eCraft2Learn

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

Deliverable D5.2

Report on the capacity building workshops for teachers

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EXECUTIVE SUMMARY

This report describes the capacity building workshops that took place in the established eCraft2Learn labs (D5.1) in Greece and in Finland targeting teachers. The workshops were carried out in two pilot rounds involving teachers active both in formal and informal education. The research team elicited feedback on training experiences, the strong and the weak aspects of the eCraft2Learn tools, the challenges that they faced, their understanding of the pedagogical ideas underpinning the eCraft2Learn initiative, and finally their confidence and preparedness for undertaking the role of the coach using the eCraft2Learn tools and technologies in the forthcoming pilot workshops with students. Their recommendations and suggestions for improvements were also documented.

1 INTRODUCTION

This report focuses on the implementation of the capacity building workshops where the teachers/trainees experience first-hand the kinds of activities that can be developed within the eCraft2Learn ecosystem towards computer-supported artefact creation. Teacher training follows the axiom ‘teachers teach as they are taught and not as they are told to teach’. The eCraft2Learn workshops approach teachers as learners first and teachers second, modelling the process of learning for students and showing teachers/trainees what intrinsic motivation, curiosity and creativity is expected.

The capacity building workshops took place in an iterative way involving teachers and educators from Greece and Finland. The first round of teacher training took place in September 2017 with the aim to familiarize the teachers with eCraft2Learn methodology, technologies, tools and resources and to prepare them for the first pilot round with the students. The second round was conducted after the first pilot with students, with the aim to address possible issues that emerged, and to inform the participant teachers about recent developments in the eCraft2Learn learning ecosystem.

To evaluate the capacity building workshops, a questionnaire with open questions, semi-structured interviews and field notes from group discussions were used, which allowed participants to provide feedback on their experiences, on the overall content, methodology and arrangements of the workshop. An effort was also made to engage the participants in discussions at the end of each session and to collect additional feedback on individual sessions and issues that emerged during that specific session. The feedback gained during the 1st student pilot round informed the teacher training content and methodology in the 2nd round of the capacity building workshops. It is worth noting that a number of other factors (i.e. recent developments in the eCraft2Learn ecosystem, comments raised during the pilot studies, observations made by the research team) also influenced the way the 2nd teacher training round was organized in Greece and in Finland.

Chapter 2 and **Chapter 3** focus on the way the capacity building workshops were organised in Greece and Finland, taking into account teachers’ needs and interests. The two (2) training rounds are described and detailed information is provided about each session. The process of familiarizing the teachers with the eCraft2Learn set up, technologies/tools and pedagogical is described.

Chapter 4 and **Chapter 5** summarize the feedback obtained by trainees after the 1st and the 2nd capacity building workshop in Greece and in Finland. The additional comments that were raised during the training workshops are also presented in sections 4.3 and 5.3. These comments arose in the context of discussions with the group of teachers that took place periodically and were reported after the end of the sessions.

Finally, **Chapter 6** presents the conclusions of the experiences gained and indicates areas that are exploitable for future workshop organization.

The work described in this report informs and assists additional project tasks and work packages. More precisely, the capacity building workshops were of great significance for the smooth implementation of Task 5.3, the deployment of the small-scale pilots with the students in Greece and Finland (WP5). It was important to familiarize the teachers with both the technical and the pedagogical core of the eCraft2Learn ecosystem, taking into account their needs and interests. The training workshops in Greece and in Finland were adjusted to the needs of the participant trainees/teachers while emphasis was placed on boosting their confidence and preparing them to undertake the role of coach in the forthcoming pilots. The frequent group discussions that were periodically and deliberately initiated brought into focus useful feedback that supported the development of the open education resources (OERs) (WP3, D3.3). Their comments to some extent also showed the way towards updating the manual for craft- and project-based learning STEAM training for teachers (WP3, D3.4). The technical difficulties that were encountered (i.e. with artificial intelligence (AI) programming, the learning analytics tool (LA), RPi3s crashes and delays) were communicated to WP4 team, opening up the way for refinements and new developments to meet end-users' needs (see also D5.3). It is worth noting that the organization of the capacity building workshops, the discrete adaptation of the training content to trainees' needs, the on-going documentation of feedback that can allow quick adjustments and the efforts to boost teachers undertaking the role of the coach in a maker space (the eCraft2Learn lab) using new technologies and tools are few but important aspects that can be disseminated, thus informing future training programs (WP6).

In the following chapters, the use of the word "teachers" refers to the trainees (formal teachers, informal teachers, educators) in the capacity building workshops in Greece and in Finland. The use of the word "trainers" refers to the project team members that run the capacity building workshops.

2 DESCRIPTION OF THE CAPACITY BUILDING WORKSHOPS IN GREECE

This chapter describes the capacity building workshops that took place in Athens, Greece in two rounds. The trainees were introduced to the eCraft2Learn ecosystem in a similar way that they were expected to work with the students later on in the pilots. It was of great significance to support them in going through the 5 stages of the craft- and project-based methodology, exploring the tools/technologies that can be used for computer-supported artefact construction in each stage and helping them explore what intrinsic motivation, curiosity and creativity was expected.

General considerations that shaped the training plan of the 2 training rounds:

1) **Respecting teachers' time**: the teachers could not devote a large amount of their time to the training. Thereby, our plan for the workshop had to take into account the whole groups' time constraints and to come up with a realistic timeframe.
2) **Teachers were novices and needed support in order to feel confident**: the participant teachers did not have previous experience in the eCraft2Learn tools/technologies. For most of them the idea of coaching was also something new. A challenge for the training team was to support them in exploring new tools and pedagogical practices without limiting the open nature of the workshop as it is engineered through the eCraft2Learn methodology that is put forward. It was important for the training team to equip the trainees with the required technical skills and confidence in order to take an active role as coaches in the forthcoming pilots.
3) **To help them explore the different tools/technologies integrated into the eCraft2Learn ecosystem**: it was equally important to scaffold teachers in exploring the different tools/technologies that support each stage of the eCraft2Learn methodology and to trigger their interest in doing increasingly more complex projects, combining different tools and entering into different subject domains. Knowing the available tools would significantly impact the stages of ideation and planning and as a result the making process.

Regarding the participant teachers/trainees, prior to the workshop an open invitation (in the form of an online questionnaire) was sent out in April 2017 (see also D5.1) to the teaching community in Greece, exploiting Edumotiva's network but also the communication channels of the Panhellenic school network. Excluding incomplete applications, 53 teachers expressed their interest in participating. In their application they attached a short statement of interest and key information about their teaching experience in formal or informal education. The teachers that were not based in Athens or nearby regions were not selected. A total of 32 teachers were invited to a face to face meeting (that was organised twice to facilitate teachers' time constraints on May 17 and May 19, 2017). In the context of this meeting, the objectives of the projects were described and detailed information was presented regarding the forthcoming capacity building workshop. The research/implementation team was open to teachers' questions, elaborating on the type of commitment that is needed from their side: it was highlighted that the teacher training included also the stage of the pilots with the students, the deployment of the eCraft2Learn tools and resources in real educational settings. After the elaboration on this and the addressing of teachers' queries, 24 teachers agreed to participate. Prior to the start of the training 4 teachers withdrew due to work responsibilities and for family reasons.

The first training workshop was carried out with 20 teachers and lasted approximately twenty (20) hours. The second training workshop was conducted with 10 teachers and lasted approximately sixteen (16) hours (see Table 1). The eCraft2Learn lab was also available to the teachers for additional practice if needed.

Table 1: Information about the trainees per pilot round in Greece

Session No.	**1st training round**	**2nd training round**
Number of trainees	20	10
Female trainees	10	5
Male trainees	10	5
Formal	7	5
Informal	13	5
Number of sessions & hours	5 sessions (20 hours)	5 sessions (16 hours) + available lab for practice
Regarding eCraft2Learn tools/technologies	No previous experience in the eCraft2Learn tools and technologies/High Interest in STEM education	All the teachers had participated in the 1st round of pilots (apart from one (1) who already had experience in programming and DIY electronics)

The trainees came from different scientific fields, namely Science (Biology, Physics), Technology, Electronics, ICT, Graphic Arts. They had not been exposed to the eCraft2Learn tools/technologies before.

The following sections (2.1 and 2.2) describe in detail the way the two (2) pilot rounds were organised in Athens, Greece. The workshops were carried out in the eCraft2Learn labs established in Athens as it was important for the teachers to start developing their skills in the appropriate context and learning environment, carefully-designed to host and inspire the making process.

2.1. Round 1

The first (1st) teacher training workshop took place in Athens, Greece from September to October, 2017. Overall, it lasted twenty (20) hours and was carried out in five (5) sessions of four (4) hours each. In total, twenty (20) teachers were trained and introduced to the eCraft2Learn learning ecosystem. Briefly, the first session focused on the pedagogical ideas and the five (5) stages of craft- and project-based methodology developed in the context of the project (for more details see D3.1). The second, the third and the fourth session focused more on practical tasks using the eCraft2Learn technologies.

The last session was dedicated to free experimentation with the introduced technologies and a discussion on pedagogical issues and the forthcoming pilot with the students.

Table 2: Description of the training sessions (Round 1, Greece)

Session No.	Short descriptions
Session 1 10:00-14:00	Ice breaking activities + Familiarisation with the eCraft2Learn pedagogical methodology + Familiarisation with electronic elements of the technical core Rpi + Arduino + Setting up the work stations +Basic wiring
Session 2 10:00-14:00	Arduino board + Wiring + Visual programming environments
Session 3 10:00-14:00	Servomotors + DIY (motor driving) circuits + GPIO visual programming control methods
Session 4 10:00-14:00	3D modelling + slicing + 3D printing + Thingiverse
Session 5 10:00-14:00	Improving remote control techniques + Pedagogical considerations and reflections

The content of the five (5) sessions and the methodology that was followed is described in detail below. Comments and requests raised by the participant teachers during the training were taken into account and informed the deployment of the training sessions.

Session 1

The 1st session took place on September 9, 2017 in Athens at the formal pilot site, 1st EPAL of Korydallos, where the eCraft2Learn lab had been established. The session lasted 4 hours from 10:00 am to 14:00 pm. It started with some ice breaking activities that aimed at bringing the team members closer and getting to know one-another. Time was then allocated to forming teams. In total, eight (8) groups of two (2) or three (3) were formed. It is worth noting that the teachers were introduced to the eCraft2Learn ecosystem in a similar way that they were expected to work with the students. Thus, forming teams was of high priority as well as showing the teachers in every stage what intrinsic motivation, curiosity and creativity was expected.

The participant teachers were then introduced to the five (5) stages of the craft- and project-based methodology (see Figure 1). The eCraft2Learn ecosystem starts with students' own ideas, gained by exploring the world (stage 1). Then a planning stage follows where the students explore the resources available and needed for the realization of their idea (stage 2). The students then engage in a making process that includes brainstorming, iterative designs, trial and error and reflection on designs (stages 3 and 4) with the aim of building (using the available tools, technologies and resources) interactive artefacts; and finally share their finished projects with the open community (stage 5).

After receiving the necessary information about the five (5) stages, in groups the teachers were encouraged to discuss each stage, its importance, relevance and applicability in real classroom settings. A set of questions was put to them with the aim of challenging their thinking and helping them form their concerns, thoughts and ideas. This task provided excellent opportunities to the research/training team to present the eCraft2Learn pedagogical considerations, the *Maker Movement* trend in education and the Do-It-Yourself culture, avoiding lectures and long theoretical discussions. The five (5) stages were analysed, discussed, composed and decomposed in the context of group discussions. A plenary discussion took place at the end with the representative of each group reporting the main issues discussed and the research team/trainers commenting on them in a fruitful and non-judgemental way. The questions put to the teachers and the pictures/diagrams that they were provided with and asked to comment on appear below.

What do you think about the five proposed stages?

Which stages are more important to you and why?

Any stages that might be skipped/omitted?

Any additional stage you would like to include?

Would you suggest a different sequence of stages?

Do you think this methodology is applicable in the school reality?

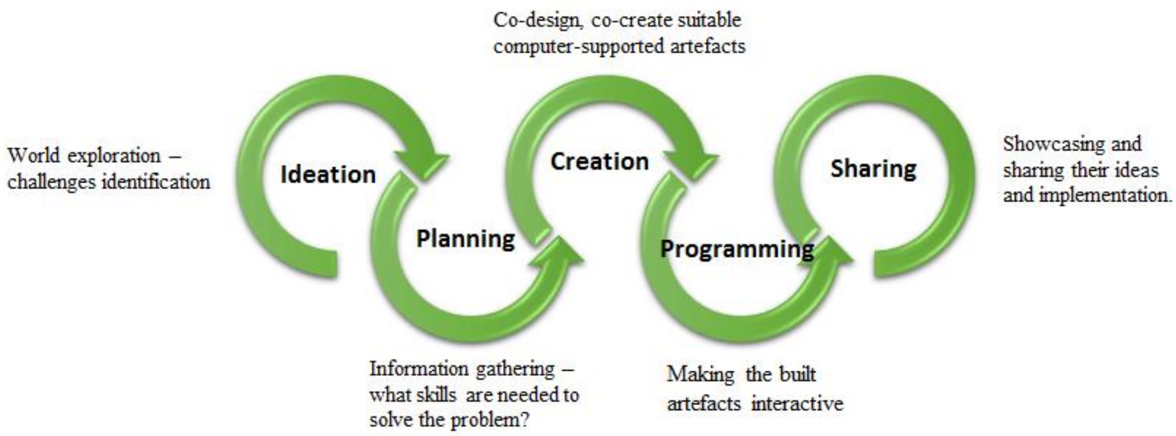

Figure 1: The 5 stages of the craft- and project-based methodology

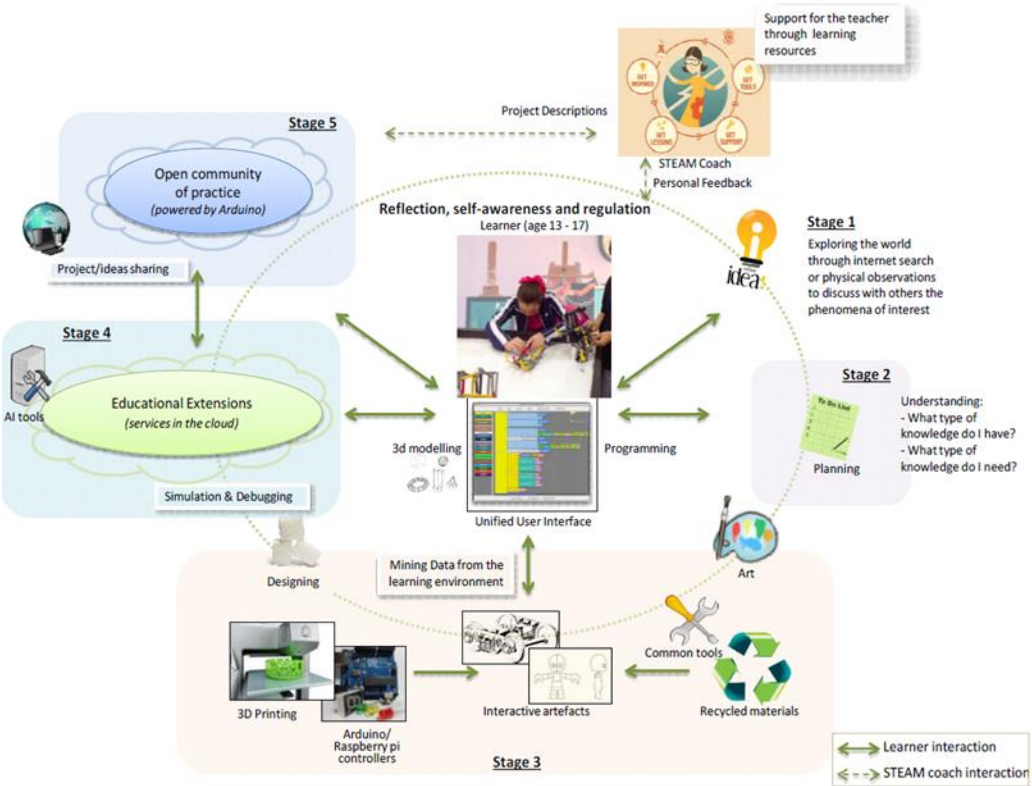

Figure 2: The five stages and the role of the students and the coach

The pedagogical discussion lasted approximately two (2) hours. The teachers documented their thoughts, ideas and concerns and all together were engaged in an interesting discussion that aimed at shedding light on the eCraft2Learn learning intervention that had just started. From the pedagogical foundations, the groups of trainees smoothly entered the technical core of the eCraft2Learn learning ecosystem. Following recommendations provided in D5.1 and D3.4, the next step was the setting up of the work stations. The teachers were given a storage pack which included the necessary equipment and were encouraged to set up the Raspberry Pi (RPi) board, to connect the monitor, the keyboard and the mouse, to access the Wi-Fi internet connection and to explore the Raspbian environment. The idea behind this stage, which took place in groups, was to help teachers from the beginning explore the main technologies that are included in the eCraft2Learn learning ecosystem. Engaging the teachers in the establishment of the work stations was also considered an important step towards helping them become adept in building similar work stations in other educational environments in the future. The eCraft2Learn team provided all the necessary support without limiting the exploratory nature of this task. The picture below demonstrates part of this process.

Figure 3: Setting up the work stations in the eCraft2Learn lab (formal pilot site)

After setting up their work stations, the trainees were introduced to the Arduino Uno boards, the Arduino software and the visual block programming tools through simple tasks. The trainees were also encouraged to look for information online, to look at exploratory illustrations of the Arduino Uno board and work in groups to 'demystify' how the Arduino board works, how it is powered, how digital inputs and outputs are connected to the available pins and more. A document with guidelines had been designed to guide the trainees through several Arduino-related activities (see Appendix, Annex I).

Figure 4: Exploring and connecting the Arduino boards

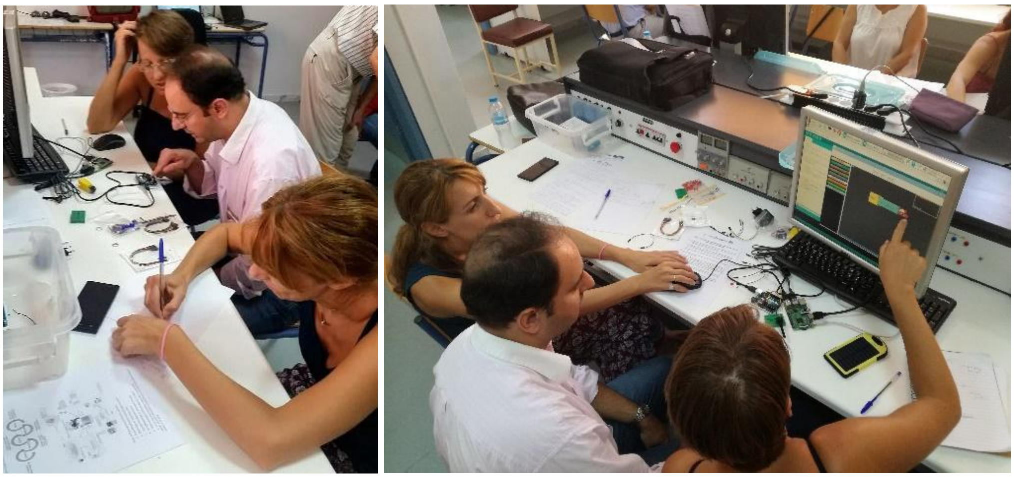

Figure 5: Designing solutions and exploring visual programming environments

The trainees were encouraged to perform simple tasks that aimed at helping them:

1. Understand what an Arduino board is and to be engaged in relevant discussions moderated by the trainers
2. Understand how to connect the Arduino Uno to the Raspberry Pi board and verify the connection settings through the Arduino IDE environment
3. Become familiar with the basic components of their Arduino kit: inputs, outputs, resistors, wires and breadboards and understand the role of the breadboards, the solderless circuit prototyping boards that one can plug wires and components into
4. Explore how to wire the Arduino board, connect the LEDs on the pins and use the LEDs in series with resistors (of typical values of 500Ω or 1kΩ) to avoid any damage
5. Explore how to do the necessary wiring to exploit the analogue inputs of the Arduino board like the A0 pin by feeding it from the GND pin, the 5V pin or the 3.3V pin, respectively
6. In conjunction with steps 4 and 5, become familiar with typical basic examples included in the Arduino IDE environment, like the “blink” or the “analogreadserial” environment so as to blink a LED or read a simple analogue value (corresponding to 0V, 3.3.V or 5V), by using the Serial Monitor tool of the Arduino IDE
7. Become familiar with visual programming equivalents of the Arduino IDE environment (like Ardublock and Snap4Arduino) through tasks that focused on making a LED blink on and off for one second at a time. *The trainees further experimented by making it blink on and off at different rates by modifying the on and off periods.*
8. Acquire further skills in visual programming by connecting the centre pin of a potentiometer to the A0 pin of the Arduino and the other 2 pins of the potentiometer to the GND and 5V pins of the Arduino, respectively) and by inspecting the readings while turning the axis of the potentiometer. The necessary code, equivalent to the “analogreadserial” example, had to be composed using the Ardublock tool
9. Better understand the physical world by replacing the potentiometer of step 8 with a photoresistor (in series with a 1kΩ or a 10kΩ resistor) to the 5V, the A0 and the GND pins

respectively, so as to make the Arduino intercept the light level changes in the classroom. The necessary code had to be created via the Ardublock or the Snap4Arduino environments

The groups of trainees carried out most of these tasks patiently, going deeper into aspects that attracted their interest, learning from failures, exchanging ideas and thoughts, designing solutions on paper and asking for support and clarification from the trainers. The document with the guidelines that had been drawn up was also used as a reference document for the next sessions and for their personal practice outside the eCraft2Learn lab. No pressure was put on the trainees to go through all the tasks that are described in the worksheet. Tasks that were not completed were revisited in the following training session.

