this brings some challenges on the teacher because everyone is in different phase of the work and needs guidance on different problems (Arduino wiring, 3D modelling, programming, engineering issues).

During the first round of informal pilots, the Unified User Interface (UUI) was widely used and the following was noticed when students were using the different tools: the eCraft Idea tool did not give very good search results if the search words were in Finnish and the eCraft Plan tool should have had more functionalities. There were also some issues with the Snap4Arduino connecting to the laptops' USB ports with the Arduino drivers as the laptops were old and required admin rights to install the needed drivers. Moreover, some sensors did not work in a stable way. In general, the equipment should be relatively robust as the malfunctioning affects student motivation negatively. The observer noticed that when students imported all the AI blocks at once, students were slightly confused at first glance as the amount of different blocks is massive. Consequently, there was a need for guidelines on how to guide the students through the usage of AI blocks when starting to utilise these blocks.

2.5. General Discussion Comparing both Finnish Settings

When comparing informal pilot site to formal Finnish site, **more ideation and planning could be identified from the informal pilot sites**. As seen during the sessions, **students were iterating their ideas more and coming back to their plan constantly by improving the original idea**. Students seemed to have more freedom in their work, being more creative and willing to create completely their own vision for the proposed topic.

There was a lot of creation in both rounds as approximately 90% of the sessions included creation in some extent for both informal and formal sites. Creation could be seen as the stage that drives the work throughout the projects and is something where all other stages are closely linked to. It was interesting to notice that in **the first round informal site pilots children were more technology oriented** as they had years of experience in electronics and programming and unlike in the formal site, in the creation part they mostly focused on the 3D printed parts and electronics and did not want to craft much with recycled materials. In addition to the creation stage, **programming occurred in a same extent in both pilot sites**. Programming was used to enhance the creations and for "bringing life to the creations" but did not involve so much time as the creation stage. Almost everything that students did and created in the sessions were involving the project or artefact construction in some way. In the first informal pilot round it was noticed that some student teams had so much off-time that they could not progress at all and were stuck for the whole session, although instructors tried to assist these teams to take next steps in their projects. Also, in the activities that introduced students to basics of electronics and programming, students did not directly construct their artefacts but these tasks were necessary to help students to further use these skills and apply them to their own projects.

More interaction between the different teams was noticed in the formal than in the informal pilot **site**. Student teams in both informal pilot rounds were very focused on their own work and did interact with other teams only in a very little extent. That was one explanation for the **higher sharing stage occurrence in the formal observation**. **Sharing should be encouraged as it may help students for example to see their ideas and plans from a new perspective, to get ideas and constructive feedback and to improve their presentation skills**. From the formal pilots especially it was seen that when students were sharing their work, they were very proud of their creations and willingly explained their work for others.

3 eCRAFT2LEARN EVENTS – ATHENS SCIENCE FESTIVAL PARTICIPANTS VIEWS

In the framework of the Athens Science Festival where the participants of the pilot presented their work, some students were asked to give us some insights on their work. Some of them referred as to what they gained out of the project. It also indicates the impact these types of project had on them:

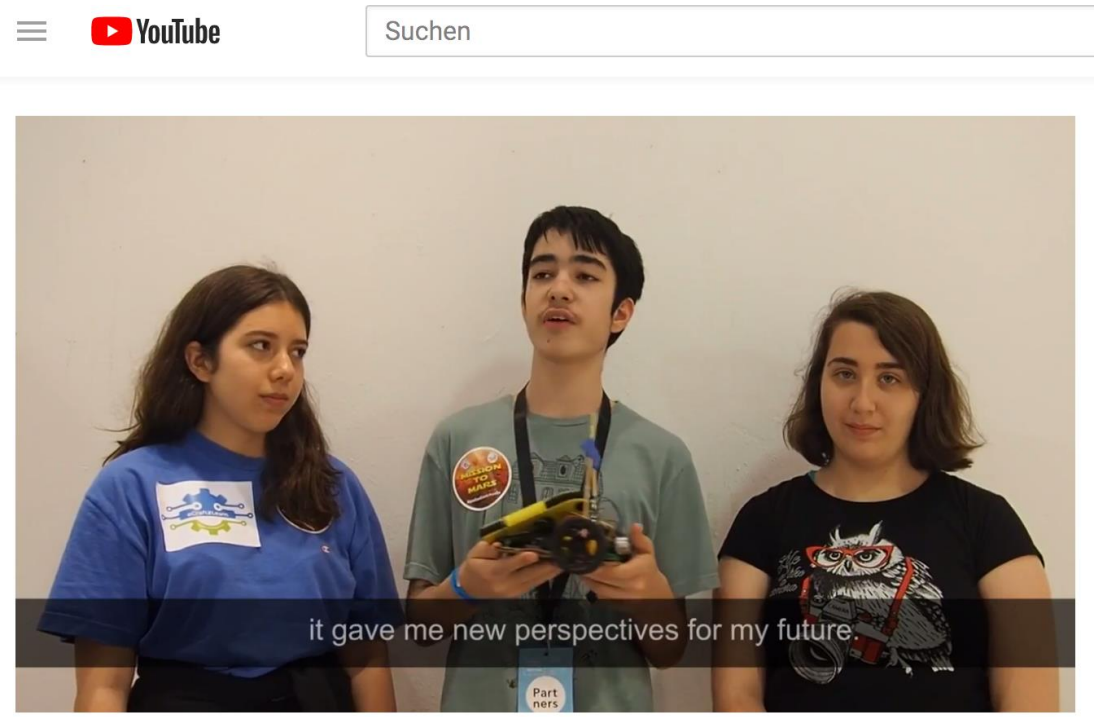

Figure 4. Screenshot of interview with students at the Athens Science Festival 2018

For once, the aspect of doing things independently, enabling students to make their ideas becoming a finalized product contributes to their self-esteem and self-confidence by being proud of their own product.