Session 2

The 2nd session took place on September 16, 2017 in Athens at the formal pilot site, 1st EPAL of Korydallos, where the eCraft2Learn lab had been established. The session lasted 4 hours from 10:00 am to 14:00 pm and was a continuation of the previous session. The trainees continued exploring the Arduino boards and using them in the context of small simple tasks (see Appendix, Annex I).

As the session was progressing, the teachers/trainees were encouraged to focus more on the visual programming environment of Snap4Arduino. Following trainees' requests once again, a document with guidelines was provided for this session (see Appendix, Annex I). The teachers used it as a reference document during the training session, stating that it would be useful as a reference tool for their future educational endeavours. The trainees were encouraged to explore the visual blocks under the Control and Motion category in the Snap4Arduino and to create a script that makes the arrow sprite (in the stage of Snap4Arduino) move forward and backward. They also experimented with the custom block. They further practiced how to save and export a project and how to make Arduino interactively communicate with the Snap4Arduino environment.

At a second stage the trainees were encouraged to connect a potentiometer in their Arduino board and to make the sprite in the stage of the Snap4Arduino environment turn according to the potentiometer settings. They were then encouraged to repeat this task by making an angle servo (that has been connected to the Arduino board) as well as a photoresistor turn certain angles according to the potentiometer settings. They then freely experimented with similar tasks, exploring further the interactive communication between the Snap4Arduino environment and their Arduino board.

The session concluded with a discussion with the teachers aimed at gaining an insight into their thoughts, ideas for educational applications, concerns and needs.

Session 3

The third session was entitled "Introduction to Remote Control of ServoMotors Using RPi3 and Arduinos and Tablet Devices". The aim was to provide the trainees with opportunities to delve deeper into electronic circuit making, to further explore the servomotors and to prepare them to control their electronic artefacts remotely by using visual programming environments. The 3rd session took place on September 30, 2017 and lasted 4 hours from 10:00 am to 14:00 pm.

The first activity of this session was the familiarisation with servomotors of moderate size so as to make them work using an Arduino Uno unit attached to the RPI3 unit. This setup requires the L293D driving circuit. Indeed, typical gear motors demand higher amperage to work than a LED, so we cannot directly connect them to the Arduino's digital outputs. In order to cover the gap, a dedicated circuit (usually the L293 chip) has to be used. The L293 chip can support up to 2 small motors (with the ability to independently rotate in both directions) or up to 4 small motors (each rotating in one direction only). The wiring diagram of the L293 is symmetrical and therefor easy to remember. As such, trainees could control a gear motor by connecting the digital pins 4 and 5 of the Arduino board to the L293D chip, making the rest of the wiring and using the Snap4Arduino environment to compose the necessary code blocks and test the results. Using this method, amperage values up to 1A can be handled per channel, while in the absence of the driving circuit no more than 50mA can be handled safely.

References to external resources were also made and the trainees were encouraged to continue their practice by consulting online resources (i.e. on the Instructables platform, the Raspberry Pi documentation page, sensorgnome.org and more - see Appendix, Annex I) and were supported by the session trainers.

In the context of this session, the trainees were also introduced to the GPIO functionality of the RPi3 and the use of the MIT Scratch environment was encouraged to control the GPIO pins of the RPi3 using broadcast messages. The steps that were undertaken involved: 1) the activation of the GPIO server, 2) the setting of a specific pin to act as an input or output and 3) the assignment of a specific value to them. Building on this practice, the trainees made a LED (attached to pin GPIO18) to blink, and by using GPIO pins GPIO23 and GPIO24, they had to make a servo motor to rotate clockwise and counter-clockwise for some seconds.

By using the installed VNC client application, under the "Internet" category of the basic RPi3 menu, trainees had access to the RPi3 unit of their neighbouring team and were able to repeat the same tests but now controlling the servomotors and the LEDs of their neighbouring team via the network.

The session continued with an introduction to the MIT App Inventor environment (http://appinventor.mit.edu/explore). This environment was chosen as it offers opportunities for remote control using tangible screens and is also among the tools available through the Unified User Interface. The teachers were supported in exploring the aforementioned environment and were challenged in programming a counter variable that changes values according to the buttons pressed.

The session concluded with a discussion with the teachers in order to set the plan in place for the forthcoming training sessions and to exchange ideas on the pedagogical application of the technologies introduced in the context of open projects for robotic artefact construction.

Session 4

This session was devoted to 3D modelling and printing tasks. It took place at the formal pilot site in Athens on October 7, 2017 and was scheduled to last four (4) hours (from 10:00 am to 14:00 pm). The session started with a brainstorming task. The trainees were invited to brainstorm a whole slew of words that came to mind from the term 3D modelling and 3D printing. The words were listed by the trainer on the whiteboard, and smoothly grouped together according to how they are related to one another and the way they are related to 3D modelling and printing. This spontaneous 'word-storm' task, that was carried out without any judgement or evaluation of the suggestions, helped the trainer introduce the topic to the trainees, explain main terminology, introduce the related eCraft2Learn technologies and provide information about key concepts included in the 3D printing that they would be involved in (i.e. slicing, Fused Deposition Modelling, etc). It is worth noting that while the trainer was revealing information, the trainees played an active role trying to connect the words, posing questions, providing examples and/or raising new topics for discussion based on their experiences and scientific or educational articles that they had read, and so on. This discussion was important in order to set the theoretical foundations upon which practical exercise could take place. Open Educational Resources (explanatory pictures and videos) that demonstrated part of the 3D modelling and printing process were also used to familiarize the trainees with the practices underpinning 3D modelling and printing. Ultimately, the 'word storm' brought also into focus the spectrum of the applications of 3D printing and the trainees further enriched the discussion based on information that they had recently come across, web articles that they had read, real life examples and much more.

As in the previous sessions, a document with guidelines had been designed to support the trainees to perform simple 3D modelling tasks and become familiar with the TinkerCAD environment (see Appendix, Annex I). The trainees created accounts on TinkerCAD (one per group), worked collaboratively while also receiving support from the session trainers. Initially, trainees were invited to design some simple 3D models and concurrently to explore the basic features of the TinkerCAD environment. The idea was to confidently work on simple tasks and then following their interests, to start exploring more advanced aspects in 3D modelling in TinkerCAD. The tasks that were carried out aimed at helping them

- understand how a shape is inserted into the work plane and is customized
- explore the concepts of 'solids' and 'holes' and how the shapes (solids and/or holes) are combined/grouped together using the available tools
- practically understand the concept of 'divide and conquer' which is behind the 3D modelling in TinkerCAD. Practically analysing the final object from a geometrical perspective, dividing it in smaller units, which were 3D modelled and grouped together in the end (see also D3.4, section 3.4)
- experiment with the use of more than one work plane
- understand how a project in TinkerCAD can be saved, imported to the slicing tool and transferred to the 3D printer (in line with guidelines provided in D3.4)

- share their model in Thingiverse (https://www.thingiverse.com/)

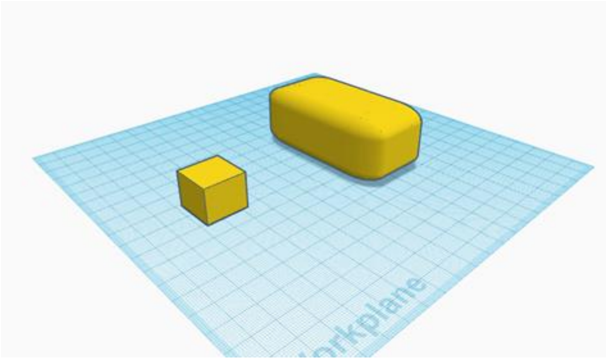

Figure 6: Example of a simple task: "From a yellow cube to a butter stick: Can you make it by customizing the initial shape?"

While the trainees were going through the tasks, they were advised to try out their own ideas or to freely extend the scenario of the task. They were then encouraged to prepare their own 3D models and to implement their own ideas. Among the models that were designed were various models of houses, boats, buttons and rings. While half of the trainees were working on 3D modelling tasks, the rest were introduced to the different parts of the 3D printer and were asked to prepare a gcode file (in Cura software) and to activate a 3D printing task with the support of the trainer (and vice versa).

Figure 7: Exploring TinkerCAD in groups

Figure 8: The 3D model of the eCraft2Learn boat

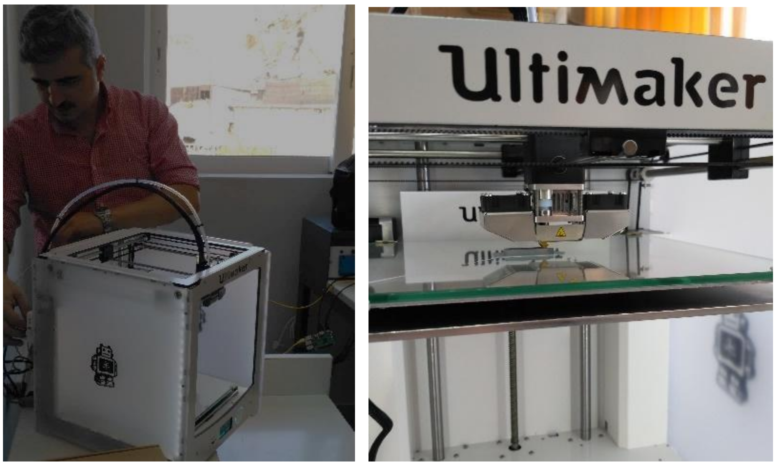

Figure 9: Presenting the components of the 3D printer and carrying out 3D printing tasks

Towards the end of the session, the teachers were encouraged to imagine how 3D modelling and printing can support the construction of a computer-supported artefact. This session lasted longer than had been originally scheduled; this was mainly due to the fact that 3D printing tasks (even for models that are significantly scaled down) are time consuming and that the trainees were enthusiastically immersed in 3D modelling trying out multiple ideas.

Session 5

This was the last session of the first (1st) capacity building workshop and was divided into two parts: the first (1st) part focused on technical skill development (following the interest expressed by the trainees) related to remote interaction using RPi3 and tablet or smartphone devices; the second part focused on a pedagogical discussion regarding the role of the teachers as coaches and reflection on the indicative scenarios for activities (provided in the context of D5.1). The session took place at the formal pilot site in Athens, on October 14, 2017 and was scheduled to last four (4) hours (from 10:00 am to 14:00 pm).

The first part of this session was actually a continuation of the 3rd session, but introducing more sophisticated techniques for (remotely) controlling elements on the RPi3. The trainees had already been informed in the previous sessions that by using the installed VNC client application, (under the "Internet" category of the basic RPi menu), that it is possible to connect to the RPi3 unit of a neighbouring team and work there using the Snap4Arduino environment or equivalent. This method, although straightforward, requires a large amount of computational power and bandwidth. In this session, they received all the necessary information on how this practice is feasible through the Snap4Arduino environment (instead of MIT Scratch which is less flexible in creating custom programming blocks or in being combined with other practical web tools), exploiting the simple HTTP requests creation mechanism the Snap4arduino has built in.

In order for the RPi3 unit to be able to intercept and handle HTTP requests by invoking GPIO pin state alterations or other pedagogically meaningful actions, a python implemented HTTP server code was relevantly modified and had to be run as a service on the RPi3 unit. During a typical implementation, simple HTTP server code like the one described in https://wiki.python.org/moin/BaseHttpServer was combined with the RPi.GPIO python library (https://pypi.python.org/pypi/RPi.GPIO) to control the GPIO pins of interest that the RPi board has. This prerequisite, most of which remained transparent for the trainees, gave them the ability to turn the necessary HTTP requests into real (remote) interaction cases.

In summary, the main task for the trainees was to gain experience in techniques for the creation of simple HTTP requests, allowing for direct access/control of the GPIO pins of either local or remote RPis. For this to be done, after their introduction to the HTTP functionality in Snap4Arduino that is available through the “Sensing” category via the “http://” block (see Figure 10-left), they were encouraged to turn on and off a LED connected to the GPIO18 and the GND pins of the RPi board by pressing two buttons in the Snap4Arduino environment. In order to facilitate trainees’ practical engagement in these tasks, a document with guidelines had been prepared for optional use (see Appendix, Annex I).

Figure 10: The trainees are working collaboratively in the Snap4Arduino environment (left), The “http://” block of Snap4Arduino (right)

The simple custom mechanism that was added to the RPi3 unit to handle HTTP requests is beneficial not only for the Snap4Arduino environment but also for any other tool able to generate HTTP requests in a pedagogically meaningful manner. So, as a next step, tasks similar to the above were practiced in the MIT App Inventor environment. More specifically, the trainees generated HTTP requests in order to remotely control GPIO pins of their RPi3 unit through their smartphone. They were then invited to experiment with the Accelerometer sensor which is built in any modern smart phone in order to turn on and off the GPIO18 pin of the local RPi3 or the same pin of the RPi3 unit of their neighbouring team.

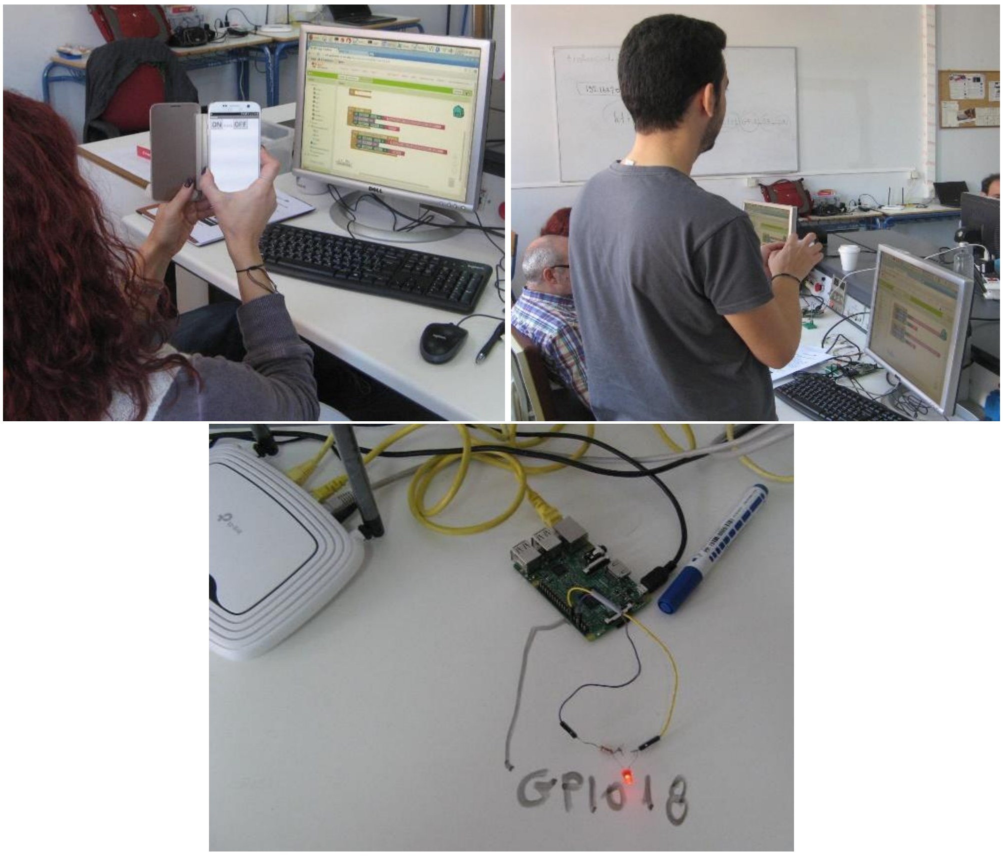

Figure 11: Working with MIT App Inventor: Whenever the trainee's smartphone was moving, the LED connected to GPIO18 of the RPi3 unit altered its state

The session was concluded with a pedagogical discussion (this was actually the second half of the session). A discussion was raised about the craft- and project-based pedagogical approach that the eCraft2Learn project is putting forward. The methodology introduced in the first session was revisited and the five (5) stages, namely ideation, planning, creation, programming and sharing where seen under the prism of the forthcoming classroom deployment. Several learning scenarios for indicative activities (that had been introduced in D5.1 and D3.4) were reviewed. The trainees were moved to envision how each stage can be implemented in the context of an eCraft2Learn activity/task, how the links to the authentic context of the real world could be enhanced, what technologies could be used to support each stage, what their role would be like and how students would be encouraged to take initiatives and to reflect on their learning. More precisely, emphasis was placed on the importance of offering students opportunities to reflect on the progress made in relation to their goals, on their value expectations and the importance of their work and on taking their experiences into future learning situations.

The role of the teacher as a coach in the context of the forthcoming pilots at both pilot sites (formal and informal) was thoroughly discussed and the trainees were freely encouraged to reveal their thoughts and concerns. The trainees were advised to take a step back, offering space to the students to explore and find solutions to the challenges without providing direct answers. Emphasis was also placed on how a topic/lesson could be transformed into an eCraft2Learn task and how an eCraft2Learn task could be designed and deployed taking on board students' interests and ideas.

Last, the current state of the Unified User Interface (UUI) was revisited and the trainees were encouraged to freely navigate the different menus and to see the relation between the pedagogical stages of craft- and project-based methodology and the tools that at that stage had been put forward in the UUI.

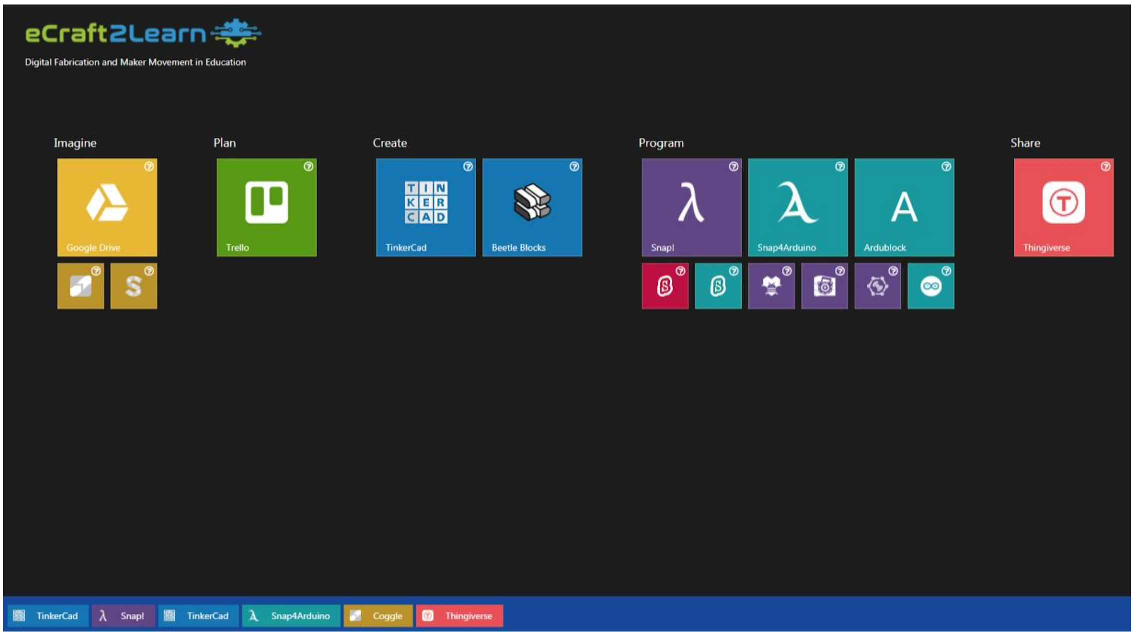

Figure 12: The Unified User Interface (UUI)

The trainees were kindly requested to provide answers to seven (7) open questions for evaluation purposes. The questions were answered in their spare time directly after the completion of the training workshop. Their responses are summarised and presented in Chapter 4 (section 4.1).

2.2. Round 2

The second (2nd) teacher training workshop took place in Athens, Greece from April to May 2018. Overall, it lasted sixteen (16) hours and was carried out in five (5) sessions of three to four (3-4) hours each. In total, ten (10) teachers were trained and introduced to the eCraft2Learn learning ecosystem. The second round was organised taking into account teachers' requests and needs as well as the recent developments in WP4 (referring to learning analytics, AI extensions and the updated version of the Unified User Interface (UUI)). It is worth noting that the participant teachers requested more time to practice 3D printing. In addition, the research team considered that more time should also be allocated to the use of the updated version of the Unified User Interface, the artificial intelligence programming (through the involvement in practical tasks in computer supported artefacts enhanced with AI extensions) and the use of learning analytics - another new feature that has been recently integrated into the Unified User Interface (UUI).

Briefly, the first session of the 2nd round focused on the pedagogical ideas and the five (5) stage methodology developed in the context of the project with reflections on the recently completed pilots with the students. The second, the third and the fourth session focused more on practical tasks using the Unified User Interface (UUI), namely 3D printing tasks, the implementation of Artificial Intelligence scenarios and the use of learning analytics. The last session was dedicated to free practice in the established eCraft2Learn lab as well as to discussions on the pedagogical context and the forthcoming pilot round with the students at both Greek pilot sites (formal and informal).

Table 3: Descriptions of training sessions (Round 2, Greece)

Session No.	Short descriptions
Session 1 17:00-20:00	Pedagogical considerations – the role of the teacher as a coach + experience sharing and reflections + Familiarisation with the updated version of the UUI (review of the tools available in each stage to support pedagogical practices)
Session 2 17:00-20:00	3D printing + practical tasks + review of related resources through the UUI
Session 3 17:00-20:00	AI extensions and functionalities + reviewing the relevant UUI resources + remote control experiments
Session 4 17:00-20:00	Familiarisation with the concept of learning analytics in education + Familiarisation with the learning analytics interface for teachers on the eCraft2Learn digital platform
Session 5 17:00-21:00	Free but plausible projects and practice using the UUI and the available tools

The content of the five (5) aforementioned sessions and the methodology that was followed is described in detail below. Comments and requests raised by the participant teachers during the training were taken into account and informed the deployment of the training sessions. For example, following teacher suggestions, guidelines in written form that could be used in the future as reference tools were provided (when needed) for optional use (see Appendix, Annex I).

Session 1

The first (1st) session took place in April in Athens at the informal pilot site, in the eCraft2Learn lab established in Technopolis. The session lasted three (3) hours. The trainees were invited to reflect on the eCraft2learn methodology that is engineered through 5 stages (ideation, planning, creation, programming, sharing) they had already implemented in the 1st round of student pilots (December 2017-February 2018). More specifically, they were invited to reflect on the following questions:

- To what extent was the above-mentioned methodology applied?
- What were the main challenges?
- Were there stages that dominated the process?

- Is there any need for changes in the 2nd round of pilots, when it comes to the implementation of the craft and project-based methodology?

The trainees were encouraged first to reflect on these questions in teams and write down their answers and then to share their reflections in the plenary. This practice further encouraged the continuation of the discussion on pedagogical issues. The next topic that was discussed was related to their role as coaches. They were encouraged to reflect on their role in the context of the 1st pilot round and to share their thoughts on what went well, what did not go well and their recommendations regarding any possible changes in the forthcoming 2nd pilot round. In addition, they were encouraged to comment on comments documented by observers during the pilots. Finally, they were invited to comment on the teacher guidelines and student worksheets that were provided during the 1st round of student pilots. Were they useful in practice? What changes would they suggest for the 2nd round of student pilots? Useful feedback was collected during this session and is reported in a next section (see section 4.3).

Session 2

The 2nd session took place in April in Athens at the informal pilot site, in the eCraft2Learn lab established in Technopolis. The session had been scheduled to last three (3) hours but lasted longer. Following teachers' interest in going deeper into 3D printing, this session focused specifically on 3D printing tasks. The Open Educational Resources (OERs) available through the Unified User Interface (UUI) were used as reference tools for the 3D printing tasks. Practical issues related to 3D printing were also discussed and trainees' questions were answered.

As far as the technical set up available in the lab is concerned, an additional printer was available in the lab in order to allow more than one team to print at the same time. To each 3D printer an i5 laptop had been attached to act as a printer server. The teams using their RPi3s could connect remotely via VNC to the laptop using different accounts. Each team could use the Firefox ESR browser to do 3D modelling in TinkerCAD and create simple 3D models. In addition to that, each team could access their own Cura 3.2.1 instance for the importing of a 3D model, slicing and 3D printing. This set-up enabled each team to practice 3D modelling, to slice their model, prepare their gcode file and to 'get in line' for 3D printing.

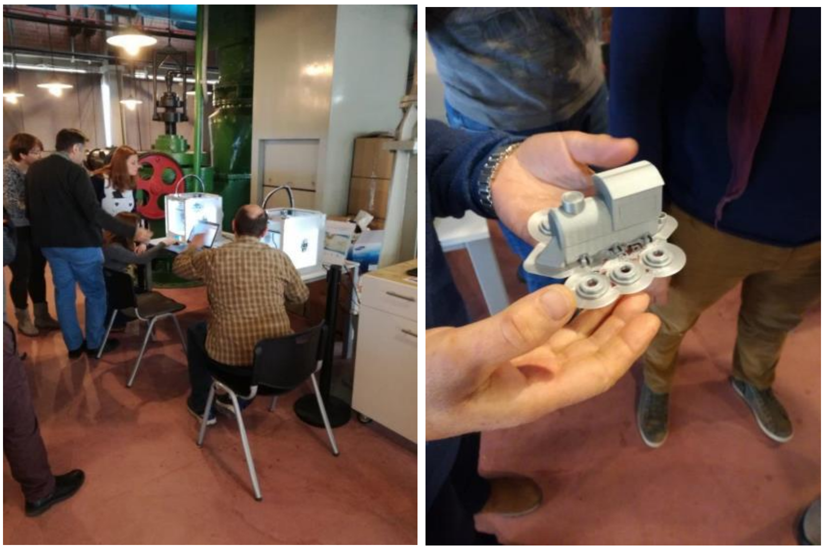

Figure 13: 3D printing practice in the eCraft2Learn lab (informal pilot site, Athens, Greece)

Session 3

During this session the main goal was for the trainees to acquire skills in Artificial intelligence (AI) issues to the extent that this was possible given the specific capabilities of the Technopolis lab. The more mature version of the UUI environment offered access to Snap4Arduino via the link https://ecraft2learn.github.io/uui/index.html.

- We focused on sound/voice recognition because AI scenarios involving images are harder to deal with in terms of network bandwidth and computational load when using the RPi3 unit as work station.
- The trainees were encouraged to review the available resources related to AI extensions in the UUI and use the updated Snap4Arduino version supported by the eCrat2Learn server.
- They practiced AI functionalities using the virtual artefacts implemented as sprites in the Snap4Arduino workspace, after which they tried to integrate Arduino GPIO pin control commands into the AI scenarios.

As most of the AI features require access to the cloud to run, the AI testing process assisted in investigating and defining the exact bandwidth requirements of such activities such as the voice recognition process. In fact, although the Snap4Arduino itself, while running though the web, requires negligible network bandwidth, the AI features require much more of it. Typically, a Greek school ADSL line has an 11 Mbps downloading speed and less than a 1 Mbps uploading speed. During the experiments we measured (using a traffic rate monitoring application) that a cloud-based voice recognition example requires around 200 Kbps of upload speed to run smoothly and thus, making the calculations and letting the rest of the applications some room to “breath” as well, no more than 2 working teams could concurrently run voice recognition scenarios smoothly. These results can be taken into account in the future while setting up scenarios involving AI features.

Apart from the native AI scenarios, the trainees refreshed their experiences on how to provide remote control of the artefacts. The whole idea was to have artefacts containing RPi3 as well (in this case the Arduino board may co-exist or be omitted from the artefact) that can be accessible through the built-in Wi-Fi interface the RPi3 units have. The experimentation that took place was focused on two different methods, both previously introduced during the first round of teacher training sessions:

- Remote access and control through Virtual Network Computing (VNC) techniques (https://en.wikipedia.org/wiki/Virtual_Network_Computing). In this case trainees used the RealVNC (https://en.wikipedia.org/wiki/RealVNC) to have access to the artefacts and remotely invoked the Snap4Arduino (or just the Snap!) environment. The VNC method was already familiar to the trainees as it was also used to provide access to the 3D printers.
- Remote access and control through the ability that the Snap4Arduino tool (on the work station machine) provides to send HTTP requests, in conjunction with a lightweight (and transparent for the trainees) server written in python that can handle these requests and provide access to the GPIO pins that the RPi3 unit (that supports the artefact) possess.

Both methods were easy to understand and experiment with and could be provided as an extra option for the students during the 2nd round of students' pilots.

Session 4

This session revolved around the topic of the learning analytics through the Unified User Interface (UUI). eCraft2Learn analytics can be used to analyse the digital traces that the Unified User Interface (UUI) and its tools collect from student activities. The session started with a presentation of the concept of learning analytics as most of the teachers were not familiar with it and then the focus was shifted to their potential for evaluation purposes in the context of the eCraft2Learn learning intervention. More precisely, an introduction to the field of learning analytics was made through a presentation covering the following topics:

- Introduction to the learning analytics
- Basic terminology
- Type of useful algorithms for analysis of student performance
- How learning analytics work in the UUI
- The potential of learning analytics in education and in the eCraft2Learn pilots

The presentation was followed by practice on the eCraft2Learn platform for learning analytics. The teachers were encouraged to work on the platform and to observe the way learnings analytics are recorded and visualised. After having experienced first-hand the learning analytics platform, they were encouraged to talk about their experiences and to comment on this new tool from an educational perspective. Their comments are documented in section 4.3.

Figure 14: Teacher practice on the eCraft2Learn interface for learning analytics

Session 5

This was an additional session that was scheduled in order to further inform the trainees about the recent updates in the Unified User Interface (UUI). Once again time was allocated for free exploration on what is available and/or had been recently added. The trainees were also encouraged to carry out different tasks on which they would like to further practice their skills. The trainees became engaged in different projects based on their interests and the trainers were offering support, helping out with demonstrations, making recommendations and facilitating the process.

For example, one trainee was interested in improving her skills in soldering; the trainer offered a demo and then supervised the trainee while she was carrying out simple soldering tasks. Another case included two groups of trainees that were interested in further practicing some programming tasks based on AI extensions for speech recognition (in order to deal with the difficulties that they had encountered in the third session). The trainees worked towards instructing their machine to follow their voice commands under the discrete support of the trainers. The whole AI testing process was based on the idea of having a voice recognition engine of reduced functionality to run locally on the work station machines, instead of using the network to access such features. Although the results were encouraging, problems persisted as the incurred processing load for the CPU of the RPi3 unit remained high during the relevant operations via the chromium browser. In fact, while experimenting with the AI features, apart from the network bandwidth issues (especially in the uplink direction) that a typical school laboratory setup may have, the computational load that the overall process incurs on the CPU of the RPi3 remains so high that things can barely work, no matter whether the relevant AI mechanisms are running locally or via the cloud. For this reason, the research team considered the upgrade of the work station implementation with a faster but still minimal (and very similar to the RPi3 unit, in terms of layout) unit such as the ASUS tinker board (https://www.asus.com/gr/Single-Board-Computer/Tinker-Board/) (see D5.3).

Figure 15: Free experimentation session - working on different free but plausible projects

3 DESCRIPTION OF CAPACITY BUILDING WORKSHOPS IN FINLAND

This chapter describes the capacity building workshops that took place in Joensuu, Finland in two rounds. The 1st training round lasted 12 hours and the 2nd 18 hours. The following Table 4 presents information about the trainees per round.

Table 4: Information about the trainees per pilot round in Finland

	1st teacher training	2nd teacher training
Number of trainees	9	6
Female trainees	4	3
Male trainees	5	3
Formal	5	4
Informal	4	2
Number of sessions & hours	6 sessions (12 hours)	6 sessions (18 hours)
	No previous experience in the eCraft2Learn tools and technologies Interest in STEM, (informal educators were master students in computer science)	All the trainees had participated in the 1st round of pilots (informal educators were master students in computer science)

3.1. Round 1

In Finland, the first (1st) teacher training workshop took place in Joensuu, Finland, during the last week of September and the first week of October, 2017. The training consisted of 6 face-to-face meeting sessions, 2 hours each for a total of 12 hours of training. During the training, 5 professional school teachers as well as 4 after-school educators were introduced to the eCraft2Learn learning ecosystem, including pedagogical ideas and the five (5) stages of craft- and project-based methodology developed in the context of the project as well as the technology usage within the pedagogical activities. A description of the sessions and the contents are given in Table 5.

Table 5: Description of the training sessions (Round 1, Finland)

Session No.	Short descriptions
Session 1 11:00-13:00	Getting to know each other activities + Familiarisation with the eCraft2Learn pedagogical methodology + Familiarisation with electronic elements of the technical core RPi + Arduino
Session 2 11:00-13:00	Familiarisation with the 'Teacher as Coach' concept and the Maker movement in education + Familiarisation with the unified user interface environment + Basic Arduino programming
Session 3 11:00-13:00	Familiarisation with the RPi3 & Arduino capabilities in the eCraft2Learn digital environment
Session 4 11:00-13:00	3D modelling and 3D printing skills – Printing simple objects + Planning plausible projects to develop during the training
Session 5 11:00-13:00	Free (but plausible) project implementation + Q&A
Session 6 11:00-13:00	Free (but plausible) project implementation + Q&A + Feedback collection

The considerations that shaped the teacher training workshops in Finland were similar to those in Greece. That is, both training workshops were designed so that teachers had enough time to familiarize with the pedagogical concepts as well as the technologies and tools put forward. Furthermore, teachers were novices in the use of DIY electronics and technology for learning and so hands-on scaffolded activities were carried out to develop their confidence in transforming their role to that of a coach or facilitator of the learning experience. Moreover, in the 2nd round of training workshops, their feedback and comments were incorporated as to provide more in depth understanding on developing and incorporating making activities into their curricular subjects through the eCraft2Learn learning ecosystem.

Session 1

The 1st session of the teacher training in Finland took place on September 26, 2017 in Joensuu Science Park, where the educational technologies lab of the University of Eastern Finland is located. The entire teacher training took place at this location. The session lasted 2 hours and started with some free introduction of the teachers and trainers (researchers in the project). Since the group of people participating in the training was small, there was no need to spend much time forming groups and people discussed and work with one another freely (the teacher already knew each other).

Following the model of the training in Greece, during the 1st session of the training in Finland, the teachers were introduced to the eCraft2Learn project in general: the vision and the concept behind the project. With this, we wanted to establish rapport with the teachers and to provide them with a general idea of what the project was about. The pedagogical concepts behind the eCraft2Learn learning ecosystem were also introduced and discussed with the teachers. These concepts included pedagogical theories of Constructivism (including social constructivism), inquiry-based learning, the do-it-yourself (DIY) philosophy as well as the *Maker* movement, in order to lay the groundwork for building a common view of the theoretical framework within which the technological core of the project was being developed and deployed. A brief discussion took place on these new concepts in relation to perceptions of the teachers. The trainees mentioned that the pedagogical underpinning of the project where to some extend familiar to them but the technological elements and their application in the classroom were new to them. During the discussions that took place in the first session, the teachers/trainees shared their views on how the proposed 5-stage pedagogy could be deployed in their curricular lesson, taking as an example and a starting discussion point the theatre robotics example shown below:

Table 6: The 5-stages and a scenario for deployment in a curricular lesson

Pedagogical Stage	***Theatre robotics action***	***Curriculum subjects***	***Remarks***
Ideation	Students choose a story or a theatre play to implement	History, literature, religion	
Planning	Information collection and story scripting	Literature, articulacy, information retrieval and media literacy	*ICT skills include use of search engines and online resources*
Creation	Robot design and building	Arts and design, ICT, engineering, technology and handicraft, mathematics, physics	
Programming	Defining scripts for the robot actors	Computer science, logic	*ICT skills focus to computer science core skills, such as programming fundamentals*
Sharing	Theatre performance	Arts, media, sports, social skills, technology	

In terms of the technological aspects, the teachers were introduced to the technical core of the project (RPi3, Arduino board, keyboard, mouse, monitor) as well as basic electronic components for learning, such as light emitting diodes (LEDs), resistors, light sensors, etc. (see D3.3 M9, M17). Most of the teachers had no previous experience with this kind of technology or their use in educational contexts. A discussion followed on the use of these technologies to assist or support their own teaching - 2 participants were biology teachers, 1 was a math teacher, 1 was a history teacher and 1 was a physics teacher. The four educators of after-school clubs were computer science students at the University of Eastern Finland.

After the introduction to the technology, the teachers discussed with the researchers in a single group the benefits of developing curricular tasks through the eCraft2Learn learning ecosystem, and their views on how the tasks could be implemented in their classrooms. The teachers needed some inspiration to start this brainstorming process, as the use of technology within the pedagogical framework was new to them. The researchers discussed several ideas with the teachers about how the tasks could be developed in the classroom, within a biology class for instance on the topic of *photosynthesis* or within a physics class on the topic of *global warming*. Teachers ended the 1st training session eager to consider new possibilities to carry out their curricular activities. They needed to prepare to discuss what projects from their subject matters could be developed through the eCraft2Learn learning environment. Figure 16 shows the environment during the 1st session of training.

Figure 16: 1st session of teacher training (Finland)

Session 2

The 2nd session of the teacher training in Finland took place on September 27, 2017 at Joensuu Science Park. During this session, the trainees were introduced to the views and ideas of transforming the role of the teacher to that of a coach of the learning process. The analogy with the role of a sports coach was given. The sport's coach:

- Helps athletes develop their full potential
- Provides training
- Analyses performance
- Instructs in relevant skills
- Provides encouragement

This was followed by a discussion among the teachers on how these points could be translated into the teaching arena. A common ground between the sports and the education arenas was highlighted in the role of the teacher as a coach: *coaching reveals skills, potential and resourcefulness.*

The teacher role as a coach was also explained through the lens of the guidance and feedback that the learners need within the eCraft2Learn learning ecosystem as shown in Figure 17.

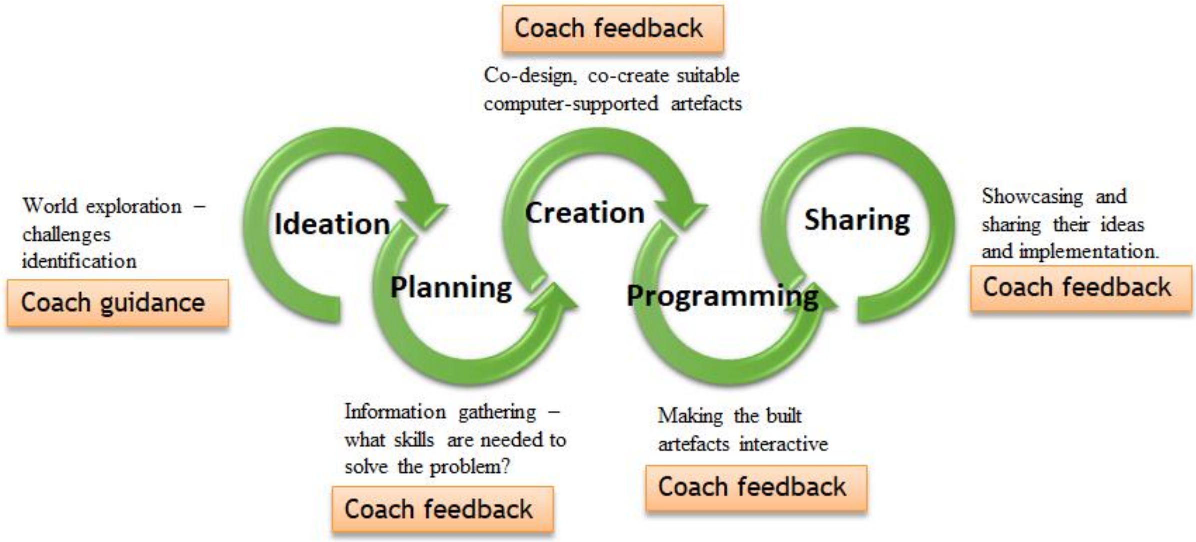

Figure 17: Role of the teacher as a coach within the eCraft2Learn 5-stage pedagogical approach

After the theoretical discussion took place, the trainees were immersed in familiarising themselves and working with the technical core elements of the project. First, the trainees worked on setting up the technical core, connecting the Arduino board to the RPi3 computer. The next task was to access the UUI and to become familiar with the presented tools in the UUI (https://ecraft2learn.github.io/uui/index.html). Particular attention was paid to launching the Snap4Arduino programming environment from the UUI.

At this point, the teachers started to work and practice the 5-stage pedagogical methodology of the eCraft2Learn learning ecosystem through the development of a simple practical activity: The Lighthouse Project (see Appendix, Annex II). With this the teachers were provided the opportunity to carry out a practical task in the same way that they would carry out their tasks and activities with their students in the classroom. The Lighthouse project had two parts: the 1st one required the teachers to physically build a lighthouse structure with blinking LEDs, completing the process by going through the stages of ideation, planning, creating, programming and sharing the results of each team (2 teams were created). To facilitate the process, diagrams of circuit creation as well as the basics programming building blocks in Snap4Arduino were shown to the teachers (see Figure 18).

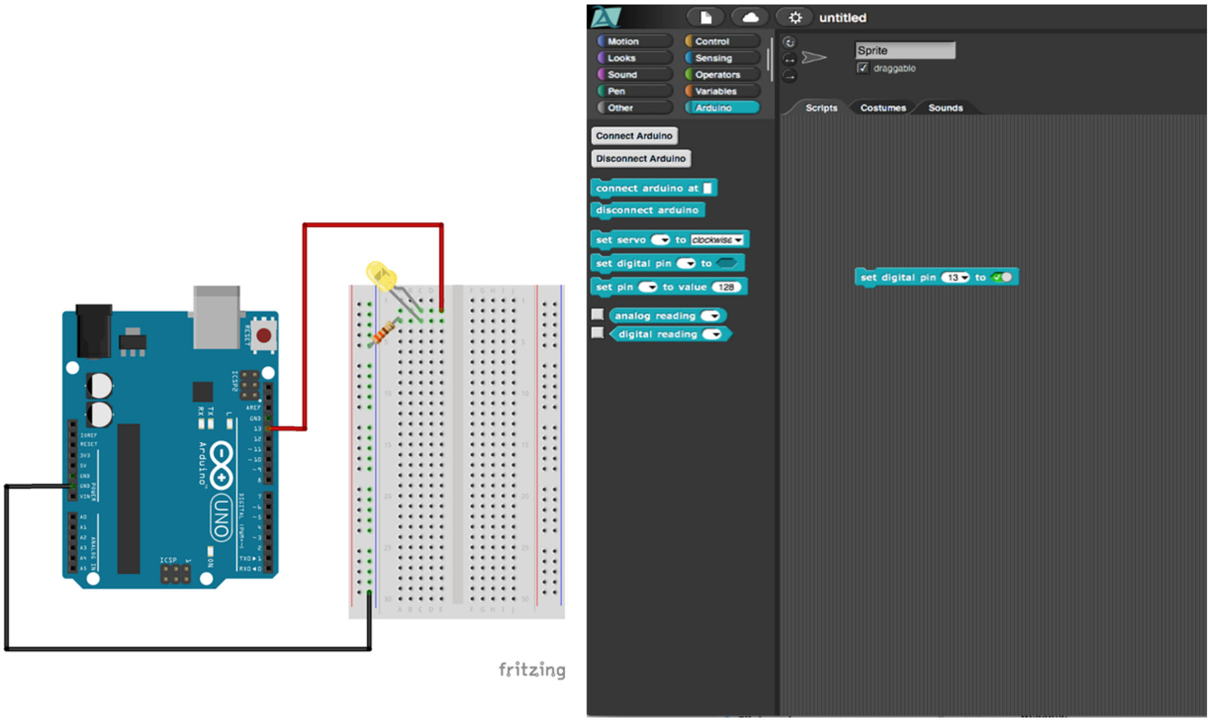

Figure 18: Diagrams used during the teacher training - The Lighthouse Project

Session 3

The 3rd session of the teacher training in Finland took place on September 28, 2017 at Joensuu Science Park. During this session the teachers continued their familiarisation with the technical core of the eCraft2Learn learning ecosystem. New electronic components were introduced and explained: sensors and actuators. With this the teacher continued with the second part of the lighthouse project, where instead of LEDs the teachers were required to use photoresistors (light sensors) to program their lighthouse functionality.