'*What we liked the most is that we made things with our own hands and we could support it as our own construction, our own work. You do something for several weeks and at the end you have the pleasure to support it as your own work... You did all by yourself. From the moment that we had the opportunity to use whatever material and program from the platform we want and do that autonomously ... we liked it! We didn't have someone to tell us how to do things...*' Participant student (student from formal pilot site, Athens, GR)

Thus, it has to be emphasized that the pedagogical concept of the 5 step model shall specifically foster the teachers' role as guiding coach that support only where needed or requested. By doing so, the **impact on increasing self-confidence and self-esteem is enabled**. Also presenting to other audiences strengthens the self-confidence: *'I managed to overcome one of my biggest fears, meaning to speak to an audience that I have not met before. Usually I feel nervous and I don't feel ready to talk. Today I managed to get over these feelings through my interaction with the audience - with kids, with adults, and by responding to difficult questions on technology and robotics'* (student from formal pilot site, Athens, GR)

Other students mentioned also an **impact as of an increased competence in solving problems and co-working**:

'For me it was definitely a groundbreaking experience, funny and I liked very much the fact that it was a workshop about STEM in which skills like solving problems and co-working were developed [...]' Participant student (student from formal pilot site, Athens, GR)

'*[...] The workshops were an extremely valuable experience due to the fact that I learned to be part of a team and co-operate with other persons [...] ' (student from formal pilot site, Athens, GR) and 'Working in teams was the major difference*

The student mentioned explicitly interpersonal and social skills that were developed. This is very much in line with the interviews with teachers, that were several times referring to the social aspect of learning in terms of teamwork: *'[...] but after a while a team of the three of us was. I think we immediately matched. We comprehend each other and we help each other with the robots.' (student from formal pilot site, Athens, GR)* Considered the decreased request of pure knowledge and the increased demand of new skills (like teamwork, communication, problem-solving a.s.o.,) this impact mentioned by the students and teachers is considered as highly important and reassures the initial assumption of the eCraft2Learn project to have a positive influence in this respect.

The students valued also the fact that they learned more advanced technologies thus they saw also some **impact on cognitive knowledge**:

'*[...] we have learned some more sophisticated things like Arduino, things that robots do, other constructions that we used as servo, sensors that we have not met before programming and programming tools related to Arduino. It was all new and I think that the implementation of technology was useful for me [...] ' (student from formal pilot site, Athens, GR)*

One interviewee of the pilot even mentioned that this type of learning opens new perspectives:

'Personally I liked the workshops very much. It was the first time that I got in touch with the branch of robotics and programming, and it gave me new perspectives for my Future.' (student from formal pilot site, Athens, GR)

This mentioned impact on considerations on future perspectives was unfortunately not specified and can be only assumed in the way that the student saw different options as to choose for job career or decision on school specifications or even only for a new interest. These are only assumptions, but it indicates that these type of learning can open up for considering more options. Thus we conclude that the pilots had an **impact on options, perspectives and/or interest** of some students.

Two of the students explicitly mentioned also the **changed role of the teacher** *'The teacher of our team was closer to us and made us feel him as our assistant and not as someone older and thus he was very helpful.'* (student from formal pilot site, Athens, GR)

The students felt this changed role as helpful for their relationship with the teacher. Consequently we can assume that eCraft2Learn contributed to a different approach of teachers towards their role, moving from the classical teaching towards coaching and supporting.

The visitors of the eCraft2Learn workshop in Joensuu (Finland) had a chance to choose from two different tasks; to develop a drum machine or a painting robot. Both tasks were planned so that they get gradually more challenging and the completion of one task would take approximately one hour and a half. Two visitors that participated in the workshop had no previous experience on programming or electronics but in just 1.5 hours they created a robot with a brush holder that paints according to their program code. Thus, there can be found some cognitive impact that the workshop had on the visitors:

'I felt that programming was easier than the building itself. We had to ideate, plan and test a lot before we came up with the final and workable solution for the brush holder. From this workshop, I learnt how to program robots.' (visitor participating in the eCraft2Learn workshop, Joensuu, FIN)

4 IMPACT OF LEARNING ANALYTICS

The learning analytics system (LA) has been piloted together with the UUI during the pilots in both formal and informal settings. The piloting took place in Joensuu, Finland and the teachers involved in the pilots were interviewed. The interviews were based on the general discussion and the questions that were designed prior the interviews. The questions asked the teachers to reflect their experiences on LA, the usefulness of LA and whether the teachers considered the data mining approach present in LA better compared to traditional learning analytics or educational data mining tools.

During the interviews, the teachers noted that the learning curve to use LA was steep. From the observations and the interviews we can conclude that there exist trade-offs between how open can a system be compared to the easiness to learn how to use the system. Although, an open system can be made easier to learn through the choices in the user interface, the level of easiness in closed systems cannot be achieved.

During the interviews, we were mostly concerned whether LA can lead to knowledge discoveries and how do these discoveries relate to the knowledge discovery bootstrapped by a traditional closed learning analytics system. The teachers pointed out that the system, when it is open, is easier to trust and the predictions made by a system are easier to comprehend when it is known why the system predicted as it predicted the performance of the students.

Also, the teachers stated that when the prediction of LA was based on the collaboration between the machine learning algorithm and the teacher, the interaction itself generated the domain knowledge. Also, when the teachers applied their domain knowledge to the model produced by the machine learning algorithm and the model was visualized in real time for the teachers, the knowledge shared by the model and the teacher was valuable enough to generate knowledge from the piloting settings. The teachers stressed that the knowledge discovery that was gained from the pilots through LA would not be otherwise possible and was due the open philosophy of LA and the interaction between the model and the teachers.

The discoveries that the teachers made were about the relevance of certain features to whether a student or a group of the students were performing well or not. In other words, the teachers learned what it means for the students to perform well in the situations where the teachers were not able to closely observe the progress of the students.