Since the teachers had no previous exposure to using these type of electronic devices for educational purposes, the teachers took their time during the training sessions to become familiar with handling the electronics, making circuits, and discussing how the pedagogical considerations of the project together with the technical core that they were learning to use could be employed in their own teaching activities.

The teachers were assisted in all of their questions and queries during the training, and the role of the coach was highlighted through the way that researchers approached problem-solving with them during the course of the training. Figure 19 shows the teachers developing their lighthouse project (second part). At the end of this session the teachers were asked to consider the topics/tasks they would like to develop with their students in order for their questions to be addressed during the upcoming training sessions.

Figure 19: Teachers working on their lighthouse projects

Session 4

The 4th session of the training in Finland took place on Oct 3, 2017, at Joensuu Science Park. During this session, the teachers were introduced to the processes of 3D printing and how the TinkerCAD simulator works to create 3D printing models. The teachers were given time to familiarise themselves with TinkerCAD simulator software by going through the tutorials offered on the website and working with them to create simple shapes. Further question and answer discussions were carried out during the course of the training.

Furthermore, the teachers also discussed plausible projects that they consider could be developed in the classroom by their students. Three topics were identified for further deployment in the classroom: photosynthesis, security and global warming. After the 1st round of training the teachers decided to implement the photosynthesis and the security topics as part of the 1st round of pilots with their students. These projects were also developed during the training from the ideation of the project to the sharing of the results. Figure 20 shows the teachers working on their projects.

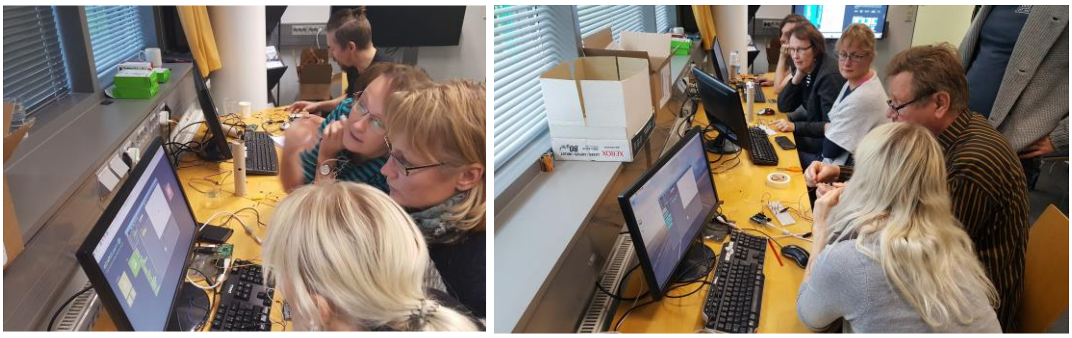

Figure 20: Teachers working on their projects

Session 5

The 5th session of the training in Finland took place on Oct 4, 2017, at Joensuu Science Park. During this session, the teachers were encouraged to develop their chosen curricular activity (photosynthesis, global warming or security). New electronic devices (e.g. sensors) were introduced and described during the development of the workshop. Furthermore, emphasis was placed on the role of the teacher in the classroom as a coach of the learning process. Figure 21 shows the teachers while developing their selected projects.

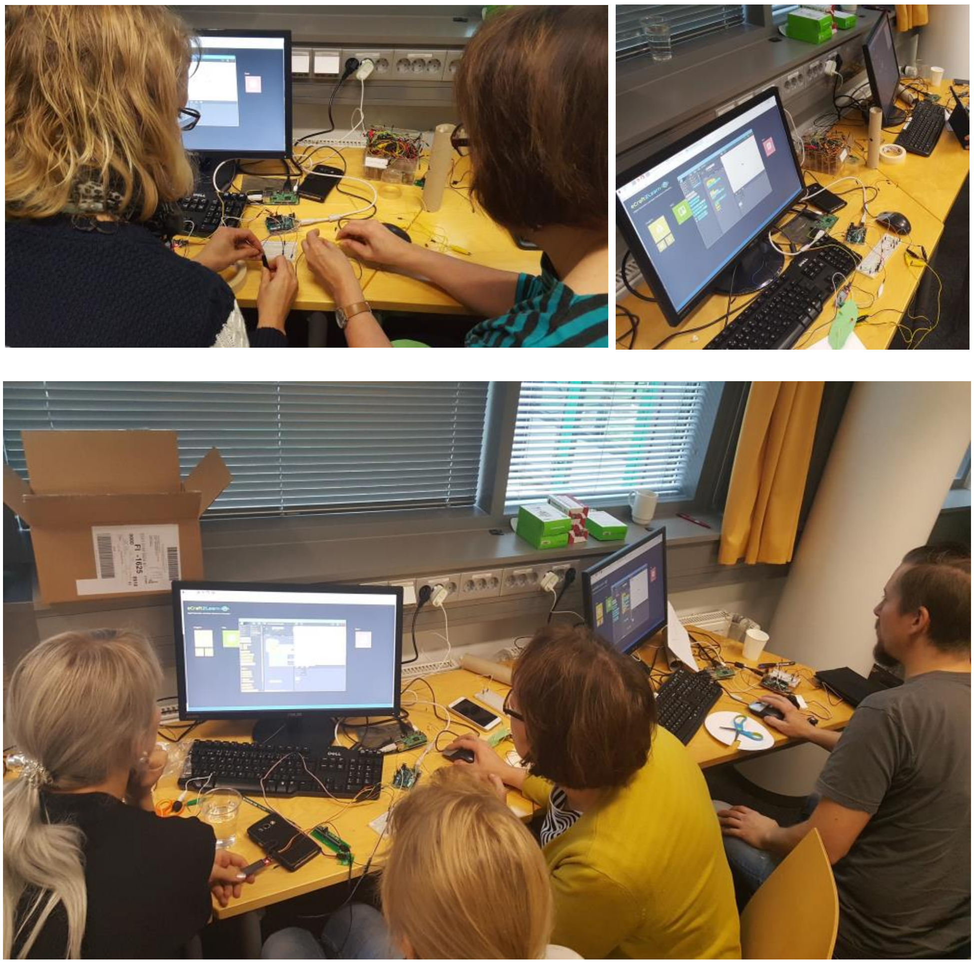

Figure 21: Teachers working on their projects

Session 6

The last session of the 1st teacher training round of the project in Finland took place on Oct 5, 2017, at Joensuu Science Park. During this session the teachers completed their projects and further question and answer discussions took place. The teachers shared their work at the end of the implementation. Figure 22 and Figure 23 show the end results of the projects that were selected by the teachers. The teachers expressed their confidence to deploy the tasks in the classroom with their students. At the end of this session, feedback was collected in the form of a group interview with the teachers and the researchers, in order to elicit their opinions on the training as a whole and on their confidence in implementing their curricular activities through the eCraft2Learn learning ecosystem.

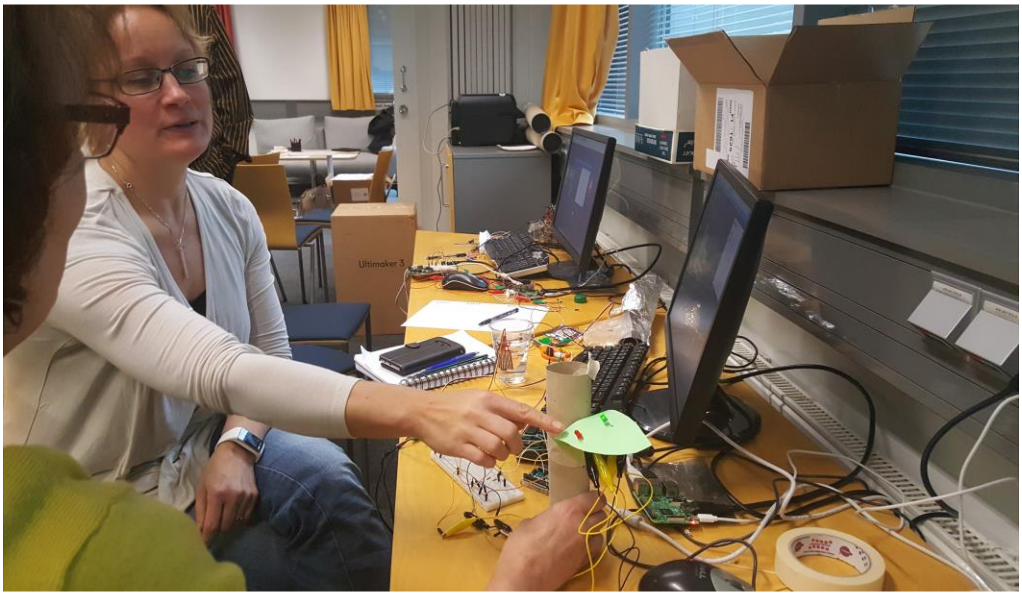

Figure 22: Photosynthesis representation - a leaf with an indication of lack of light (photoresistor), lack of water (water sensor) or CO2 (slider)

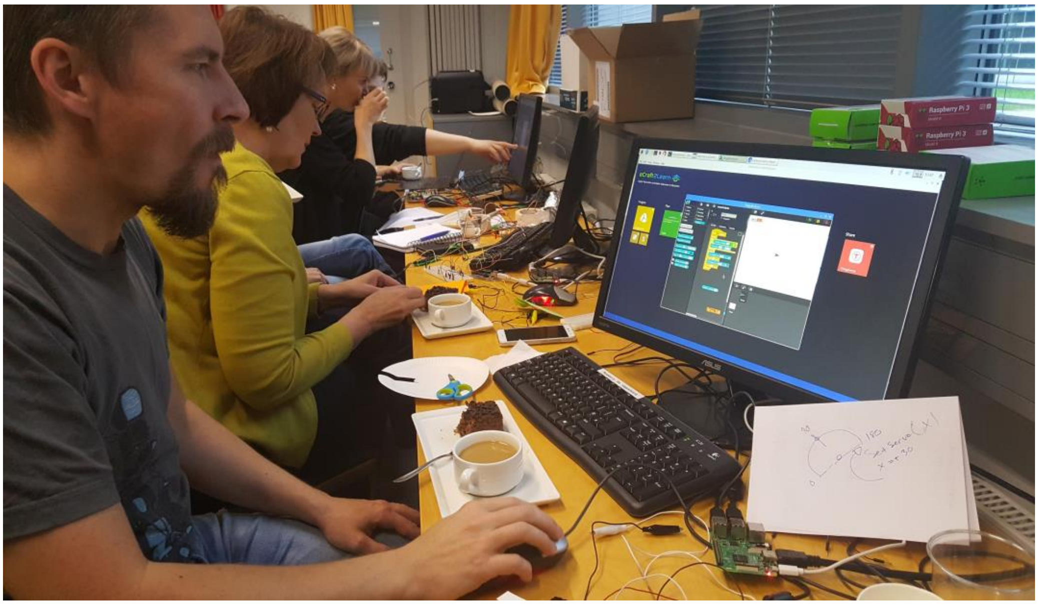

Figure 23: Security representation - an alarm system that is triggered when the object is lifted

3.2. Round 2

The second (2nd) teacher training workshop took place in Joensuu, Finland in March 2018. In total, 18 hours of training was carried out in six (6) sessions of three (3) hours each. Six (6) teachers were trained and introduced to the updated eCraft2Learn learning ecosystem from which four (4) were from a formal and two (2) from an informal educational setting (after-school club educators). The content of the second round was planned and organised based on the experiences gained during the first project pilots and the current developments in WP4. The most significant developments that the research team considered noteworthy revisiting during the 2nd round of pilots were the updated version of the

Unified User Interface (UUI), the artificial intelligence (AI) programming blocks and the new learning analytics teacher interface. Moreover, teacher feedback was accommodated in the training plan as they felt that they needed more practice with the programming environment where the AI blocks were developed.

In brief, the first session of the 2nd round of training focused on revising and reflecting on the pedagogical core of the project. The second and third sessions included practice targeted at the familiarisation of the UUI tools in each stage of the eCraft2Learn pedagogical framework as well as the basics of visual programming and artificial intelligence programming. During the fourth and fifth sessions, the participant teachers developed their own projects from the topic they wanted to deploy in the classroom with their students. The different pedagogical stages and UUI tools were tested in a natural context and the knowledge in artificial intelligence programming and 3D printing was strengthened during the test project work. The last session focused on free familiarisation and experimentation of the learning analytics tool and discussion on its pedagogical use.

Table 7: Descriptions of the training sessions (Round 2, Finland)

Session No.	Short descriptions
Session 1 12:00-15:00	Pedagogical considerations – The role of the teacher as a coach and how to achieve it + Familiarisation with the OERs through the UUI
Session 2 11:00-14:00	Familiarisation with the UUI tools and their importance in each stage to support pedagogical processes + Building a project – practical experience with the AI blocks through the UUI
Session 3 12:00-15:00	Guided practice with Snap! (and Snap4Arduino) + AI blocks
Session 4 12:00-15:00	Test project part I + Steps to carry out an eCraft2Learn activity + Role of the teacher as a coach + Scaffolded learning + AI blocks and functionalities
Session 5 12:00-15:00	Test project part II + 3D printing
Session 6 12:00-15:00	Familiarisation with the concept of learning analytics in education + Familiarisation with the learning analytics interface for teachers on the eCraft2Learn digital platform

Session 1

The second capacity building workshop started by inviting the teachers to reflect on their role as a learning facilitator in the classroom based on their experiences gained during the first project pilots. Teachers wrote down their ideas first individually and later deepening the discussion in groups on the five following concepts with regard to projects developed with the eCraft2Learn learning ecosystem (see Figure 24):

- *Scaffolding*
- *Time management*

- *Agile management (prototype fast, fail fast, recover fast)*
- *How to motivate students?*
- *How to support student self-regulation?*

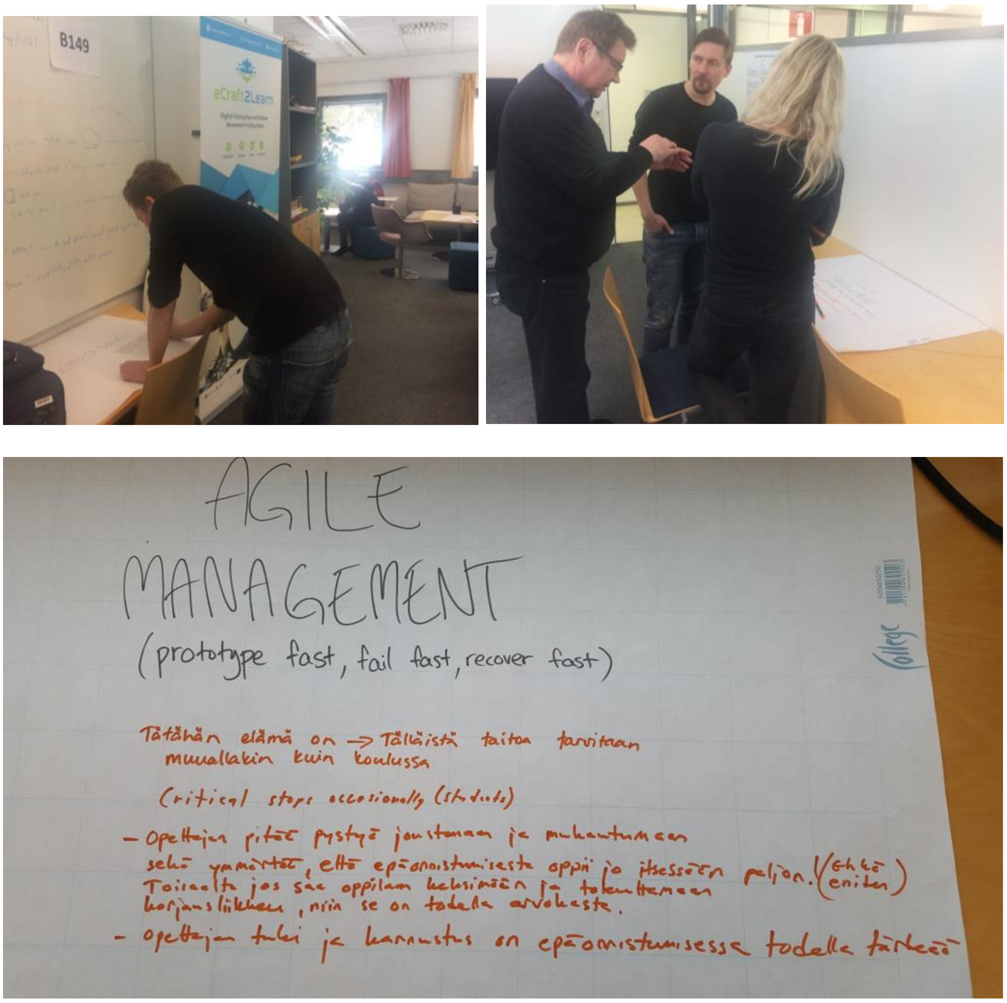

Figure 24: Sharing experiences and ideas about the different concepts in eCraft2Learn pedagogical core

Teachers were encouraged to share their experiences and thoughts from both the effective practices and possible issues. The experiences provided a great opening to a discussion on how a teacher can achieve the role of a coach in different learning situations. To support this role, a new feature of the Open Educational Resources (OERs) was created and implemented in the UUI. The last hour of the first session was devoted to the guided familiarisation of the OERs (Figure 25). Teachers were encouraged to explore the educational resources and to participate in a discussion on how these resources can help the teacher's role as a facilitator, student self-regulation and support the eCraft2Learn projects in general. In addition, teachers were invited to give recommendations on how to improve these resources.

Figure 25: Free experimentation on the Open Educational Resources

Session 2

The first half of the second session focused on familiarisation of the UUI tools and features, most of which were new or updated since the participant teachers had used them during the first project pilots. After a short explanatory session by one of the project members, the teachers were invited to explore and try out the different UUI tools at their own pace. Teachers were asked to reflect on these tools regarding the usability and different pedagogical stages and processes from both the teachers' and the students' perspectives as well as to provide suggestions for improvement. Teachers were referring to the following aspects: what works well and is usable in the classroom, what could work with refinements and what is too challenging or time consuming to use.

Figure 26: Familiarisation of the UUI tools in each stage of the pedagogical framework and support by the trainer

Artificial intelligence programming was introduced to the teachers in the second half of the 2nd session. Teachers were guided to install and upload the AI blocks corresponding to the instructions found in the UUI and simulating the real situation in schools. A small exercise was assigned to the teachers in which they were asked to light up an LED using the speech recognition AI blocks. Through personal and independent experimentation, teachers could become familiar with the artificial intelligence programming and the project members were supporting this work whenever teachers were in need of a guidance.

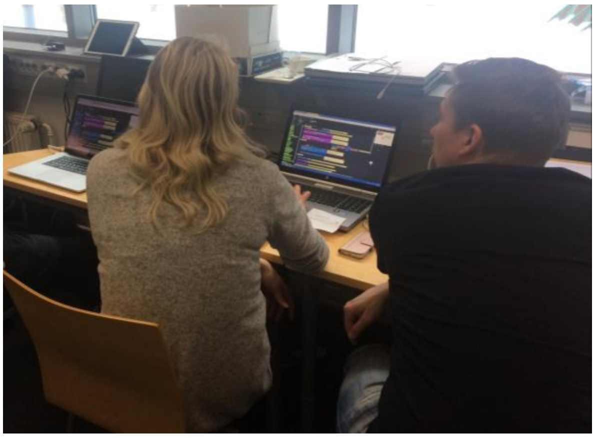

Figure 27: Familiarisation with the artificial intelligence programming

Session 3

Based on the challenges faced during the second training session, the third session was dedicated to programming practice. Programming was also mentioned by the teachers as their weakest skills in the whole eCraft2Learn ecosystem. During the guided practice teachers worked with Snap! and Snap4Arduino, both of which use visual programming language and were used during the first pilot projects. The guidance was based on the Snap Reference manual (https://snap.berkeley.edu/SnapManual.pdf) and proceeded step-by-step, introducing the basics of programming. Teachers learnt to work with different blocks, variables, loops, conditionals, nesting and recursion and by the end of the practice were able to build their own blocks.