Also, the teachers made discoveries on what kind of features are relevant for some students or groups to be mode similar to each other's than the rest of the students. Again, through the interaction of the (cluster analysis) model and the teachers led to the better understanding of the context.

5 IMPACT OF USING AR FOR 3D PRINTING

Due to the implementation and testing of augmented reality (AR) appliction, the partner MDH was involved in a small scale study on the possible impact of 3D printing and AR during summer 2018. The following section has been adapted from the publication Ameri, A., Cürüklü, B., Sauter, B. (2018) The Effects of Augmented Reality on the Learning & Design Process of Students (forthcoming)

5.1. SMALL SCALE AR AND 3D PRINTING PILOT

16 students from the Fredrika Bremer technical high school in Eskilstuna participated in the small scale pilot. They were paired into teams and were assigned the task to create an original phone holder/stand design. The requirements were that the phone holder needed to be stable (not fall over), should allow the phone to be charged from its power cord, and the design should have a minimum of 2 parts. Furthermore, all components were required to be smaller than $10cm^3$. The student pairs were randomly selected to be a part of one of two groups. Group 1, the 'non-AR group', would only have the CAD model to design, whereas Group 2, the 'AR group', would be able to utilize AR through the phone app Augment. All of the students had some prior CAD skills.

The students were given a preliminary lecture on what their task was as well as the requirements. The AR group was given further instructions and a walk-through on how to use the AR phone app. Afterwards they were given an hour to start designing and practice using the AR app. The students were also shown how to operate the 3D printers. Then they were given a 2-week period to CAD and 3D print their models. During this time, they were given two more in-class opportunities to design. The remainder of the work was completed outside of class as necessary. They were allowed to repeat the process of redesigning and 3D printing as many times as they needed until they felt that the model was finished. The students were directed to keep a journal where they would describe their thought processes, what went right/wrong with their printed models, and what they thought was hard/easy about the day.

Data was also collected each time a student 3D printed their model. The calendar day, which the student would print, was recorded and they would be asked questions concerning what/why they were changing something in their design. All 3D printed models were weighed after printing.

At the end of the two week period, the students were given a questionnaire to complete with both open and closed ended questions regarding the test, what they liked/didn't like, and their opinions on if the AR affected their design process.

5.2. THE AR APP

This section describes the AR app, *Augment*, which was used by half of the student groups. The Augment app allows the user to upload their design to the Augment website, which is connected to the user's phone through a user login id. Once the design is uploaded, settings such as size and position can be set. The user then opens the correct file on the phone app, which can then be seen on the phone screen, super imposed over the background environment. An extra feature is that a separate picture can be used as a tracker. Once the tracker has been confirmed, then the model can be seen sitting on top of the tracker. The model is attached to this image and therefore can be rotated by rotating the tracker, or the user can move the phone around the model to see it from different angles. Commands for the app include resizing the model by zooming and rotating the model. A disadvantage of the app is that the model seen through the screen is static, and therefore individual components in an assembly can not be moved or interacted with.

5.3. FINDINGS

During the two-week period, the AR groups completed their models sooner and therefore printed their models sooner compared to the Non-AR groups. This can be due to that by using the AR app, they were able to make decisions on their designs more quickly. Table 88 also shows how many times each group printed, with the overall average being 2 prints. Only two groups deviated from this, with a low print count of 1 and a high print count of 3. Therefore, it seems that the use of the AR app did not change the students' outlook on modelling after the initial print. This is further supported by how the students answered on a survey question, responding that "the AR app came across as unnecessary after one use" (see Table 89, question 9).

Table 88. Numerical answer averages and standard deviation from final survey. Key: Strongly agree (1) - Strongly disagree (5)

	AR Ave.	NonAR Ave.	AR STDEV	NonAR STDEV
5. It was easy to find a solution to the task	2.00	2.57	0.76	0.98
6. Our design fulfils the requirements	1.75	3.14	1.39	0.69
7. It was easy to visualise the design in the real world	2.38	3.43	0.92	1.40
8. It was easy to visualise the design with a real world object, for example a phone	1.88	2.71	1.13	1.60
9. (AR) Do you think the augmented reality app helped you design 11. (NonAR) Do you think it would be easier to design if you used the AR app?	4.38	3.50	0.92	0.58
10. (AR) Will you use the augmented reality app again to help you in the future 12. (NonAR) Do you want to use the augmented reality app to help you design in the future?	3.13	2.00	1.13	0.82

As mentioned earlier, all groups printed on average two times. Each time they came in to collect their model, data was taken as to what was problematic about their design. The points of issue can be seen in Figure 5 and Figure 6 can be grouped into the following categories: 3D Modelling, 3D Printing, and Physics. Within the 3D Modelling category, issues included having a wrong fit between parts, 1 or more parts wasn't the correct size, or the students wanted to change a design aspect.