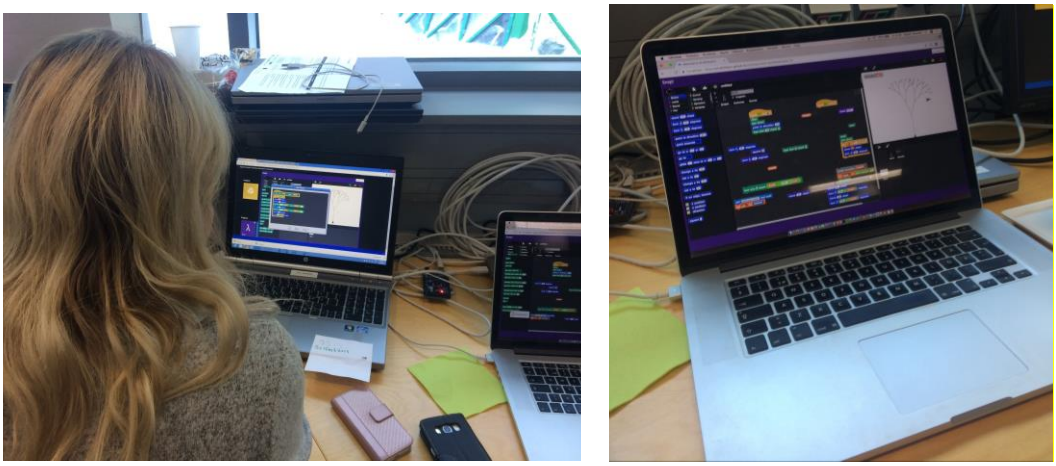

Figure 28: Guided practice with the Snap! programming environment

After mastering the basics of visual programming it was only natural to move on to artificial intelligence programming practice and continue the work done during the previous session. The same task, lighting up an LED using speech recognition, was developed further and speech recognition was accompanied by speech synthesis where the machine forms speech based on your commands. By the end of the third training session teachers were able to create a responsive and interactive artefact by using the Arduino Uno with one LED and AI enhanced programming code.

Session 4

In the fourth session it was time for teachers to develop their own plausible test projects. Teachers started by ideating possible project topics and planning task descriptions for the specific student group. After the idea was clear, teachers started going through the project as a simulation of what could happen in the classroom. Teachers followed the 5-stage pedagogical framework and used the different UUI tools.

The work was facilitated by the practical '*Quick guide to developing an eCraft2Learn task'* instruction manual which had been created to support teachers in transforming a curricular activity into an eCraft2Learn task (see D3.4 (M16)). Teachers' work was supported in all phases by the project members and both pedagogical and technological challenges were dealt with. Teachers were also encouraged to evaluate the possible easy and difficult points that may be faced during the projects in the classroom and to reflect on ways to support students by scaffolding learning as a coach among students.

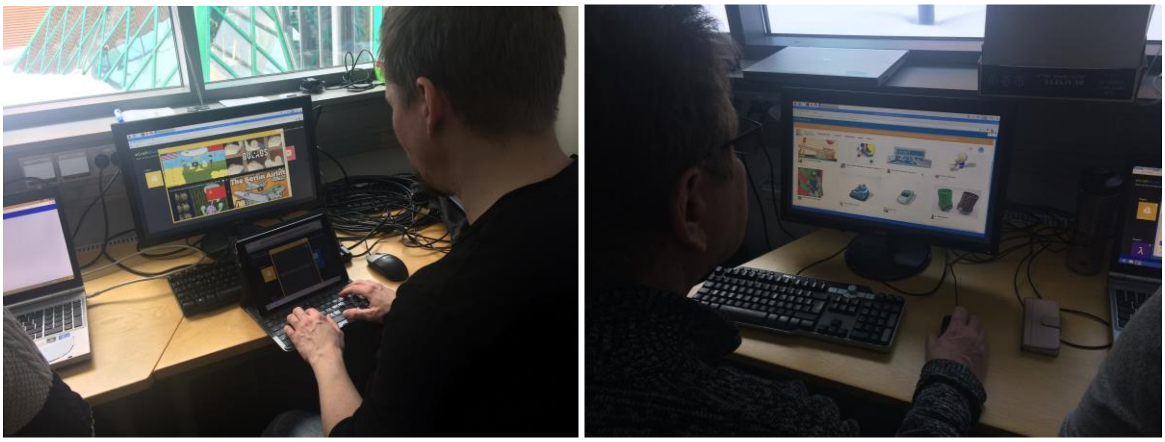

Figure 29: Teachers in different stages of creating their own plausible eCraft2Learn projects

As it was encouraged, teachers wanted to implement AI programming in their projects with the students. Building on the teachers' gained knowledge about the programming itself and artificial intelligence programming as well, teachers were working collaboratively and testing various ways on how to incorporate AI programming into the student projects. The shared discussion among teachers only and teachers and project members dealt with the following questions: What is possible with AI programming and how to apply it to the own projects, how AI programming should be introduced to students, how capable students are of using AI blocks, what type of issues may emerge when using AI programming and what should be taken into account when implementing AI programming.

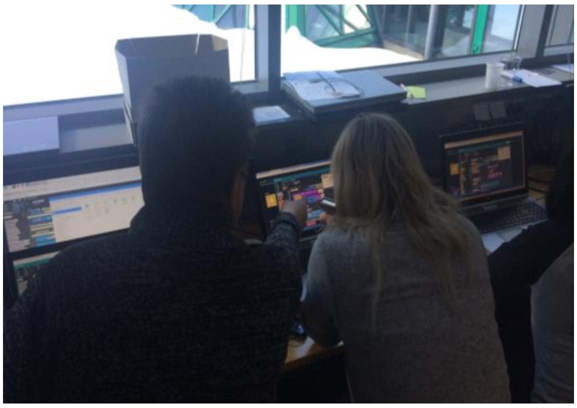

Figure 30: Collaborative work among teachers when applying artificial intelligence programming in their own eCraft2Learn projects

Session 5

The fifth session was a continuation of the previous one where teachers started their own test projects. After going through their own plausible projects there was also time for free experimentation with the eCraft2Learn environment.

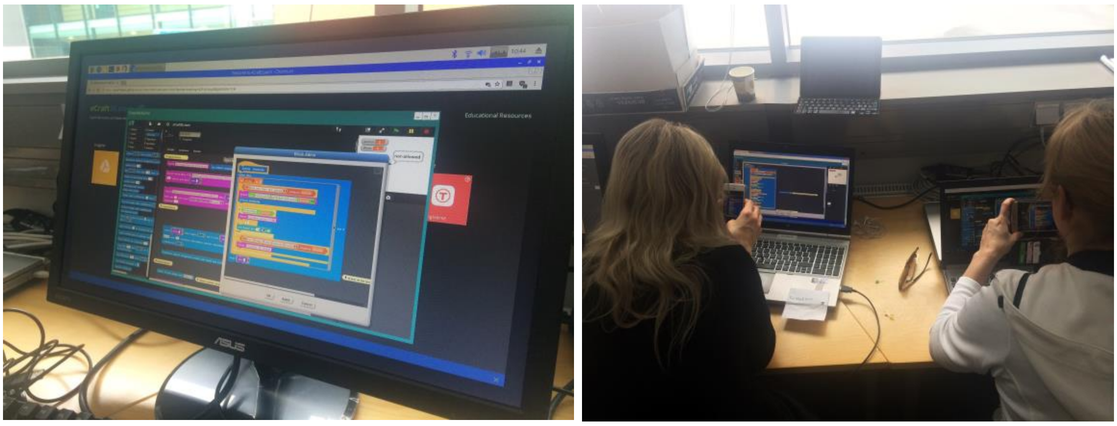

Figure 31: Mastering artificial intelligence programming and saving the work for upcoming project pilots

As 3D modelling and printing had only been briefly introduced during the 1st teacher training and some participant teachers admitted needing further practice with these technologies, the fifth session provided time and support for a small 3D printing project. Teachers were encouraged to create a key chain of their choice. They could create the model from scratch or use the Thingiverse maker community as their inspiration. Another option for the 3D exercise was to follow a Thingiverse tutorial where the task was to go through specific tutorials in the environment and implement the given ideas and tips in their own project.

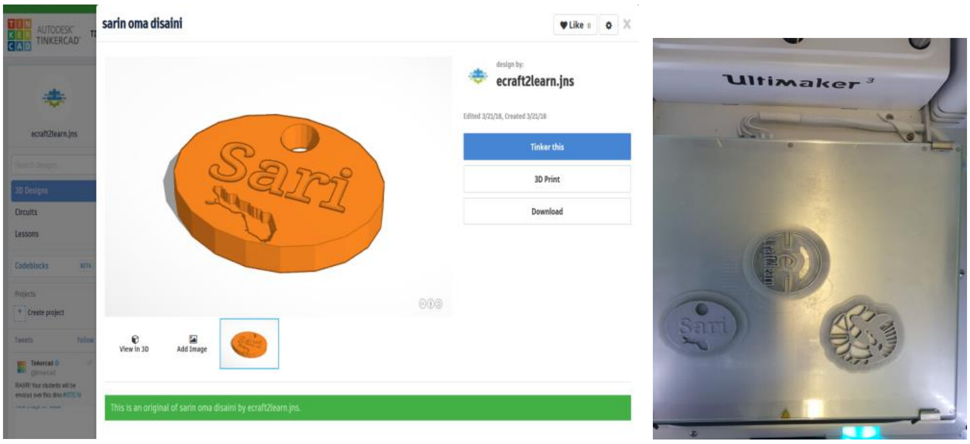

Figure 32: Results of the 3D printing practice; a key chain and two charms designed by the participant teachers

Session 6

The last session was dedicated to the new feature of UUI, learning analytics. The learning analytics tool is able to track student team performance and assist teachers in identifying the different learning needs of the teams. An overview of this new tool was given by one of the project members similarly to the 2nd teacher training in Greece. Teachers were first introduced to learning analytics in general and the key concepts and terms from the field of learning analytics and machine learning were explained. Then, teachers were shown how and from which tools the learning analytics data is collected in the UUI. The introductory presentation also included an explanation of different types of useful algorithms in learning analytics and how they support teacher actions as well as how teachers can use them to facilitate student learning.

The presentation was followed by a brief discussion based on the thoughts that had arisen from the introduction and about how the learning analytics tool is shown and could be used in the eCraft2Learn context. After the discussion, free practice on the learning analytics interface for teachers on the eCraft2Learn digital platform for learning analytics took place.

The project members used the eCraft2Learn UUI in order to produce data from different learning events. This data was then collected by the learning analytics tool and teachers could practice with the incoming data in real-time and analyse the different learner profiles. Teachers were practising to generate the predictive tree for real-time classification and generate student profiles for UUI adaptation as well as to interpret the different graphs.

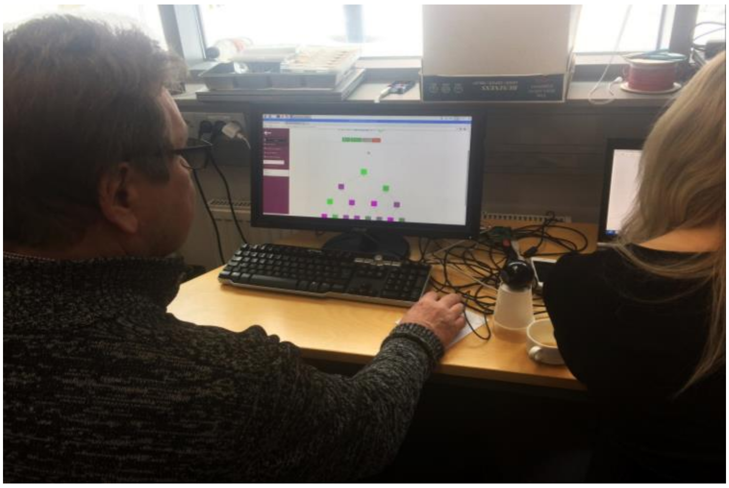

Figure 33: Familiarising with the learning analytics tool - analysing student data

4 FEEDBACK RECEIVED FROM THE TRAINING WORKSHOPS IN GREECE

This section summarizes the feedback received by the participant teachers through the online questionnaire. The teachers were encouraged to complete the questionnaire at their own pace after the completion of the workshop. The following open questions were put to the participant trainees after the completion of the 1st and 2nd training rounds, respectively. It was important to preserve anonymity and conceal identities and thereby maintain the confidentiality of the data provided by participants and for this reason the name field was optional. When reference is made to a teacher's statement either a pseudonym or a general descriptive term, i.e. participant teacher, is used.

The set of questions put to the participant teachers appear below:

- *Based on the experience gained during the training course, please mention the strong points of the eCraft2Learn technologies/tools that were introduced in this training workshop.*
- *Based on the experience gained during the training course, please mention the weak points of the eCraft2Learn technologies/tools that were introduced in this training workshop.*
- *Which are the main challenges that you encountered during this workshop?*
- *As a result of this training, do you feel more confident in your capacity to use the eCraft2Learn technologies as teacher/educator in the classroom or in other educational activities?*
- *Did the training course help you understand the pedagogical ideas underpinning an eCraft2Learn project?*
- *What changes should be made to enhance/improve this training workshop in the future?*
- *You will be invited to participate as a coach in the forthcoming pilots with the students. Please write your suggestions for the better implementation of the pilots both in a formal and informal educational setting here.*

The sections below summarize the feedback gained by trainees after the 1st and the 2nd capacity building workshop through online questionnaires. More precisely, the teachers' responses were grouped together under coming threads running through them and are summarized below (see section 4.1 and 4.2). The comments made during the training workshops and the field notes kept by the trainers have been documented and critically presented in section 4.3. These comments arose in the context of periodically scheduled discussions with the group of teachers, during the training and after the end of specific sessions. The evaluation tools used are shown in Table 8.

Table 8: Evaluation tools for feedback collection

	Evaluation tools	
1st workshop	Online questionnaire with open questions	Field notes during group discussions*
2nd workshop	Online questionnaire with open questions	Field notes during group discussions*
Notes	*in the context of the training and/or at the end of the training session	

The following Table 9 provides information about the number of teachers that took part in the workshops providing us with their feedback.

Table 9: Participants teachers per workshop round

	1st workshop	**2nd workshop**
Number of teachers that completed the questionnaire	16	5
Number of teachers that participated in discussion providing comments during the training workshop	20	10
Total number of participants in the workshops	20	10

4.1. Results from the questionnaires (round 1)

This section summarizes the feedback gained by the sixteen (16) trainees that completed the online questionnaire after the 1st pilot round. The feedback is viewed in conjunction with the comments made during the 1st training workshop and documented by the session trainers/moderators (see section 4.3).

It is worth noting that the teachers that participated in the 1st teacher training workshop recognise the strong aspects of the eCraft2Learn technical core emphasizing the open source nature of the tools, the great variety and their low cost. Although they seem to recognise the educational value underpinning the eCraft2Learn initiative, they struggle to imagine how it will be to act as a coach in the class. Some are more confident than the others but there is a general anxiety and concern related to the co-learning and co-designing task. The teachers ask for educational resources, guidelines and worksheets for students as they think that these can act as reference tools supporting their role as coaches, their efforts and the learning process. Their feedback is presented in detail below and is thematically discussed.

Reference to the strong points

The participant teachers were asked to outline the strong points of the eCraft2Learn technologies/tools that were introduced in the context of the 1st capacity building workshop. This was an open question and no prompts were given. Sixteen (16) answers were collected; it was worth noting that their answers focused not only on the technological core of the eCraft2Learn ecosystem but also on the pedagogical approach and the overall experience gained. Overall, a number of strengths were highlighted by participants including the rich variety of the technologies/tools that were explored during the workshop, the nature and the features of these technologies and tools, the pedagogical approach that was followed, the interactive discussions and the good communication with the trainers/project team.

More precisely, the participants highlighted the following positive aspects related to the eCraft2Learn technical core:

- Free and open source technologies and tools
- A great variety of technologies and tools that can support a wide spectrum of educational projects
- Technologies that enable the connection between the digital and the physical world
- Technologies that are low cost and can be easily extended into the school classrooms
- Technological solutions that enable remote interaction among the machines

Explicit reference was also made to specific technologies that are part of the eCraft2Learn ecosystem. More precisely, the trainees highlighted the flexibility in extending/advancing their project by connecting to the I/O Arduino pin multiple sensors and feedback components. The teachers highlighted also that visual programming environments ease the process for novices to step into the experience of programming without limiting opportunities to create more advanced programs. Their comments bring into focus Resnick's call (which draws on the ideas of epistemological pluralism (Turkle & Papert, 1990)) for learning environments that have not only a low floor (easy to get started with) but also a high ceiling (opportunities for increasingly complex explorations over time) and wide walls (a wide range of different explorations) (Resnick, 2007; Resnick, et al (2005)).

The participants also highlighted the 3D printing technology, which was described as a hot topic in the world of technology with the potential to open up new opportunities in the field of education. A lot of new knowledge was acquired and the opportunity to practically explore how software and hardware are brought together for the creation of a computer-based artefact was appreciated.

Interestingly, as was mentioned earlier, the trainees' answers did not revolve merely around the technologies and the tools introduced during the training; but also around the **pedagogical deployment** in real classroom settings, their feelings during the training, the value of hands-on practice and their interaction with the trainers. These are exemplified by the quotes below:

"The hands-on experience was the stronger point, along with the interesting technology (Arduino, 3d printing, etc), that we don't usually come across. What is more, completing each task offers a sense of achievement in terms of making something from scratch. New knowledge was acquired and there was good collaboration among participants and trainers"

Participant teacher

"I see the familiarization with technologies and software that can clearly facilitate educational purposes as the strong aspect. Many tools were covered and I tried them out and thanks to that I can make good suggestions to my students while they will be working on their constructions"

Participant teacher

References to the weak points and recommendations

The participant teachers were asked to comment on the weaknesses of the eCraft2Learn technologies/tools that were introduced in the context of the 1st capacity building workshop. The issues raised by the participant teachers were not strictly related to the selected eCraft2Learn tools but rather to the time that is required to master these tools. The majority of the teachers mentioned that time was a critical factor in becoming familiar with the eCraft2Learn tools and technologies that support the five (5) stages of the craft- and project-based methodology. Based on their comments, the time that should be allocated cannot be easily pre-defined and is dependent on individuals' time constraints and needs (for instance some teachers needed more time in becoming familiar with visual programming while others needed more time in the design of the electrical circuits).

"The software tools require time to get familiar with"

Participant teacher

"...my mind could not get easily around blocks and programming […].I needed some time to gain understanding. It was a slow learning process for me"

Participant teacher

Very few teachers (two (2) out of sixteen (16)) directly linked the free experimentation sessions with the lack of clear educational goals.

"[…] confusion was kind of a characteristic of the free practice sessions. Perhaps more clear goals are needed for these sessions"

Participant teacher

One (1) teacher appears also to be sceptical about whether the eCraft2Learn initiative will be of interest to the students. Is he/she projecting his/her own anxiety on the students? How valid might such a concern be? These questions cannot be easily addressed at the moment but it worth revisiting after the completion of the pilots with the students.

> *"Perhaps, it may not fit into the interests of all students, because of the initial fear a student may have regarding technology"*
>
> *Participant teacher*

In light of the issue identified above, respondents made the following recommendations:

- A well designed and organised set of educational resources should be provided to the teachers
- More time should be allocated in the training that focuses on that specific set of tools
- Need for pre-developed simple examples for artefact construction
- Suggestions for 'homework-type tasks' to practice with
- Preparatory courses for novices in key thematic areas (i.e. in electronic circuit design)

In general, the participant teachers mentioned that they had gained an understanding of the **pedagogical ideas** underpinning the eCraft2Learn initiative. However, they stated that this occurred gradually as the training workshop was progressing and it is not easy for them to state the level of their understanding. The teachers also mentioned that regardless of the clear presentation of the pedagogical ideas, it is the actual implementation with the students that can confirm or not the level of their understanding.

> *"I did in the end [she is referring to the understanding of the pedagogical ideas]. First, I did not really get it. The whole coaching idea instead of being a traditional teacher"*
>
> *Participant teacher*

> *"The pedagogical ideas underpinning the eCraft2Learn project were clear enough. Maybe we can tell more after working and planning activities with the students"*
>
> *Participant teacher*

Challenges

The participant teachers were also asked to state to the challenges that they had faced during the 1st capacity building workshop. The documented challenges fall into three (3) categories:

1. challenges related to the eCraft2Learn technologies/tools
2. challenges related to the methodology that is put forward
3. challenges related to time

It is worth mentioning that the challenges that have been identified by the participant teachers have (to some extent) previously been reported by them as weak points. Regarding technology/tool-related challenges, some teachers (nine (9) out of sixteen (16)) mentioned that they mainly faced challenges with the DIY electronics (the construction of electrical circuits using the Arduino Uno board and the related components) and the programming. They closely relate the challenges that they encountered to the absence of previous experience and pre-knowledge.

Five (5) out of sixteen (16) participants remarked as the main challenge the transfer of the eCraft2Learn learning methodology from theory to practice. In addition, the open nature of the forthcoming learning intervention and their new role as coaches was brought to the fore by the participant teachers.

> *"The main challenges were: A. to take responsibility of my learning, B. to explore, largely on my own, how to learn subjects I was not familiar with C. I realized that I do not have to know all the details on the subject because later on -with the students- I will continue learning too"*
>
> *Participant teacher*

> *"The biggest challenge is to accept the new spirit of teaching"*
>
> *Participant teacher*

Last, two (2) participants, whilst enjoying the content, had found the sessions quite intense owing to the range of tools practiced in each session.

Regarding confidence & recommendations

The teachers were also queried about their suggestions for the better implementation of the forthcoming pilots. Twelve (12) answers were provided, all of which related to the provision of guidelines for the teachers, worksheets for the students and supportive educational resources for both groups (namely, teachers and students). Based on their answers, access to these resources a) will support their pedagogical and technical skill building b) will offer them a more comprehensive idea on the spectrum of the applications that can be carried out with the suggested technologies c) will help them see their educational deployment in the context of an open craft- and project-based activity. Indicative comments follow:

> *"It would be useful to have access to organized educational material for both trainers and trainees [..] These can support the development of the projects in the pilots with the students"*
>
> *Participant teacher*

> *"[...]More activities and guidelines so that everybody may become more confident with the technologies and software in focus"*
>
> *Participant teacher*

> *"Creation of possible scenarios for projects. These can help new ideas to emerge. Descriptive worksheets for the students [..]"*
>
> *Participant teacher*

Based on their answers, organised educational resources related to the eCraft2Learn learning initiative and the components of the technological core can act as reference tools supporting their role as coaches. Their comments were taken into account (see also D5.3) and effort was put in enriching the Unified User Interface (UUI) with educational resources properly categorised per thematic topic, methodological stage and technological tool (see also D3.3 and D3.4). Building on teachers' comments, guidelines for teachers were prepared (for optional use in the context of the 1st pilot round) as well as worksheets for the students for those projects that have been agreed well in advance by the participant teachers and students (these are available in the current version of the Unified User Interface-UUI).

Interestingly, among the comments collected, three (3) describe a process that was very far from the eCraft2Learn concept. More precisely, three teachers requested pre-developed code and scripts well in advance for specific/predefined projects. This request could not be easily completed by the project team as it was in contradiction with the ideas underpinning the role of the teacher as a coach. Reflecting on their answers and the discussions that took place during the training sessions, it seems that they fear that they will be under-prepared and not be able to address students' queries or help them out properly. *'What if we cannot answer their questions or fail to support them?'* In other words, it seems that some teachers tried to negotiate their role as coaches, approaching it from the more traditional and 'somehow safe' perspective of teaching. This type of 'negotiation' was expected given that the teachers were invited to go beyond their usual teaching practices and to exit their comfort zone. Some of them appeared to be more confident, other less confident but willing to take up the challenge and few others more reluctant. The statements below are indicative of the different levels of confidence that were observed in the groups.

> *"Maybe we need a more detailed (written) outline of an indicative activity; and (even better) we may try to do it in the lab before the workshop with the students. We can test it before hand, even if we are described as coaches. A good coach should know the subject and be so familiar with it, so that he can coach in a "cool" way and effectively"*
>
> *Participant teacher*

> *"I do not feel sufficiently confident. However, I don't fear that I will not be able to coach a small team of students. It will be a challenge for me".*
>
> *Participant teacher*

> *"Yes, I do feel confident. I really have to see it actually working with students in that special approach of learning -teaching"*
>
> *Participant teacher*

From another point of view, the participant teachers' request for pre-developed code and scripts raises the issue of the extent to which the use of black boxes can be accepted. If the teachers find it confusing or scary to open, hack the boxes and ask for pre-developed scripts and explanations, then how can we encourage them to wonder about and be curious about the interior of the black box? Learning can be influenced by emotional factors such as resistance, fear and the discomfort of not being as supportive as is expected (Pearson, 2010). The challenge for the project team was to boost the teachers' confidence and discretely support them in order to find their own way of coaching. Half-baked solutions that leave space for explorations may be the way to support their training in the beginning and to help them gradually build more confidence in demystifying black boxes.

But despite the issues highlighted above, the majority of participants remarked that the workshop content had been well pitched to suit all needs and was delivered in an open and respectful way which encouraged mutual learning and sharing of opinions. This approach was seen as supported by the fact that many of the workshop participants early from worked well together from early on and 'gelled as a group':

> *"I think that the workshop moved us smoothly to start thinking our role as students' counsellors, facilitators and partners. It also helps us get in the students' shoes and realize what it is expected from them. That's why I would not make any change. I enjoyed the discussions within the team and the collaborative spirit of this training"*
>
> *Participant teacher*

In the light of the issues identified above, the trainers made the following recommendations for future workshop improvement:

- Access to thematically organised supportive educational resources for teachers (guidelines, etc.)
- Access to educational resources that can be used by the students (i.e. worksheets)
- Need for pre-developed simple examples for artefact construction
- Suggestions for 'homework-type tasks' to practice with
- Preparatory courses for novices or teachers with no background in STEM in key thematic areas such as electronics and programming
- Available final computer-supported artefacts to be used as demos before the beginning of the teacher training course
- Organization of visits to educational places where this methodology is already in use
- Extended time especially for training sessions related to electronics and programming

4.2. Results from the questionnaires (Round 2)

This section summarizes the feedback gained from five (5) trainees that completed the online questionnaire after the 2nd pilot round. The feedback is viewed in conjunction with the issues raised during the 2nd training workshop and documented by the trainers/moderators of the sessions (see section 4.3). The following table summarizes the way each session was shaped, taking into account recent technical developments in WP4 and teachers' needs (for more detailed information see chapter

2, section 2.2). All the respondents, apart from one (1), who was a newcomer to the group, had participated in the 1st round of the eCraft2Learn pilot with the students. The newcomer already had a good background in Do It Yourself (DIY) electronics and visual programming so she could easily follow the rest of the group in the 2nd teacher training.

It is worth noting that the teachers that participated in the 2nd teacher training workshop appeared to be far more confident in using the eCraft2Learn tools and technologies in the forthcoming pilot workshop with students. They seem to understand the underpinning pedagogical ideas and to recognise the value of the eCraft2Learn initiative. They referred to the challenges faced during the workshop (mainly problematic situations when practicing artificial intelligence programming) and they also foresee the challenges for the upcoming pilot workshop with students. Their feedback is presented in detail below and is thematically organised.

Reference to the strong points

The participant teachers were asked to mention the strengths of the eCraft2Learn technologies/tools that were introduced in the context of the 2nd capacity building workshop. This was an open question and no prompts were given. Five (5) answers were collected; it is worth noting that their answers, similar to after the 1st capacity building workshop, focused using not only on the technological core of the eCraft2Learn ecosystem but also on the pedagogical approach and the overall experience gained. Overall, a number of strengths were highlighted by participants including the recently updated version of the Unified User Interface (UUI). The updated version of the Unified User Interface (UUI) received positive comments and was seen as an environment that brings together all the eCraft2Learn tools/technologies and related resources.

> *"UUI as an educational tool is considered strong and focused on the topics it is supposed to introduce to the trainees"*
>
> *Participant teacher*

> *"The technologies are modern, evolving, with potential to attract interest and offer exciting opportunities for learning. With the new developments, the UUI tends to become an environment that integrates all the technical aspects and the tools"*
>
> *Participant teacher*

Explicit reference was also made to the 3D printing technology and the environments for 3D model design. As was the case after the 1st capacity building workshop, the trainees' answers did not revolve merely around the technical core of the eCraft2Learn ecosystem but also around the **pedagogical aspects** related to the deployment in real classroom settings. More precisely, the emphasis on hands-on activities, and the way the role of the coach is engineered through the eCraft2Learn methodology were also identified as strong points.

References to the weak points and challenges

The participant teachers were asked to mention the weaknesses of the eCraft2Learn technologies/tools that were introduced in the context of the 2nd capacity building workshop. Two (2) teachers referred to the connectivity problems due to lack of network bandwidth and the sluggishness of the RPi3 while testing artificial intelligence scenarios that included voice recognition.

> *"...The session regarding AI seems that have not worked as expected or in my case did not work at all"*
>
> *Participant teacher*

Indeed, the laboratory network configuration at the time of the training session was not fast enough to support the full voice recognition process which demanded fast bidirectional communication with remote servers. Apart from the need for greater network bandwidth, the AI scenario testing was also computationally demanding and in some cases pushed the RPi3 machines to their limits. As a response to these failed attempts, additional practice on artificial intelligence programming took place in the context of the 5th session.

Two (2) teachers focused on the time that is needed to become familiar with the eCraft2Learn tools and technologies and the personal time that should be invested. They further pointed out the challenging task of introducing the tools and the technologies into the formal school curriculum.

The main challenges that were documented by the teachers seem to be closely related to the aforementioned weak points. Table 10 presents the challenges were encountered and/or foreseen:

Table 10: Challenges encountered & foreseen

Challenges encountered	• Failures with AI scenarios due to network bandwidth or computational load • RPi3s were performing slow or occasionally crashed
Challenges foreseen	• Concerns about the need for allocation of additional time for personal exploration/practice • The process of integrating into and adapting the eCraft2Learn initiative to the school reality

Understanding of the pedagogical ideas

Based on teachers' statements after the 2nd round, a clearer understanding of the pedagogical ideas underpinning the eCraft2Learn initiative has been achieved (compared to their understanding after the 1st capacity building workshop). The teachers reflected positively on the knowledge and understanding they had gained in relation to pedagogical ideas underpinning the eCraft2Learn initiative, particularly in relation to their understanding of the 5-stage methodology that is put forward and facilitation throughout the making process. However, it remains to be seen to what extent this change can be associated with the experience already gained in the context of the 1st pilot with the students.

> *"Yes, the workshop helped me to see how a 'maker' can feel when he has the space to imagine, design and apply all his ideas"*
>
> *Participant teacher*

> *"the 5 stages are interlinked, not separate, going forward and backward, in order to ensure the quality of every step of the project towards the final construction"*
>
> *Participant teacher*

Regarding confidence

All the respondents appeared to be confident in carrying out the second (2nd) pilot with the students using the eCraft2Learn tools/technologies. Some respondents closely linked their increased confidence to the experience gained during the first pilot round with the students. They were not encouraged to enter a new, unfamiliar area; they already knew what this new area is like and the new challenge now for them is to further improve their coaching skills to support the making process. This is also exemplified by the statement below:

> *"There is some experience this time that makes you feel much more confident (but it is important to continue building on this good start)"*
>
> *Participant teacher*

The increased confidence is also linked to the fact that real hands-on practice took place during the training. An attempt was made to provide teachers with as much space as possible for personal hands-on practice with the eCraft2Learn tools/technologies in order to experience first-hand the type of activities that are expected to take place in real classroom settings. In addition to that, the existence of the updated version of the Unified User Interface (UUI) seem also to play a role in the teachers' enhanced confidence.

> *"It was crucial that I had the opportunity to watch in action and actually try for example HOW to design and print my object. Definitely, this hands-on workshop gave me a strong sense of how I can use this technology in my classroom"*
>
> *Participant teacher*

Recommendations & suggestions for improvement

In general, the respondents expressed their satisfaction related to the 2nd eCraft2Learn capacity building workshop. Three (3) teachers mentioned that they would not make any changes to it. They seem to highly value the training through hands-on tasks and they think that the new mission for the training team is to maintain a pleasant and supportive atmosphere live.

> *"I would not make any change. Keep up with the hands-on practice. It is important. Do not spoil the pleasant learning and supportive environment that exists"*
>
> *Participant teacher*

One teacher asked for stronger guidance which somehow contradicts with the open spirit of the training that is put forward, thus posing a new challenge for the training team on how the support that is offered to the teachers can be further enhanced without stepping into the traditional and guided ways of training.

> *"The guidelines were helpful and could be revisited. But we also need a stronger guidance to keep on track"*
>
> *Participant teacher*

Another teacher brought the critical factor of time into focus. The time that should be spent in each training workshop significantly challenged the training team. On the one hand as described above (see Chapter 2), the teachers' availability and time constraints should be respected; on the other hand, the deployment of the eCraft2Learn methodology and the familiarisation with the eCraft2Learn tools and technologies is a time-demanding task especially for novices. Not all the teachers had the luxury of spending time in long training sessions. In addition, the needs per teacher differ; the same applies to their interest in additional practice in the eCraft2Learn lab. Future iterations of this workshop and other educational initiatives might seek to reconsider the balance between scheduled sessions and free open sessions for experimentation, perhaps organizing a pre-workshop for those in need in order to free up more time for practical skills training and a 'walk through' of the five (5) stages of the craft- and project-based methodology.

As far as their **suggestions for the forthcoming pilots** are concerned, these focus on the **projects** that the students are going to work on, the need for **spare technological equipment** and the need for **additional opportunities for sharing projects and experiences**. More precisely, according to two (2) teachers, it would be interesting if the computer supported artefacts that the students would be creating in groups could be united in a common project. In this case, the new objects would be the connectors of the common "set". In addition, another issue that was raised by a formal education teacher is the re-use of the technologies for the creation of new artefacts. He highlights that it is important to have spare technologies available (i.e. Arduino Uno boards, breadboards, wiring cables) in order to avoid breaking down already produced artefacts to re-use the technological equipment. Last, the sharing aspect was also brought up, with one (1) teacher stressing the need for enhancing features in the UUI that will enable the sharing of projects, educational material and experiences. The teacher highlights the importance of the sharing aspect in the making process and closely links it with the formation of new ideas for computer-supported artefact construction.

4.3. ADDITIONAL COMMENTS RAISED DURING THE TRAINING IN GREECE

At the end of each session (when applicable) the training team was encouraging the participant teachers to join an open group discussion in the context of which they could freely talk about their experiences, concerns, expectations and suggestions for improvement. The trainers were also initiated discussion about issues they may have observed or comments raised during the training. No pressure was placed on the teachers to participating in these group discussions. The comments made during the sessions are documented and discussed below. It is worth noting that many of the issues that are detailed in the following paragraphs are also reflected in teachers' responses through the questionnaires (see section 4.1 and 1).

Round 1

During the discussion organised in the **1st teacher training session**, the trainees commented on the 5-stage educational methodology, offering constructive feedback. They suggested that the 5 stages should not be used in a serial/linear way; the stages should be rather fluid and adaptable to students' needs and interests. Others added that students might start from different stages each time; for instance, a student might be in a situation where no initial ideas emerge and must start with the sharing step to form some ideas. Others suggested encouraging reflection on the different stages and recommended a "controlling stage" where students check their work and control their progress. They suggested that evaluation and self-evaluation should be part of the learning process. Some emphasised that connecting the ideation stage with students' needs and interests would help the generation of good ideas for student projects. Others noted the interplay between ideation and planning and suggested that these stages are closely connected to each other. All agreed that sharing is a very important stage: students should share their projects at the end of each session or at the end of the pilots.

Another interesting remark initiated a lively discussion about the role of the student's apprenticeship and the initiation in learning process; the teacher expressed the opinion that the students learn better while working next to a 'wise' mentor. The discussion revolved around the question: 'how could the eCraft2Learn methodology offer such an initiation i.e. provide links to a community of experts?'

Regarding students' involvement in the projects, suggestions were made that students should undertake different roles within their group acting as "programmers", builders", "presenters" and so on, and rotate their roles in the next sessions based on their interests.

In the **2nd teacher training session** the trainees were observed working with great interest. Some were curious to try out their own experimentations with Ardublock and Snap4Arduino programming tools going beyond the tasks proposed by the trainers. They were supportive to their peers; for instance, they were eager to help one another; to share new knowledge (for example, after they had learnt a new tool). They seemed to enjoy their technical tasks and, when finishing a task, shared their achievements with the rest of the group.

They asked for more technical support including video, tutorials and references: for instance, in Snap4Arduino what does each block stands for? When new tools/devices are introduced some pictures of the tools/devices with some explanation would be helpful. They found that concurrently monitoring the Ardublock visual interface and Arduino IDE code helps to understand the code. They felt that making the circuits may be hard for students; a bigger breadboard or a breadboard properly marked to show how it is wired would be of help.

Regarding the training methodology, some trainees suggested that the training tasks should always be based on a scenario to make them more meaningful; they might then extend the scenario themselves depending on their interests.

Interestingly, in the **3rd teacher training session,** though the training tasks in that session were more advanced, the trainees found the tasks easier than those of the two first sessions, possibly thanks to the experience they had gained and the skills they had already developed. This provides positive indications that our training methodology followed a stepwise approach. The trainees liked App Inventor and appreciated it as a good programming tool for kids. However, they warned to avoid giving too much information for children, since this might make the tasks difficult. Instead of this, they recommended providing proper information for children as 'food for thought' and foster inquiry learning, providing tools for the students to search for any information needed. They found the tasks and topics interesting but they expressed some doubt about whether all the students would be able to design their own circuits (like they did in the context of the training). Similar concerns were documented through their final questionnaires (see section 4.1)

In the **4th teacher training session** it was observed that the trainees were enthusiastically engaged in 3D modelling and printing activities, staying longer in the lab than scheduled. The familiarisation tasks were considered well-selected for novices and the session well-organised; in addition, they stated that they liked the intuitivity offered by the 3D modelling and printing tasks that they went through. They also seemed to start thinking about each technology and tool not separately but as a whole set that brings together technologies and tools that complement one another for the building of interactive artefacts.

> *'by today's 3D modelling and printing experience, things are getting glued together and completed, for example, we have learnt how to equip the artefacts with sensors, servos, logic and now how to give them a meaningful shape' (participant teacher)*

At the end of the **5th final session** a plenary discussion was held for the overall evaluation of the 1st training round. Teachers appreciated they had made important progress during the course, acquiring knowledge and skills to deploy the eCraft2Learn technologies and the educational methodology. They recognised that the training methodology had offered a well-balanced mixture of "ready to use" and "left to discover" learning materials.

However, some teachers serving in the school education system were rather sceptical about the implementation in their school class. They felt insecure and that they would be inadequate in students' eyes because they do not have full knowledge of the tools. They asked for indicative solutions and detailed lesson plans for each project idea including objectives, tools, methodology, worksheets, and evaluation tools. Furthermore, they believed that school students do not have the basic knowledge of electronics, are not aware of the proposed tools and as a consequence would be not capable to finalize more than 2-3 of the proposed scenarios. They suggested to giving at least a worksheet to students with a short guide for the DIY electronic tools and the software to use in each learning session. Other suggestions included the provision of detailed materials for students and 'something to begin with'. These requests and concerns were also documented through their responses collected from the questionnaire (see section 4.1 about confidence).

The scepticism and/or anxiety expressed by some of the teachers who serve the Greek public school education system is well understood. The education system in Greece is mainly centralised and teachers are used to following directives and instructions coming from central educational authorities which rule the whole learning process in schools (Dimitropoulos & Kindi, 2017). In addition to this, there are stereotypes for the role of teacher as an intellectual authority in the class who has ready answers for everything arising in the learning process. As a consequence, the teaching methods are rather guided by the teacher and based only on handbooks approved by the ministry of education (Dimitropoulos & Kindi, 2017), not leaving much space for teacher and learner initiatives and resulting in predictable learning outcomes. Used to acting in such a framework, the eCraft2Learn teachers are suddenly invited to undertake a very different role, the role of the coach; to leave the initiative to students, to work in an unknown and challenging environment using completely new tools. All this can explain well and justify some frustration and anxiety obvious in some school teachers' attitudes. On the other hand, we noticed that trainees not serving in public schools (i.e. private school teachers, non-formal educators, young prospective teachers) were more open and confident in undertaking their new role, to adopt new tools and methods, and to be surprised by their students in the pilots to come. However, they expressed their apprehension that the equipment was not available at home to continue their training at their own private place and pace.

Round 2

In the **1st session of the 2nd training round**, the trainees were invited to reflect on the 5 stages of the craft- and project-based methodology (ideation, planning, creation, programming, sharing) they had already implemented in the 1st round of pilots, on their role as coach and on the technical resources and worksheets given in the 1st round of pilots. They provided interesting feedback useful for the evaluation of the pilots (to be reported in the forthcoming deliverable 5.5). Moreover, their comments on the point offered some evidence that they had understood well and to a significant extent applied the eCraft2Learn methodology. For instance, they emphasized the learning process rather than the final products and had encouraged their students to make their own explorations.

"I left my group to make explorations, so we did not complete all the projects" (participant teacher)

In another case, teachers worried that their role was not adequate as that of a coach:

"The kids needed help to program and I had to provide instructions which may affected my role as coach" (participant teacher)

This was an interesting shift in their attitudes; from negotiating how much coaching is needed to be a coach, they now seen to worry that specific activities may have a negative effect on the role that they would like to successfully perform.

In the **4th training session,** the trainees and trainers together studied the **learning analytics tool** provided through the Unified User Interface (UUI) and at the end were encouraged to freely document their thoughts on this. The participant teachers did not have any previous experiences related to learning analytics. The positive aspects mentioned by the teachers as far as the learning analytics service is concerned were:

- Depicting the student performance has educational interest
- The tool can potentially act as an external observer becoming an assistant/advisor for the teacher
- Identification of students' attributes/peculiarities and learning profiles would be useful

Their considerations **(as for April 2018)** can be summarized as

- It seems that this tool is not mature enough for deployment in the classroom
- Need for knowledge of statistics to use it - zeros and ones have no interpretive value for teachers
- It does not seem easy to use
- It does not seem to include/record any qualitative data
- The duration of the use of each tool in UUI is not recorded
- The criteria for extreme values were not clear to the teachers (the teachers asked if they can they set their own values)

They finally suggested that a didactic transformation is required for the learning analytics tool and made some concrete suggestions for:

- The creation of a total report per student / group
- The creation of a graph showing the order in which the tools were used per input
- The creation of a graph for each student/group
- Showing group progress in a report
- Diaries and text-based evaluation tools that might give input into such a system and probably a text mining evaluation tool might be included

At the end of the 2nd training round teachers made some useful suggestions for their role in the 2nd round of pilots based on their experiences from the 1st one. For instance, they asked to have a more free role walking around the lab and supervising more than one group of students instead of coaching one or two groups.

5 FEEDBACK RECEIVED FROM THE TRAINING WORKSHOPS IN FINLAND

This section summarizes the feedback received by the participant teachers after first and second round of eCraft2Learn capacity building workshops in Finland. After completing the first training round a semi-structured interview was held where all participant trainees gave their impressions and experiences of the eCraft2Learn project and the implementation of the project in the schools. The semi-structured interview used as guidelines for the questions in the online questionnaire in Greece. Table 11 shows the evaluation tools used in Finland.