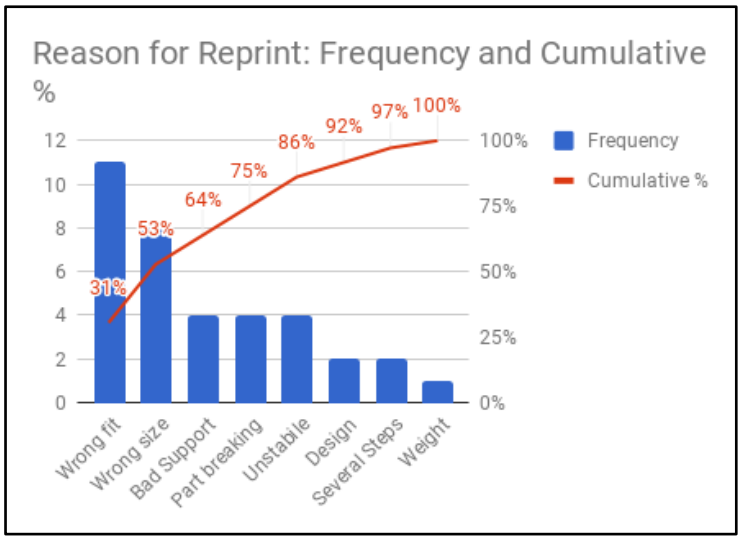

Figure 5. Reasons for reprinting a model Frequency and Cumulative

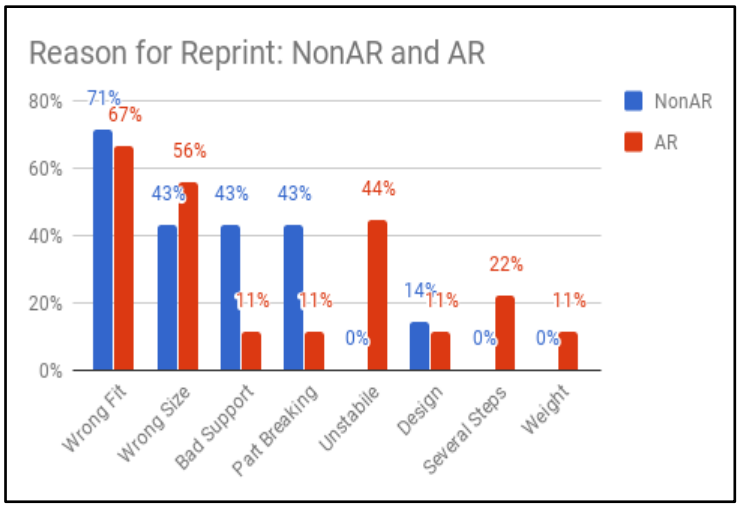

Figure 6. Reasons for reprinting a model, NonAR and AR groups shown separately

As can be seen in both Figure 5 and Figure 6, student's encountered the most problems when it came to fit issues, or how two components connected. This issue however is something that must learned from the 3D printing process, and cannot be known from the CAD model alone.

The second most encountered issue was that of parts having incorrect overall dimensions (dimensions that did not pertain to two components fitting together). Figure 6 shows how the AR groups had a higher percentage of issues when it came to sizing of parts. This can be due to that as they used the AR app, they gained a sense of size of their CAD models, however this sense of size was incorrect. Therefore the tool which should have helped them, especially with spatial attributes such as size, affected them negatively instead. The groups' at home journals also revealed that the NonAR groups typically noted that they used rulers to gain a sense of the size of the real life phone and digital phone holder to make sure that the size was correct. One group even noted how they 3D modeled a phone as well to make sure the phone holder would be the correct size.

Redesign was not as prominent of an issue, however it was behind some student's reasons for reprinting. Redesign means that the students wanted to alter their model due to aesthetic reasons. Figure 6 shows how NonAR groups had a slightly higher percentage of reprinting due to this as opposed to the AR groups. This may be attributed to that the AR app made a slight difference between

the groups and by allowing the AR groups to see their model super imposed in real life, they were able to gauge if their models were aesthetically pleasing, and alter the model before printing if needed.

Within the 3D Printing category and the Physics category, issues included having bad support, parts breaking, the printed model being unstable and the printed model having an undesired mass. The first two of these issues, bad support and parts breaking, must be learned from the 3D printing process and therefore neither the AR app nor CAD modelling would have affected this. The second two issues, stability and undesired weight, would have been easiest for the students to notice as a result from testing the model in its printed state. Therefore these factors could not have been know to them through AR or the CAD model either.

The end of study survey displays the differences between the Non AR groups and the AR groups and can be seen in Table 89. The averages show that the AR groups felt they had a relatively easier time with the task than the Non AR groups did. The AR groups answered that it was easier to find a solution to the task (Q5), they believed more in that their design fulfilled the requirements and was complete (Q6), they found it easier to visualize their design in the real world (Q7), and they found it easier to visualize their design with a real world object (Q8). These numerical responses were further supported by their written responses such as that the AR students answered more positively overall when describing how their model fulfilled the requirements (Q6). When describing how it was to come up with an original design, the AR students answered more positively again, describing the process as 'easy' while the Non AR students described the process as hard. This data can suggest that the AR students gained additional confidence in their concept models and were less burdened with the task.

However, when the AR students were asked if the AR app helped them design (Q9), they mostly disagreed. Multiple students responded that they didn't use the app very much, and they felt the app became unnecessary after using it the first time to see the initial mode. Another common response was that they didn't need the app afterwards because they could use their first 3D printed model to determine what needed to be altered in the design.

Table 89. Notable similarities and differences in survey answers between AR and NonAR groups

Survey question	**Student responses**
1	Similar: Most said that they liked modelling and then printing so it was brought to life in the real world
2	Similar: Most students said that the time frame was too short for printing, and they wish there was more time. Also that they didn't like that it was outside school time.
3	Similar: Most commented on learning how to 3D print, while other comments included learning about tolerances, construction, product development steps and CAD skills
4	
5	Similar: Most commented that it was easy to come up with a design.
6	Different: AR students answered more positively overall
7	Different: Most AR students mention 'it was easy', while most NonAR students mention 'it was hard'.

8	Similar responses
9	Different: Most AR students replied that the AR app came across as unnecessary after one use

Overall, the students were excited to take part in the study, and all commented on how it was interesting to test the AR app as well as 3D printing. On the final survey, all students responded that the process of CADing and 3D printing was fun, as it allowed them to see their models brought to life, and gave them an insight into the hardships of doing so. When asked if they learned anything during the study, students responded that they learned about tolerances, construction, product development steps and CAD skills. This can suggest that by allowing them to carry out all of the steps themselves, the students were engaged in the process through interactions with design and 3D printing. Both groups, AR and NonAR answered relatively the same, which may suggest there the AR app did not influence the students' learning process in the test.

In the end, the **AR students were ready with their designs faster** (by about a week) and therefore printed their models earlier. However the AR group generally had more sizing problems. Even so, the AR students **seemed to gain a higher sense of confidence** from using the app, which can be suggested both from them 3D printing earlier and from surveys where they responded more positively overall regarding the test. The app itself did not help with the sizing problem, but if fixed to do so, would account for the second leading problem for the students. The app did seem to slightly help with design aesthetics. The app seemed unnecessary to the students after the first use, but if told to students in the future that it would explicitly help sizing and aesthetics issues, they may be more willing to utilize it in the design process. In addition, if the app allowed for more interaction, such as the ability to move assembled parts individually, then the app may prove more useful and aid in the learning process. As the app is now, it did not seem to affect the learning process enough to deem it necessary to include it for future teaching purposes unless the above named suggestions are changed.

6 REFLECTIONS AND SUGGESTIONS FOR REFINEMENT AND IMPROVEMENT

During the pilots themselves as well as during the analysis of the data, much insights and knowledge could be gained. As outlined, the eCraft2Learn ecosystem had an impact on several levels like motivation, knowledge, creativity, self-esteem and on other 21st skills of students. By this result, it can be concluded that eCraft2Lear clearly has contributed with its established ecosystem to a next generation education that shall be driven towards an increased hands-on learning, more self-steered and empowered students. eCraft2Learn fosters several learning dimensions that are wishful for the next generation. Still, some limitations are evident in terms of learning type of students, environment, interest of students and teachers, a.s.o. Of course every development requires time and resource investment. This holds also true for eCraft2Learn, but given the positive outcomes of this impact analysis it is *"... worth to do more."* (Student from Finnish Pilot)

Several issues and recommendations for improving the eCraft2Learn projects emerged and by fostering a change in education and empowering teachers, following recommendations and suggestions can be given to coaches that start an eCraft2Learn activity (or a similar digital making project).

Teachers and students highly value learning with hands-on activities. It has been pointed out, that a high value of the eCraft2Learn project lies in the fact that it allows students to learn and create in a tangible way. Students learn by trying and kind of fail and again learn from this, feeling also the success. Also, for students with special needs, hands-on making is a suitable and great way to learn.

Consequently it is recommended to integrate and foster **hands-on activities** in classroom as well as in informal learning settings.

Students highlighted the opportunity that they had to share their work and interact with a big audience. Also coaches agreed that it is important to share the work with others. Students showed a strong sense of ownership of the final artifacts and will (in most cases) be happy to explain every aspect of the technical solution and the related STEAM concept. Presenting to others will enhanced confidence, communication and collaboration skills. According to students, the presenting of their results was a valuable experience for them. Still, 76,91% of the formal pilot sessions did not include sharing in any extent. Also in the informal settings students went through sharing much less than any other pedagogical stage. It is recommended to **exploit different ways of sharing**, adapted to the possibilities and facilities of the teacher/school/ecosystem. Sharing does not need to be done only by project presentations in the end of the project when the artifact is ready. Instead, sharing can for example happen between different student teams when students are sharing ideas and knowledge and helping other teams to solve problems, students can keep a learning diary or update a blog or gradually build their instructions to be later uploaded to Thingiverse community.

They seem to recognize the importance of having the teachers by their side as coaches and facilitators and they clearly identify a difference in the "teacher-student" relationship developed in the eCraft2Learn lab in comparison with the ones developed in the context of their daily school life. It is recommended to **re-think the own role as teacher** and understand the importance of acting as coach. In this respect, teachers might also need to **get familiar with different pedagogical teaching methods** (i.e. co-learning and co-designing).

In rather tightly settled curriculums, it is expected that there might be tensions between the open nature of the eCraft2Learn learning intervention and the timely predefined (i.e. by the Greek Ministry of Education) school sessions. As a result, the students from the formal pilot site require more time

for the eCraft2Learn workshops. The teachers are trying to smartly solve this issue by integrating the eCraft2Learn workshop in 'the free and creative zone'. Given the high value of the eCraft2Learn pilots and similar projects it is recommended t**o request (teachers) /enable (ministries) more flexible time** for these type of projects.

Teachers and students need **time and proper pedagogical and technical support** in order to develop confidence in applying the new eCraft2Learn pedagogies and stances (the level of support differs from teacher to teacher, some feel more confident than others). Often that time is underestimated or does not correspond to the time scale of the curriculum planning.

In addition, teachers as well as students need **time to adapt a changed role behavior**: teacher to move from classical teaching role towards a coaching and facilitating role. The same holds true for students, actively steering his/her own learning moving away from passive 'consumption' of presented knowledge and solutions.

Also, we recommend to **promote a change in attitude** and performing the activities under the premise that failing does not mean that a student has not learned something, but that the student has the chance to recover after a failure and find ways to cope with the challenges and difficulties.

It has been observed that the time management of students is often difficult. Consequently we recommend that the teacher/coach **sets time frames for students**. Within these time frames the students decide and steer their learning process self regulated.

For students to feel the continuity of the project work and sense the "flow" in the work, it is great if **the sessions can be organized in longer working periods**. As each time in the beginning of a new session, time goes for collecting materials, recalling what was the stage of students' artifact creation, at least two 45-minute lessons as one session are recommended as students can work more effectively without so many pauses.

The support from an experienced **community group** that is well-versed on the topic is recommended. This applies not only in knowledge on how to use the technology but also the application in schooling context is of a great help for teachers that would like to launch projects.

Projects that have **connection to real life has positive influence on the motivation** of students. Thus, it is advised to let students choose their own projects that relate to their living environment. Especially projects that solve a specific identified problem shall be preferred.

Teachers noticed that **mixed groups lead to better learning experiences** and results than ability grouping of students. Consequently, it is advised to group students heterogeneously in terms of competences since students learn well from each other.

It is important to clearly outline the possible outcomes of these projects. Obviously teachers have some expectations when launching projects. It has to clearly said that not all students will be able to perform in the same way. It has been observed that all students will **get at least familiar with some technological skills and will improve skills in social and collaboration but some students will acquire deeper skills than others**.