Table 11: Evaluations tools for feedback collection

	1st pilot round	2nd pilot round
Number of teachers that completed the interview or the questionnaire	5 (semi-structured interview)	2 (questionnaire)
Number of teachers that provided comments during the training workshop	5	4

A semi-structured interview approach was decided on since the training group was small and the opportunity presented itself for getting the feedback immediately after the training ended. We also considered that through this method more insights could be elicited from the participants. The following topics were discussed during the interview.

- Based on the experience gained during the training course, please mention the strengths of the eCraft2Learn technologies/tools that were introduced in this training workshop.
- Based on your experience gained during the training course, please refer to your impressions and experiences of the eCraft2Learn Unified User Interface (UUI) platform. How did the UUI support or guide your work throughout the project?
- Based on your experience during the training course, please state your impressions and experiences of the technologies used in this project.
- Please describe the main challenges that you encountered during this training.
- How well did you understand the pedagogical considerations underpinning the eCraft2Learn project?
- Please describe how you will implement the eCraft2Learn ecosystem as a teacher/educator in your classroom.
- How do you see the teacher's role as a coach or a facilitator in the classroom?
- How would you enhance/improve this training workshop in the future?

The feedback after the second round of capacity building workshops was collected through an online questionnaire, as per the method used in Greece. The teachers were encouraged to complete the questionnaire at their own pace after the completion of the workshop. However, only half of the participants returned the feedback on this occasion. The following open questions were put to the participant trainees in the online form.

- Based on the experience gained during the training course, please mention the strengths of the eCraft2Learn technologies/tools that were introduced in this training workshop.
- Based on the experience gained during the training course, please mention the weaknesses of the eCraft2Learn technologies/tools that were introduced in this training workshop.
- Please describe the main challenges that you encountered during this training.
- As a result of this training, do you feel more confident in your capacity to use the eCraft2Learn technologies as teacher/educator in the classroom or in other educational activities?
- Did the training course help you understand the pedagogical ideas underpinning the eCraft2Learn project?
- What changes should be made to enhance/improve this training workshop in the future?
- You will be invited to participate as coach in the forthcoming pilots with the students. Please write your suggestions for the better implementation of the pilots both in a formal and informal educational setting here.

The sections below summarize the feedback gained by trainees after the 1st and the 2nd capacity building workshop. The feedback is viewed in conjunction with the comments raised during the 1st training workshop and documented by the observers/moderators of the sessions.

5.1. Results from the questionnaires/Interviews (round 1)

After the first round of teacher training a semi-structured interview was held. This interview led to a discussion about the general view of the training and the eCraft2Learn technological and pedagogical core as well as the future deployment of eCraft2Learn methodology in schools. This section summarizes the teachers' views and feedback after the first round of teacher training. In general, the participant teachers started viewing the project more and more from the pedagogical perspective during and after the first teacher training workshop.

Reference to the strong points

Teachers identified many skills the eCraft2Learn projects can improve. Creativity, collaboration and ICT skills were mentioned several times. Nowadays teamwork is a substantial part of study and work life. Peer learning is usually very effective among pupils and it should be emphasized in teaching. Teachers think that students should learn future skills, which include the usage of ICT. Teachers consider using technology in schools as essential when preparing students for their future life. That is why it is important that pupils can explore and become familiar with different technologies. Especially understanding of technology was found important. It is also important to start using technology now, because students will more likely need it in their future education and work.

Teachers agreed that learning by doing supports learning. When students notice that something does not work or a different solution could have been better, they will analyse the problem, search for information and assimilate or accommodate new knowledge with already existing knowledge. Problem-based learning gives students a chance to do things by themselves, facing the problems and challenges and solving them. The next time they manage to do things more smoothly.

> *"...there is the opportunity to learn when we notice if it [solution] is working or not, maybe we should have planned it a little more carefully. And then we learn and I think it is always -- the journey is important not necessarily the result. Learning happens along the way..."*
>
> *Participant teacher*

Teachers realised that during the project they were easily asking help instead of trying to find the information needed to solve the problems themselves. Teachers feel that students will be happy to help each other and teachers encourage them to do that. Moreover, sometimes students accept help more easily when it comes from a peer than from a teacher. This may lead to improved internal motivation and better learning outcomes.

Teachers stated that it is common to start projects by posing a problem to students. Then students will investigate the problem, gather relevant information and create possible solutions. Students can work alone or in groups, but teachers mostly made reference to the importance of teamwork in the stages of ideation, planning and creation. The pedagogical model of an eCraft2Learn project also includes self-reflection. Students reflect on their learning, analyse results and think about what went wrong or where they succeeded. Self-regulation occurs in the project in different stages.

The 5-stage pedagogical framework of the project can be followed through a problem-based learning method. In this method, learning proceeds step-by-step. Exercises start from simple tasks and move on to more demanding ones where students have to apply knowledge. Thus, students will improve their critical thinking and metacognitive skills. Teacher can provide possible equipment (for example lamps, batteries, etc.) to complete a task but shift the responsibility to students to figure out how to make the lamp light up. Students have an active role when thinking, trying and making on his/her own. Students will be the makers in the learning situation.

The platform was considered as logical and understandable and the usability of the platform was good. One teacher noticed that the user interface was more intuitive than the ones she has used before. However, teachers think that it is more challenging to use the platform if all the information there is new.

Teachers admitted that they have quite limited knowledge and a narrow or stereotypical view of technology. During the teacher training they learnt new aspects and got different perspectives on using and creating technology. One teacher was amazed how many new possibilities for the creation of technology he discovered during the project. He had also discussed the creation of technological devices with his colleague. Through the project there truly ignited a spark of interest towards making and creating technological devices and innovations at home in daily life and as a tool for learning in schools.

> *"And if you mention robots or robotics, I always come to mind that *teacher makes robot sound* and some kind of rolling object -- that very easily just restricts thinking and you get stuck that now we have to make some type, when we talked about sensors it opened my eyes, that there is so much that can be measured and those infrared things and... And then oh, there are so many possibilities, we discover more and more all the time, the amount of possibilities becomes endless."*
>
> *Participant teacher*

Teachers were also positive that through the project students may engage in and get excited about the various areas of technology. Teachers saw the great value of the project as it is suitable for all students, allowing students with different backgrounds, knowledge and skills to work at their own level. As an ultimate goal, one teacher mentioned that some students would probably get very interested in and motivated about making computer-supported artefacts and continue working on them after the project as well. Thus, the project can raise or increase students' interest towards technology.

"I believe [during and after this project] some students will think about technology and maybe even the content on their free time. And that is the purpose, or the prize actually"

Participant teacher

References to the weak points

Teachers were able to identify a possible challenge when implementing the eCraft2Learn ecosystem in schools. They felt that if there is no prior knowledge or experience regarding the different technologies, the platform might be challenging to use, especially in the programming stage. Therefore, it would be useful for students to know something about programming before they started the project. For example, an introductory session on programming could be held when starting the project. The programming practice was seen as time consuming when looking at the whole project.

"It's [the platform] quite easy to use. Well, it is easy to use when you get to know it, but there is, there comes that programming, if you have not used Scratch or practised programming at all, the platform is pretty challenging"

Participant teacher

Challenges faced

When starting the teachers' own projects during the last sessions of the first round of capacity building workshops teachers noticed challenges in the ideation phase. Teachers noted that they would have needed more background information about the eCraft2Learn technologies such as different sensors and other electronic components. This knowledge would have facilitated the ideation process where teachers also felt they needed more guidance.

"I had the biggest challenges in the ideation. When, perhaps, my imagination wasn't enough to see how much is possible to do. Like where you could apply it. I had difficulties how to apply these technologies in the subjects I teach, somehow how to bring it there and then there was lack of imagination that how to apply everything"

Participant teacher

"So you can get hang of it, what are we supposed to do, so you can improve the ideation part, particularly like hey this is how it works, then the world opens, that what can be done here"

Participant teacher

The pedagogical model, containing the stages of ideation, planning, creation, programming and sharing, was partly understood but the integration of this model and practical work in classrooms must be revised before teaching. Although the pedagogical model behind the project is familiar, teachers recognise that they aren't using much programming when teaching different subjects. In the programming phase teachers confronted difficulties and asked for help.

Regarding confidence & recommendations

It should be noted that teachers feel they should know everything about the subject they teach or the tool they are teaching with, although they know they don't have to. One teacher mentioned that the usage of new devices creates pressure that you have to know how it works before you can go and teach with it. Consequently, teachers want to feel confident in the classroom and in order to obtain confidence they want to gain deeper knowledge before teaching the topics to students. Nowadays the rapid growth of technology forces teachers to update their teaching methods and tools to respond better to today's and tomorrow's learning needs. Teachers may need to step outside of their comfort zone and adapt quickly to the changes. These new requirements affect also the time teachers can spend becoming familiar with new technological devices.

> *"...because first it is thought that now I should master this completely and I have to know everything about that device so I could go to the classroom with it, but it isn't like that"*
>
> *Participant teacher*

Because the project introduced new tools and applications for the teachers, teachers were a little unsure whether or not they would be able to manage problematic situations. They wonder where they can find help when they face a problem, for example if a lamp does not light up. Teachers discussed the idea of finding answers from Google or asking help from a co-worker. Teachers understand that when facing difficulties or problems, the teacher does not have to know everything. Answers can certainly be found together with students. Working on the same level with students may allow students to trust the teacher more and bring students the joy of discovery and learning. Students will realise that their effort is important and each student has the possibility to learn and discover and help others. The teacher also has a responsibility to trust students' capabilities. It is also believed that a teacher's attitude and enthusiasm has a great effect on students' attitude and engagement.

> *"... Yes, students will then now. But like trusting that they will search the information or find it somewhere"*
>
> *Participant teacher*

Inquiry-based and student-centred learning are familiar approaches for the teachers. Shifting the responsibility to students and allowing students to control their learning processes was thought important. This way students take responsibility for their own learning. However, you cannot always guide students to find out answers on their own, especially when you are working with difficult matters. Teachers admitted that it will take time before these student-centred methods are adopted as common practice in schools.

Teachers are familiar with the new role of a teacher as a coach or a guide that facilitates learning. Some of them had already tried this approach and felt it is much more suitable for teaching than the traditional model. All the same, one teacher feels there is a place for more traditional teaching as well. Teachers see the reality in schools, that there has to be a balance between student- and teacher-led learning. When introducing and processing difficult content, a teacher cannot shift all the responsibility onto students. It is necessary to use a degree of scaffolding depending on students' level.

> *"And yet there is a concern in some difficult subject, that we can't place all responsibility to students' hands. It is too much for a student, in some cases"*
>
> *Participant teacher*

When considering the implementation of eCraft2Learn in schools, one teacher identified an issue of bringing something new to the usual teaching. The Finnish national curriculum emphasizes the usage of technology in teaching and learning and demands the teaching of programming skills under the mathematics subject area but does not refer to very detailed teaching and making of electronics. Therefore, the usage of the eCraft2Learn ecosystem can be justified best when it is merged into the national curriculum. Consequently, the eCraft2Learn methodology should not be used as an extra task; instead, it should be implemented as a part of an already existing teaching method and subject matter.

It can be said that the project changed and increased teachers understanding about technology. The project offered new ideas, thoughts and above all, experience and knowledge about technology in learning and teaching. Within the technological context, teachers understood their roles as makers, not just users. The value of making, rather than using, is shown as students engage in the topics and develop important skills. The training was relatively short but sufficient to demystify the use of technology in education and engage teachers to increase their technological competences in educational settings.

The first teacher capacity building workshops were held in a total of two weeks' time with three sessions per week. Teachers saw the importance of having the capacity building workshops over a longer period which allowed teachers to digest the new information. However, teachers recommended that the training sessions could be longer. This would allow teachers to go deeper into the new concepts and apply this new knowledge during the same day.

5.2. Results from the questionnaires (round 2)

A total of four (4) teachers provided feedback during the second capacity building workshop, two (2) of which (2) completed the online questionnaire. The teachers who participated in the second round of the eCraft2Learn capacity building workshop were the same trainees that had already gone through the first teacher training and the first pilot round.

During the second capacity building workshop, the Finnish teachers appreciated the emphasis on providing support on using the eCraft2Learn technological core even more effectively. Unlike in the the discussions during and after the first capacity building workshop where the teachers' considerations were emphasizing the pedagogical core of the project, now teachers pointed out experiences and ideas from a strong technical perspective. Teachers mentioned both the strengths and the need for improvements and also valued the updates made on the technological side since the completion of the first pilot round.

Reference to the strong points

Teachers saw great value in the practical work of the second round of teacher training. The tutorials about creating electronic circuits and programming were considered very useful. During the first round of pilots, one teacher was hoping to find a simulator for Arduino wiring and programming. This tool, TinkerCAD Circuit Design, was then added to UUI and during the second teacher training the teachers became familiar with it - this addition addressed the teacher's wishes well.

During the second workshop, a strong emphasis was placed on programming practice and the usage of AI blocks with Snap4Arduino as the first round of pilots had shown a deficiency in the programming skills of teachers. Moreover, few participant teachers had already finished their first pilot round some months before the second teacher training took place, thus some practice was seen as relevant. The teachers put a lot of effort into recalling the programming principles and gave positive feedback on the relevance and usefulness of the practice.

> *"The most useful to my 2nd round might be AI-blocks. I think I can manage to guide the basic commands on programming Arduinos"*

Participant teacher

Teachers could also imagine the students' enthusiasm for the AI blocks as students have not experienced anything similar in schools before. Practice with the artificial intelligence in programming would truly be in the essence of the technological skills needed in the 21st century. Also, teachers believe these blocks offer various possibilities for students to drive their own learning and create a sense of ownership of their work as projects with different AI blocks are easily customisable.

> *"Students can easily create their own projects and expand their knowledge"*

Participant teacher

Teachers appreciated the Open Educational Resources (OERs) that were also added to the UUI since the first capacity building workshop. The "bank of information" for the technological core in particular had already been requested by the teachers during the first pilot round and the OERs addressed this need. Teachers saw great value in the OERs as they collect essential information on one platform and support both the students and the teachers by providing help on the technological aspect in particular. Teachers mentioned two possible uses of the OERs. First, a teacher is able to study the relevant concepts and find ideas for projects before introducing the eCraft2Learn projects to the students. Second, a teacher can encourage students to find the missing information by themselves and so foster self-regulative learning.

Reference to the weak points

In the feedback collected through questionnaires, one teacher referred directly to the UUI planning tools. He considered them to be clumsy and difficult to use. He wondered that if a tool is too challenging or time-consuming to use, the students might very easily change to a method they feel more comfortable with. As a consequence, students will find their preferred planning methods if the tool provided by UUI does not provide any added value for the work.

Challenges faced

Teachers identified mainly practical challenges from the second capacity building workshop. These challenges included the following aspects:

- technical issues,
- organisational issues,
- challenges concerning the workshop language.

One participant teacher mentioned issues of the actual devices that were used during the second teacher training. He was experiencing multiple problems with the Raspberry Pi (RPi) which naturally affected the usage and functionality of the eCraft2Learn ecosystem. These problems included the sluggishness and the crashing of the RPi. The teacher felt frustrated as a part of the practice time went towards solving these unnecessary technical issues.

> *"The power of Raspberry was clearly a problem. If you were watching a tutorial video or making a 3D sketch the device got stuck. My practice did slow down/end every now and then because of these issues"*
>
> *Participant teacher*

The organisational challenges included the curricular schedules of the participant school and time allocation in particular. One teacher found that the time between the teacher training and the second round of project pilots with the "real action" was excessively long. The teacher suggested that some of the good practices about programming would be forgotten and the teacher would need to recall them before starting the pilots. However, this issue was due to the scheduling challenges in the participating pilot school as the project pilot could not interrupt the current study period in the specific school. In addition, the spring term is relatively busy in some schools with the intensive assessment period, especially during the last grade of middle school in Finland when the 15-year-old students get their final marks. The eCraft2Learn second teacher training was held at the end of March, taking into consideration the suggestions and timetables of all participant teachers and making a big effort in choosing a schedule that suits everyone.

At the organisational level, another challenge was brought up in the questionnaires. One participant teacher experienced the most challenges and work in organising the lessons devoted to the project for the chosen pilot class. The teacher explained that arranging the specific pilot class schedules with different teachers and the school curricular timetable was fairly demanding.

The second training was partially held in Finnish and partially in English. Although the level of English among the participant teachers was high, one teacher felt that occasionally during the training English brought challenges to the work. In particular, the specific pedagogical vocabulary was difficult to use. The teacher had to consider her feelings and experiences and felt it hard to put them into words in a non-native language. The issues with the training workshop language were identified by the project members before the workshops. Therefore, some of the materials were provided in Finnish and there was a Finnish speaking project member present at all times to facilitate the work and flow of ideas.

Regarding confidence & recommendations

The second capacity building workshop built on the first one and the aim was to enhance teachers' capabilities in using the updated eCraft2Learn technological tools and applying the pedagogical core to their teaching. Teachers had gained valuable experience from the first project pilots and could reflect on these experiences during the second capacity building workshop. Teachers could position themselves better in the eCraft2Learn ecosystem as they understood their own competence level as well as that of the students.

Results from the questionnaires confirmed the observations made by project members during the second teacher training; teachers are indeed more confident in using the eCraft2Learn technologies as educators in the classroom. Teachers were more daring to acquire new knowledge and skills from the new technologies introduced and to go deeper into the ones they already had the basic knowledge of. Teachers also felt familiar with the pedagogical considerations behind the eCraft2Learn pedagogical core and were competent in applying both the pedagogical and the technological principles in their teaching.

Teachers were giving recommendations for the eCraft2Learn project in terms of the following aspects:

- capacity building workshops,
- organisational challenges (schools),
- project implementation (classroom environment).

The recommendations concerning the capacity building workshops were mainly about the overall structure, but also the scheduling of the workshops. Teachers were satisfied with the structure of the second teacher training. One participant teacher described an ideal training being organised as follows: "*start with the basic commands and tools in the beginning of training like we did in Joensuu on first Thursday*." The optimal length of the teacher training was under discussion during both the first and the second capacity building workshops. The session length was lengthened based on the feedback gained from the first capacity building workshop and each session was now one hour longer. For some teachers this schedule of six (6) three-hour sessions was suitable but one participant teacher would have preferred even longer sessions, for example having one longer day of training which would reduce the number of training days.

One participant teacher identified the timing challenges regarding the school schedules and felt that the time between the teacher training and project pilots was too long. As a recommendation, this teacher proposed shortening the time between training and student work. One possible solution, according to the teacher, could have been to agree on the pilot dates and schedule them the last day of the teacher training. However, the school timetables varied among schools and grade levels which brought challenges for the capacity building workshop schedules. Also, the idea behind the eCraft2Learn capacity building workshops is to work as a springboard and as such the training aims to provide all necessary knowledge and information to support teachers to start implementing their eCraft2Learn projects and to acquire more knowledge independently based on their interest after the training sessions had ended. Thus, the competences actively develop as teachers implement different projects with the students.

The next recommendation is related to project implementation inside classrooms in general. One participant teacher arranged the first round of project pilot sessions according to his subject matter schedules. This meant two pilot sessions during each week for the specific pilot class. During the second pilot project this teacher plans to have longer sessions, meaning few whole days of project work. Despite the long sessions being more challenging to fit into school schedules, the participant teacher feels that the longer sessions better foster different inquiry-based learning projects, such as eCraft2Learn projects, as students are able to focus more strongly on the work. However, the teacher also admits that long sessions with intensive project work can fatigue the students.

> *"Longer days, for example 9 - 15 would be more convenient, but I know working with a computer is very tiring, so shorter periods have their benefits too"*
>
> *Participant teacher*

5.3. ADDITIONAL COMMENTS RAISED DURING THE TRAINING IN FINLAND

The aim of the teacher training workshops in both rounds was to create a safe and relaxed environment where teachers could explore, practice and pose questions and improvements at any time. Teachers were encouraged to discuss and share ideas with each other and with the project members. The following additional comments and reflections are based on noteworthy discussions and observations.

Round 1

Although the first round of teacher training focused on both the pedagogical and technological core of the eCraft2Learn ecosystem, the participant teachers viewed the project increasingly from the pedagogical perspective during and after the first teacher training workshop. This may be due to the Finnish teacher education system where a strong emphasis is placed on the pedagogical considerations in both pre-service and in-service teacher education. Teachers are trained to review any new teaching methods regarding its pedagogical purpose and value. Therefore, the discussion and remarks include a lot of pedagogical reflection. The teachers pointed out that the concept of transforming the role of the teacher to that of a coach of the learning process was familiar to them, although they had not implemented it through the craft- and project-based pedagogical approach presented to them during the training. They were, however, eager to learn how technology fits in the pedagogical considerations being discussed. Hence, throughout the training in Finland, the teachers were intrigued by how the introduced technological components (e.g. eCraft2Learn technical core, electronic components such as sensors and actuators, etc.) could be integrated into their curricular activities and strived to understand the underlying principles of basic circuit making and programming.

After the 3rd training session in Finland, it was noticed that the teachers were quickly adjusting to the idea of using electronics for learning within the craft- and project-based pedagogical framework. They were eager to learn how to work with new sensors and devices and started to discuss how these elements could provide positive enhancement to their lessons.

Although the teachers were from two different schools, they were collaborating and working towards the common goal throughout the training. It was noteworthy that teachers were planning to work together to create tutorial videos for the students about the project itself, programming and 3D printing. These videos could be shown in the beginning and during the project and they could be utilised by a number of teachers who wanted to implement eCraft2Learn projects.