It is recommended to **seek the support of other stakeholders** in the ecosystem (like director, other colleagues, parents, local companies, ...) since they can enrich the projects and its outcomes to a great extend. In specific the collaboration to other teachers is an obvious (and often practical) way on finding additional support.

Especially the request of getting **support in time** when needed requires sufficient teachers/coaches. Thus a collaboration with other teachers/coaches is highly recommended, also since they might also bring in different aspects.

In Finland the eCraft2Learn setting with all the devices and other electronic components wasn't set up in any particular classroom, thus the teachers needed to move the eCraft2Learn equipment from one classroom to another. This reassembling and taking down the setting took relatively much time from one 45-minute lesson which could have been used more effectively for the actual project work. Although it is shown that the eCraft2Learn ecosystem is flexible and can be used in different environments, **it is recommendable to have it set in one place** (for example a media or ICT room or a makerspace) where computers and screens are already set up and all other equipment is easily accessible.

Arduino handbook was useful in showing different examples of circuits with big variety of electronic components. Though, it did not have any help on how to create the programming code with Snap4Arduino. A **guide on how to create circuits with Arduino and code with Snap4Arduino** would help students to be more self-regulated. These instructions will be created for the second pilot round and can be found through the eCraft2Learn Unified User Interface.

Technical comment: the RPi3 boards are adequate for the needs of the project but faster units (like the ASUS Tinker Board) can be a promising alternative for the near future (More have been documented in D5.3). More documented technical feedback in D5.3

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ANNEX I – DATA COLLECTION MECHANISMS

All materials/templates used for the analysis i.e. student diary, observation forms, semi-structured interviews, teacher diary

Coach/Teacher semi structured interview guide

Notes for the interviewer

- Aim of the interview is to understand:
  - What are the impacts? What has changed on the levels of
    - social learning (i.e. way students interact with each other, ...),
    - educational (ie. taking over own learning, enhanced problem solving skills, ...)
    - cognitive (ie. knowledge on programming, knowledge on electronics, ...) understanding.
  - What are the added values to education? Did you notice differences to 'traditional' learning and teaching?
  - What needs to be changed? Any suggestions of improvements
  - Any issues or difficulties?
- Language: native Language or English – depending on what they feel more comfortable with.
- Possibly share the questions with the interviewee before the interview is done.
- Semi-structured interviews only give a raw guidance. The interviewee shall tell his/her story, framework a.s.o. In any case please **record** all interviews.
- EVERY question needs a proper answer, explaining WHY the answer is yes or no. Thus **please make sure to get some reasoning/justification/story from them**! (ie if a teacher/coach answers with 'Yes' when asked for his own perception of teaching, pl. do ask him in what way ... or ask for examples what exactly they have been observing, a.s.o.)
- Pl. make sure to explain the interviewee the reason for this interview and how the data is stored as well as the fact that all answers are anonym.

Team……..... Coach…….

Date of Interview ……..

A) Framing the setting

1. *** Can you describe and explain your projects (or group) and the respective setting?

Please make sure that you cover following questions:
Number of students:
Age of students:
Topic covered:
Materials used:
Description of classroom environment or setting:
Number of teachers/coaches supporting the projects in your team:

B) Pillar - Expectations

1. * What were your expectations when you started the workshop?
2. * Were these expectations met? Pl. explain why they were met, not met or even excelled.

C) Pillar - Impact social, skill and cognitive

1. *** Was there any change you were observing compared to the way they usually work or interact? i.e.
    a. In the way how the students were working?
    b. In the way how students were interacting with each other?
    c. Behaviours of single students that changed?
    d. Group dynamic of the class/group?

2. *** Were the students in the position to drive their own learning? i.e.:
    a. ... choosing their own topics/projects
    b. ... choosing their own materials they would like to use
    c. ... determine their own timing
    d. ... finding own ways to solve their problems
    e. ... choose if and with whom they would like to do their project

3. *** Did the workshop influence
    a. ... your own way of teaching or your own perception of your role as a teacher and coach?
    b. ... your perception of learning, skills and soft skills?
    c. ... your own hesitation/acceptance/fear towards technology?
    d. ... your view on future needs and abilities that students need to gain?
    e. ... the self-esteem of the students?
    f. ... each students individual development – if so how?
    g. ... any other influences that you possibly observed?

4. *** In your opinion, what do the students learn from the projects on a cognitive, social and soft skill (like teamwork, self-steered learning, ...) level?
   a. Did the projects increase the students' level of digital competency like:
      i. Programming (yes/no)
      ii. Making and/or Crafting (yes/no)
      iii. Electronics (yes/no)
      iv. Problem solving (yes/no)
      v. Internet search (yes/no)
      vi. Any other, if so which: _____
   b. Did the projects decrease the students hesitation/fear towards technology?
   c. Did the projects allow the students to be creative?
   d. Did the projects allow students to develop own solutions for issues they faced?
   e. Did the workshop offer opportunities for co-learning?
   f. Did you learn something new from the students?

D) Pillar - ecosystem

1. ** In your opinion: What would be the ideal conditions to implement projects like these, in terms of:
   a. The school environment (rooms, facilities, ...)
   b. Regulations and rules (ie. school curricula)
   c. Support from other teachers or headmasters or
   d. Support from parents or local community incl. ?
   e. Financial support
   f. Any other?

2. ** Were you able to observe the different stages of the pedagogical framework
   (1. Ideation - Exploring the world;
   2.Planning a project;
   3. Designing and building computer-supported artefact;
   4. Programming the built computer-supported artefact;
   5. Sharing.)
... and was this framework useful to you? Explain why or why not.

3. ** Have the projects facilitated interdisciplinary learning?

4. * Was the pilot recognized by other teacher colleagues, the headmaster or the parents. If so, what was the reaction?

E) Pillar - UUI

1. What advantages do you see in using the UUI?
   a) it provides a central place for project management
   b) it provides guidance towards a curated set of tools
   c) it is a means to gather data for learning analytics
   d) it is a nudge towards using our 5 pedagogic stages
   e) any other: _____
2. Have you observed any issues using the UUI?
3. Are there any improvements for the UUI that you would suggest? If so, which ones?

F) Topic Gender

1. ** Did you observe any differences between male and female students (i.e. in the interacting, the learning with the UUI or the project itself)?

2. Do you see the projects as a way to increase the share of girls/women in science and technology?

3. Would you launch different projects for male or female study groups? If so, why?

G) Topic Drop- out

1. *** How many students from your team dropped out of the workshop and do you know why these students dropped out?

ANNEX II – INDEPENDENT SAMPLES T-TEST (QUANTITATIVE DATA ANALYSIS)

Table 90. Independent samples T-test group statistics, Informal site, pilot round 1 and pilot round 2 analyzed together, comparison between countries

	Finland			Greece			Independent samples T-test statistics		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	df	t	p
Collabration	20	2.65	0.37	38	2.92	0.18	24.21	-3.107	.005
Problem Solving	20	2.40	0.45	38	2.76	0.48	56	-2.820	.007

Table 91. Independent samples T-test group statistics, Informal site, pilot round 1 only, comparison between countries

	Finland			Greece			Independent samples T-test statistics		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	df	t	p
Collabration	10	2.65	0.41	20	2.93	0.18	10.82	-2.015	.069
Problem Solving	10	2.45	0.50	20	2.80	0.34	13.36	-2.004	.066

Table 92. Independent samples T-test group statistics, Informal site, pilot round 2 only, comparison between countries

	Finland			Greece			Independent samples T-test statistics		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	df	t	p
Collabration	10	2.65	0.34	18	2.92	0.19	12.31	-2.301	.040
Problem Solving	10	2.35	0.41	18	2.72	0.60	26	-1.741	.093

Table 93. Independent samples T-test group statistics, Formal site, pilot round 1 and pilot round 2 analyzed together, comparison between countries

	Finland			Greece			Independent samples T-test statistics		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	df	t	p
Problem Solving	56	2,21	0,63	35	2,57	0,47	86,05	-3,076	0,003
Making	56	2,32	0,58	37	2,63	0,52	91	-2,642	0,010

Table 94. Independent samples T-test group statistics, Formal site, pilot round 1 only, comparison between countries

	Finland			Greece			Independent samples T-test statistics		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	df	t	p
Problem Solving	28	2,14	0,56	19	2,61	0,39	45	-3,116	0,003
Making	28	2,26	0,53	20	2,75	0,32	45	-3,947	0,000

Table 95. Independent samples T-test group statistics, Formal site, pilot round 2 only, comparison between countries

	Finland			Greece			Independent samples T-test statistics		
	N	Mean	Std. Deviation	N	Mean	Std. Deviation	df	t	p
Problem Solving	28	2,29	0,70	16	2,53	0,56	42	-1,198	0,237
Making	28	2,38	0,62	17	2,49	0,66	43	-0,559	0,579

LINEAR MIXED-EFFECT MODEL

The LME investigates simultaneous effects of multiple variables and takes into account both fixed and random effects. The equation used in the LME is explained below according to our data:

$$y_{ij} = \beta_1 + \beta_2 X_{1}^{1} + \beta_3 X_{2}^{2} + b_i + e_{ij}$$

where,

y = sum of variable, (collaboration and problem solving for the informal site, problem solving and making for the formal site)

X_i^1 = country, (0 = Finland, 1 = Greece)

X_i^2 = pilot round, (1 = Round 1, 2 = Round 2)

Consequently, in our data the dependent variable was in the first model *collaboration* and in the second model *problem solving*. In the formal site, the first model looked into *problem solving* and the second model into *making*. The subject variable was the student class and the parameters the country and the pilot round.

Table 96. The linear mixed-effect model for formal site

	Random coefficient model + interaction for problem solving	Random coefficient model + interaction for making
Fixed Effects		
Intercept	2.60 (.000)	2.61 (.000)
Country	-0.36 (.005)	-0.31 (.114)
Pilot Round	-0.06 (.623)	0.03 (.855)
Random Effects		
$\sigma^2_{residual}$	0.33 (.000)	0.31 (.000)
$\sigma^2_{intercept}$	0.00[a] (.)	0.00 (.977)
$\sigma^2_{country*pilot\ round}$	0.00[a] (.)	0.01[a] (.)
-2LL	164	160

a. Covariance parameter is redundant and therefore test statistics cannot be computed.

Table 97. The linear mixed-effect model for informal site

	Random coefficient model + interaction for collaboration	Random coefficient model + interaction for problem solving
Fixed Effects		
Intercept	2.92 (.000)	2.72 (.000)
Country	-0.27 (.000)	-0.36 (.007)
Pilot Round	-0.005 (.937)	0.09 (.490)
Random Effects		
$\sigma^2_{residual}$	0.07 (.000)	0.22 (.000)
$\sigma^2_{intercept}$	0.00[a] (.)	0.00 (.)
$\sigma^2_{country*pilot\ round}$	0.00[a] (.)	0.00[a] (.)
-2LL	19	82
b. Covariance parameter is redundant and therefore test statistics cannot be computed.		

ANNEX III – DETAILED RESULTS OF TEACHER DIARIES FROM GREEK PILOT SITES

Informal - 1st round

Ideation/ Imagine. Did the students go through this stage today?				
Group	No	Yes	Yes but to a limited extent	Group Sum
Group 1	0	7	1	8
Group 2	0	6	1	7
Group 3	0	0	1	1
Group 4	0	3	3	6
Group 5	1	5	2	8
Group 6	0	4	0	4
Group 7	1	5	2	8
Group 8	0	3	2	5
Total Sum	2	33	12	47
Planning. Did the students go through this stage today?				
Group	No	Yes	Yes but to a limited extent	Group Sum
Group 1	0	5	3	8
Group 2	1	3	3	7
Group 3	0	0	1	1
Group 4	0	3	3	6
Group 5	5	0	3	8
Group 6	0	3	1	4
Group 7	1	5	2	8
Group 8	1	2	2	5
Total Sum	8	21	18	47

Create. Did the students go through this stage today?				
Group	No	Yes	Yes but to a limited extent	Group Sum
Group 1	0	6	2	8
Group 2	1	6	0	7
Group 3	0	0	1	1
Group 4	0	3	3	6
Group 5	1	6	1	8
Group 6	0	3	1	4
Group 7	1	4	3	8
Group 8	0	5	0	5
Total Sum	3	33	11	47
Program. Did the students go through this stage today?				
Group	No	Yes	Yes but to a limited extent	Group Sum
Group 1	1	5	2	8
Group 2	3	2	2	7
Group 3	0	0	1	1
Group 4	1	1	4	6
Group 5	2	4	2	8
Group 6	0	3	1	4
Group 7	2	2	4	8
Group 8	0	1	4	5
Total Sum	9	18	20	47
Share. Did the students go through this stage today?				
Group	No	Yes	Yes but to a limited extent	Group Sum
Group 1	1	3	4	8
Group 2	1	6	0	7
Group 3	0	0	1	1
Group 4	1	2	3	6
Group 5	3	4	1	8
Group 6	0	2	2	4
Group 7	3	3	2	8
Group 8	3	0	2	5
Total Sum	12	20	15	47

	In the following scale….(1 = traditional teacher ….5 = coach) ….where do you place your role in the workshop based on today's experience?						
Group	1	2	3	4	5	No Answer	Group Sum
Group 1	0	0	1	4	3	0	8
Group 2	0	0	2	3	2	0	7
Group 3	0	0	0	1	0	0	1
Group 4	0	1	0	4	0	1	6
Group 5	1	1	1	5	0	0	8
Group 6	0	0	3	1	0	0	4
Group 7	0	0	6	2	0	0	8
Group 8	0	0	3	2	0	0	5
Total Sum	1	2	16	22	5	1	47

Informal - 2nd round

Ideation/ Imagine. Did the students go through this stage today?				
Group	No	Yes	Yes but to a limited extent	Group Sum
Group 2	0	1	0	1
Group 4	0	2	2	4
Group 5	1	1	1	3
Group 7	0	0	1	1
Team 8	0	0	1	1
Total Sum	1	4	5	10

Planning. Did the students go through this stage today?				
Group	No	Yes	Yes but to a limited extent	Group Sum
Group 2	0	1	0	1
Group 4	0	1	3	4
Group 5	1	0	2	3
Group 7	0	0	1	1
Team 8	0	0	1	1
Total Sum	1	2	7	10

Create. Did the students go through this stage today?				
Group	No	Yes	Yes but to a limited extent	Group Sum
Group 2	1	0	0	1
Group 4	0	1	3	4
Group 5	1	1	1	3
Group 7	1	0	0	1
Team 8	0	1	0	1
Total Sum	3	3	4	10

Program. Did the students go through this stage today?				
Group	No	Yes	Yes but to a limited extent	Group Sum
Group 2	1	0	0	1
Group 4	1	1	2	4
Group 5	2	0	1	3
Group 7	1	0	0	1
Team 8	0	1	0	1
Total Sum	5	2	3	10

Share. Did the students go through this stage today?			
Group	No	Yes but to a limited extent	Group Sum
Group 2	1	0	1
Group 4	1	3	4
Group 5	2	1	3
Group 7	1	0	1
Team 8	1	0	1
Total Sum	6	4	10

Formal - 1st round and 2nd round

Ideation/ Imagine. Did the students go through this stage today?			
Group	Yes	Yes but to a limited extent	Group Sum
Group 1	9	0	9
Group 10	2	0	2
Group 2	6	0	6
Group 3	6	0	6
Group 4	7	0	7
Group 5	7	0	7
Group 6	3	0	3
Group 7	3	0	3
Group 8	2	1	3
Group 9	3	0	3
Total Sum	48	1	49

Planning. Did the students go through this stage today?			
Group	Yes	Yes but to a limited extent	Group Sum
Group 1	9	0	9
Group 10	2	0	2
Group 2	6	0	6
Group 3	6	0	6
Group 4	6	1	7
Group 5	7	0	7
Group 6	3	0	3
Group 7	3	0	3
Group 8	3	0	3
Group 9	3	0	3
Total Sum	48	1	49
Create. Did the students go through this stage today?			
Group	Yes	Yes but to a limited extent	Group Sum
Group 1	5	4	9
Group 10	0	2	2
Group 2	4	2	6
Group 3	4	2	6
Group 4	3	4	7
Group 5	3	4	7
Group 6	1	2	3
Group 7	1	2	3
Group 8	1	2	3
Group 9	0	3	3
Total Sum	22	27	49

Program. Did the students go through this stage today?				
Group	No	Yes	Yes but to a limited extent	Group Sum
Group 1	2	3	4	9
Group 10	0	2	0	2
Group 2	2	2	2	6
Group 3	2	3	1	6
Group 4	2	1	4	7
Group 5	2	4	1	7
Group 6	0	3	0	3
Group 7	0	3	0	3
Group 8	0	3	0	3
Group 9	0	3	0	3
Total Sum	10	27	12	49
Share. Did the students go through this stage today?				
Group	No	Yes	Yes but to a limited extent	Group Sum
Group 1	5	0	4	9
Group 10	2	0	0	2
Group 2	4	1	1	6
Group 3	4	0	2	6
Group 4	5	1	1	7
Group 5	4	1	2	7
Group 6	2	0	1	3
Group 7	2	0	1	3
Group 8	2	0	1	3
Group 9	2	1	0	3
Total Sum	32	4	13	49