Round 2

In the first session of the 2nd round of the capacity building workshop teachers reflected on the following pedagogical concepts: *scaffolding, time management, agile management, student motivation* and *student self-regulation*. The participant teachers felt that scaffolding guides each student in a correct direction while always encouraging and giving positive feedback. All ideas are valuable as a basis. This will lead to student's improved self-confidence which in turn ignites the urge to develop and learn. Moreover, the teacher should also support students to be critical of their work and progress and help students to see learning or the result of it from a distance.

Regarding time management, the participant teachers had detected multiple challenges during the first pilot round. Students were for example spending time on the ideation phase profusely and were stalling. On the one hand, it would be important to know how to prevent an excessive amount of time being spent on the start of the project, and on the other hand, how to tolerate it as a teacher. It would be ideal if the timetable could be created with the input of both the teacher and the students. During the work, the teacher should support students to set goals with the schedule and remind students to monitor their work in relation to the goals. This will also foster students' self-regulation skills. Teachers should remember that students are in the process of practising time management and there should be always enough flexibility in the schedules. Too tight schedules can excessively limit the work and learning. One participant teacher also emphasized that all projects should be introduced and implemented by remembering that it is the student who is the main actor in the classroom.

The concept of agile management was chosen in the exercise as it describes well the inquiry-based underpinning of the craft- and project-based methodology of the eCraft2Learn learning ecosystem where students need to learn how to prototype or plan fast, fail fast and recover fast from the possible failures. Teachers saw the value of this type of learning and noticed that it prepares students well for life. The idea behind agile prototyping is not to avoid issues or failure; instead, fast recovery will create students that are creative, flexible, agile and resistant to uncertainty. The participant teachers appreciated this but added that the teacher needs to be able to adapt to the situation, accept the failures and understand that students will learn from the failure possibly even more than from the success. The teachers stressed that support and encouragement are very important in the phase of the failure.

When discussing how to motivate students, the participant teachers proposed multiple teaching strategies in order to meet the needs of all students. Teachers can showcase good examples of previous work in the beginning of the project, foster peer assessment or create the opportunity for the students to share the results of their projects. Significant emphasis was placed on providing positive but realistic feedback to help students to drive their own learning. In addition, teachers should strive to provide learning opportunities where students can influence the work; how to go about it, which tools to use, etc. Creating something personal will establish ownership and the inner motivation will lead to greater learning results. Ownership and motivation can also be supported by assisting students to create their own goals and sub-goals for the learning as well as the actions needed to reach these goals. Furthermore, these are essential when supporting students' self-regulation. Teachers should encourage students to self-reflect on their work and observe the effect of their actions. Besides, positive feedback and a feeling of trust in the classroom will foster self-regulation.

Teachers were also invited to share their ideas on the teacher's role as a coach. Teachers considered it essential that the teachers themselves are interested in the topic and project. Thus, students would embrace this enthusiasm throughout the task. It is also important that a teacher have good knowledge of each student. Student groups are usually heterogeneous with students of different abilities and skills. Teachers can differentiate learning by encouraging students to identify and set their own individual goals for the task to develop and scaffold students based on these goals. The teacher as a coach can ease their workload by fostering collaboration among students. Thus, students would use the specific skills of each individual in the group and learn to have ownership and responsibility during their learning. One participant teacher mentioned that the UUI could have a feature where students' work is saved from each session and students could recall the work done in previous sessions. This would also help the teacher to more evenly spread the time to support individual students and student teams.

During the 2nd teacher training after the teachers familiarised themselves the Unified User Interface (UUI) updates, one teacher pointed out that the eCraft2Learn UUI is something that could help students not to get so easily distracted in the learning situation. For example, compared to using a normal search engine, the search tool in the UUI is much more suitable to the classroom setting as it provides only relevant search results that are needed for the development of the students' task, filtering out suspicious or irrelevant content. Search engines gives thousands of hits, most of which may be irrelevant. In the UUI all the information is filtered and tailored to suit these type of inquiry-based projects in schools.

Based on teachers' experiences during the first pilot round, teachers shared their ideas and recommendations for the improvement of the UUI tools in relation to the eCraft2Learn pedagogical framework. This discussion proceeded from one eCraft2Learn pedagogical stage to another. One participant teacher brought to the discussion the notion of extended ideation due to its important role when starting a task through the eCraft2Learn learning ecosystem. With this notion he made reference to the growing digital world as there already exists a vast number of ideas in different communities. Teachers can encourage students to explore and modify these existing ideas and to make new ones with slight alterations from those seeds.

For the creation stage, teachers agree that the ready-made circuits in TinkerCAD Circuit Designer will help students to create wirings when students get to know new sensors and actuators. It also gives hints for the programming stage by showing both visual and textual programming code with the components used in the simulation. Teachers pointed out that this can be the first step before students learn to build and modify the circuits by themselves.

During the first pilot round there was no uniform recommendation for how the sharing of eCraft2Learn project should be carried out. Therefore, each teacher created their own instructions for sharing that suited each particular student group the best. The second round of teacher training generated discussion about what sharing in eCraft2Learn learning ecosystem means. It was noted that teachers had difficulties in defining the sharing stage and how the sharing could be seen in practice. One participant teacher commented that sharing usually happens naturally in the classroom when students are generating ideas, checking other teams' solutions and progress and helping other teams to solve issues. Other teachers saw sharing as being the showcase of each team's journey and result. The teachers discussed the idea that sharing is not directly a tool for assessment, although could be a part of it.

In the second teacher training, artificial intelligence (AI) programming was practiced during multiple sessions. The training team observations indicated that AI blocks may be challenging to learn for people with no previous exposure to programming environments and decided that teachers needed to have the fundamental knowledge about programming before using them. These observations were supported by comments from participant teachers. Having knowledge of the fundamental understanding of the programming environment (i.e., Snap! and Snap4Arduino) allowed teachers to build on that knowledge to understand the new AI programming blocks, such as speech or image recognition, more profoundly.

During the last session of the second teacher training the participant teachers familiarised themselves with the learning analytics tool. Teachers were encouraged to try the tool at their own pace. None of the teachers had previous experience using tools or applications that collect and analyse data from students' learning. All four teachers who participated in the second capacity building workshop considered the eCraft2Learn learning analytics tool highly valuable in supporting teacher actions when guiding students in different learning situations. The analytics cannot be followed blindly but the real value is seen as a supporting tool for the teacher and for the students. Teachers also pointed out that becoming familiar with the learning analytics tool would take some time and that it needed to be seen working with real data in the classroom before the tool could be utilised to its full potential. Nevertheless, the teachers did not see this as an extra workload; instead they were happy to be in the frontline of the new teaching era.

6 CONCLUSIONS

The aim of this report was to describe the capacity building workshops that took place in Greece and in Finland and to document the views of the teachers who participated in them. The capacity building workshops in Greece and Finland covered the following topics: the role of the teacher as a coach, the development of scaffolded learning, the implementation of the craft- and project-based methodology for computer-supported artefact construction, hands-on familiarisation with the UUI tools (i.e. electrical circuit making, visual programming, artificial intelligence programming, 3D modelling, 3D printing and more), learning analytics and practical project building activities.

In the training courses reported in this deliverable, teachers undertook several roles. They first underwent two training rounds that offered practice within the eCraft2Learn ecosystem. In-between, they acted in the student pilots as coaches for children while supporting them to do their own projects. This role allowed them to become observers and co-learners with children in the eCraft2Learn lab. Simultaneously, they become evaluators of the eCraft2Learn ecosystem through questionnaires and discussions where they provided their constructive feedback. All this resulted in the experience of a holistic training approach.

Analysing the trainees' questionnaires and feedback during the training sessions, we have found that this entire training experience was useful for teachers in multiple ways. They experienced the physical participation in an authentic maker space (the eCraft2Learn lab) which offers a broader concept of STEAM methods and tools; they conducted self-reflections on their experiences from the eCraft2Learn lab which helped to assimilate and adopt good practices, and they critically reflect upon their eCraft2Learn educational endeavour, the problems and the challenges that they faced.

We are sensitive to the fact that in complex, multifaceted and frequently centralized domains such as this of formal education, no single report can provide all the answers, and this is one no exception. However, the experiences that are documented here from our interaction with trainees in Greece and Finland (that are active in either formal or informal education domains) can significantly inform future capacity building workshops, limit traditional teaching practices and prepare teachers to take on the role of the coach going through the stages of defining the new role, doubting its applicability, negotiating its characteristics and nature, trying out, going through challenges, recognizing its educational potential, adopting it and keeping on improving it. This is what happened in the context of the two eCraft2Learn capacity building workshops in Greece and in Finland (including the experience from the in-between pilot round with students). Most of the teachers got into the role of the coach with success while others understood its educational affordances and tried to find their own way of coaching.

The teacher training workshops invited trainees to dive into something they had not known how to do before, to explore a set of new tools and technologies and no matter the difficulties, the trainees took up the challenge and through their constant feedback showed us the way to support their educational journey. Their requests for educational resources and guidelines as well as tools for sharing were reviewed and informed our project work and indicative possible supportive means to accommodate trainees' preferences and allay their anxieties.

The teachers understood at their own pace that the aim is not the final artefact or the completed project but the underpinning learning process towards the completion that matters the most. Within the eCraft2Learn learning ecosystem, the teachers had the opportunity to see themselves leaving behind the role of the consumer/user and smoothly undertaking that of the maker. From that position, they can more easily stand by the students as co-designers and co-learners and it is more likely to calm their concerns and anxiety addressing an answer to the question: "what if I cannot answer the students' questions?"

Apart from STEM-related skills, the teachers recognised that the eCraft2Learn learning intervention can also support social skills (i.e. collaboration, communication, team work) that are so important in today's labour market but also in the exploration of many different subject areas and interdisciplinary domains.

The challenges that were encountered were many, with the time factor being a common challenge in both countries. On the one hand the teachers' time constraints should be respected; on the other hand the deployment of the eCraft2Learn methodology and the familiarisation with the eCraft2Learn tools and technologies is a time-demanding task especially for novices. Future iterations of this workshop and other educational initiatives might seek to reconsider the balance between scheduled sessions and free open sessions for experimentation, perhaps organizing a pre- workshop for those in need of covering key concepts in STEAM or basic skills in assembling circuits, in using sensors and actuators and so on, in order to free up more time for practical skills training through projects that follow the five stages of the craft- and project- based methodology.

Technical challenges that were faced by the trainees were documented and communicated to the WP4 team. The ideation stage was also brought into focus by the participant trainees. How can ideation be triggered? Is it always feasible to come up with new ideas? The teachers seem to understand that this stage is critical and at the same time challenging especially within tight timeframes and so they bring forward the value of the stage of sharing which can in fact support ideation and trigger imagination. The entering into a sharing process, the interaction with other makers and their artefacts might be inspirational and reinforce the ideation stage.

To sum up, we see our work as contributing to teacher training in the STEM education field offering direct experiences and practical training in an authentic maker space environment. The work reported in this deliverable, combined with other outputs of the eCraft2Learn project, especially D3.3, D3.4 D5.1, offers a full training package available for teachers and teacher trainers who wish to introduce digital fabrication and the maker movement in formal and informal education. This whole package might be also integrated into academic STEM education courses for under- or post- graduate student-teachers to enrich the academic teaching practices with practical training in authentic maker spaces, preferably with the parallel participation of young makers in the lab. Our collaboration that was developed in the context of the eCraft2Learn training courses with the post-graduate course in STEM education run by the Universities of Patras and Athens in Greece (academic year 2017-18) was a first step to this end. This collaboration will hopefully continue in the future with more academic institutions and teacher training authorities at the European level.

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Appendix

Annex I

Guidelines for Session 1 (Round 1)

“Getting familiar with Arduino programming environment and visual block programming tools” (Based on the Lighthouse project/artefact)

1. Connect your arduino uno unit to the Raspberry Pi board and verify the connection settings through the Arduino IDE software menu.>Tools -> Port. Tip: The USB cable is used for both power supply and communication issues.
2. Try to make the LED on pin13 of the Arduino Uno board to blink (to alternate from on to off state) every one second. Tip: From within the Arduino IDE software menu go to File -> Examples -> Basics -> Blink and upload the relevant code.
3. Make the LED on pin13 to blink at different rates by modifying the on and off period duration.
4. Make the pin8 of the Arduino Uno board to blink instead of the pin13. Tip: Use a led in series with an 1kΩ resistor.
5. Read and inspect analog values from the pinA0 of the Arduino Uno board using the File -> Examples -> Basics -> AnalogReadSerial code and the Tools -> Serial Monitor option. Tips: Connect the A0 pin to the ground / 5 Volt / 3.3 Volt pin (each time) using a wire – what do you see? Connect the A0 pin to the 5 Volt pin to the center pin of a potentiometer using a wire(the other 2 pins of the potentiometer should be connected to ground and 5 Volt respectively) – what do you see ?
6. From the Arduino IDE, under Tools menu, invoke the Ardublock tool and try to implement tasks 2 through 5 using the visual block programming capabilities of this tool.
7. Connect (instead of a potentiometer) a photoresistor / 1kΩ resistor to the pin A0 of the Arduino and write down the corresponding values, for day and darkness conditions (use curtains or your hand to change the light level).
8. Make the LED connected to pin 8 to be on only at darkness.

Guidelines for Session 2 (Round 1)

Activity: “Migrating from native Arduino programming environments to Raspberry Pi assisted tools”

1. Using the *Chromium Web Browser* environment (under Menu -> Internet tab) invoke the Snap4Arduino App using the *Apps* icon. Selecting the necessary visual blocks provided by the *Control* and the *Motion* category, make the arrow sprite to move 2 steps forward and 2 steps backward (don’t forget to use wait commands between the two motion commands), continuously. Create a custom block under the *Other* category, name it *salsa* and drag &drop the initial motion and wait blocks into it. Finally, use the *salsa* block into the initial block and activate the new script. In order to save your work, select the *Export project …* option from the top left menu (see page symbol).

2. Connect your Arduino Uno unit to the Raspberry Pi board and verify the connection settings through the Arduino IDE software menu Tools -> Port. Load the StandardFirmdata firmware on the Arduino Uno using the File -> Examples -> Firmdata -> StandardFirmdata sketch. This makes the Arduino to interactively communicate with the Snap4Arduino environment. Finally, close the Arduino IDE.

From the Arduino tab of the Snap4Arduino environment press the *Connect Arduino* button. Using suitable commands make the pin13 of Arduino to blink infinitely. Don't forget to press the *Disconnect Arduino* button before quitting the app or loading another project (via the *Import Project* option). If problems appear press the Reset button of Arduino and try again.

3. Connect properly a potentiometer to the pinA0 of the Arduino Uno board and, using the *Arduino* tab and the *Variables tab*, assign the consecutive readings into a variable named *turn*. Make these values to be continuously updated on the scene place. Make a second variable called *angle* (= f(turn)) to vary from 0 to 180 (approximately), as turn varies from 0 to 1023, and make it visible as well.

4. Make the arrow sprite to turn at *angle* degrees, according to the potentiometer settings.

5. Connect an angle servo on the Arduino board (brown cable at ground, red cable at 5V, orange cable at pin8) and make it to turn at angle degrees, according to the potentiometer settings.

6. Connect (instead of a potentiometer) a photoresistor / 1kΩ resistor to the pin A0 of the Arduino and repeat steps 3 through 5. Try a new costume instead of arrow.

Guidelines for Session 3 (Round 1)

Activity: "Introduction to Remote Control of ServoMotors Using RPi3 and Arduinos and Tablet Devices"

1. **The goal** in this session is to have a servomotor turning connected on a DIY motor driving circuit, as an actuator device, connected on an Arduino Uno unit which is attached on an RPi3 board. The Snap4Arduino software will be used to program the system.

   The motor driving circuit will be based on the L293D chip and will be assembled using a small breadboard like in http://www.instructables.com/id/Control-your-motors-with-L293D-and-Arduino/. The whole datasheet of the chip is available in http://users.ece.utexas.edu/~valvano/Datasheets/L293d.pdf . The direction of the rotation of the the motor depends on the values of 2 digital output Arduino pins.

2. The RPi3 has its own GPIO pins, the specific pinout is available in https://sensorgnome.org/@api/deki/files/14074/=RPi2_Pinout.png. So, it will be very efficient to have methods providing direct control to these pins. During our first approach, an indicative programming of these pins will be done using the MIT Scratch environment equipped with the GPIO functionality (https://www.raspberrypi.org/documentation/usage/scratch/gpio/README.md).

   From within the Scratch environment, the GPIO pins of RPi3 are managed using broadcast messages. The common process is to activate the GPIO server, to set a specific pin to act as input or output and assign a specific value to it. So, using the abovementioned method make a LED (attached to pin GPIO18) to blink for one second at each state.

3. Using GPIO pins GPIO23 and GPIO24 make a servo motor to rotate clockwise and counter-clockwise for 5 seconds at each direction.

4. Using the installed VNC client application, under the “Internet” category of the basic RPi menu (top left), connect to the RPi3 unit of your neighbouring team and repeat steps 1 through 3.

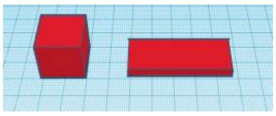
5. As an introduction to visual programming of tablets, that will be useful in the forthcoming remote control cases, using the MIT App Inventor environment, program a counter variable to change its value according to touching of two buttons (“+” and “-”, namely).

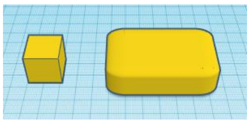
Guidelines for Session 4 (Round 1)

3D Modelling familiarization tasks in TinkerCAD

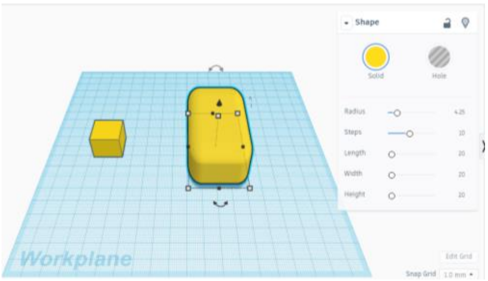
Shape customization

1) Enter a shape on the design surface/workplane and experiment with its dimensions, colour and main features. For example, (a) can you give a cube the form of a label? (b) Can you make a cube look like a piece of butter? Experiment freely with various shapes.


(a)

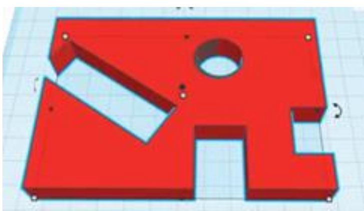

(b)

Tip:



Play with radius, length, width and height

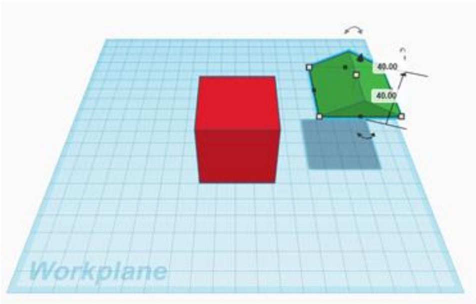
2) A three-dimensional shape in TinkerCAD can be solid but can also be hole. What is the difference between solids and holes? Can you make the following using solids and holes (or some other model of yours, for example an emoticon, or the packman's avatars ...)?



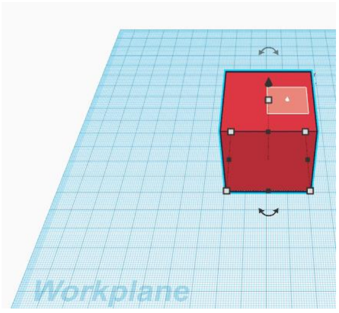
Tip: Select your solids and holes with your mouse. After that, make a Group so as to remove the "shape-holes" from the "solids-shapes".

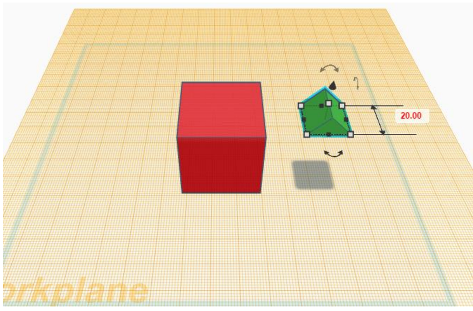
Combining shapes

Can you put a roof on a cube to form a house? What solids do you need? How do you make them touch each other?



Tip 2: Insert a new workplane on the top of the base of the house. The new three-dimensional shape you enter will be placed on the new workplane and will be fully tied to the base of the house. Is there any other way to achieve the same result?



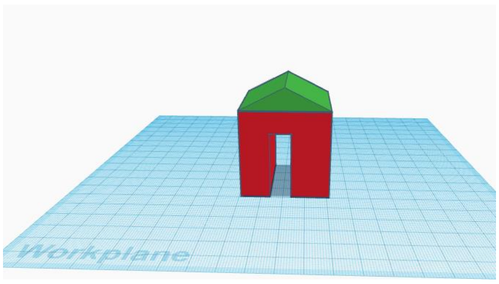
(a)


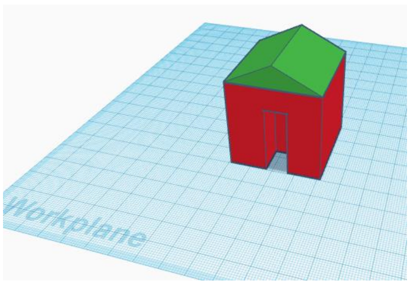
(b)

Add a new workplane on the top of the cube (a) and then insert the roof from the basic shapes menu (b)

Creating holes

Our house needs a door! Try to make a door for the house (see pictures a & b below).



(a)


(b)

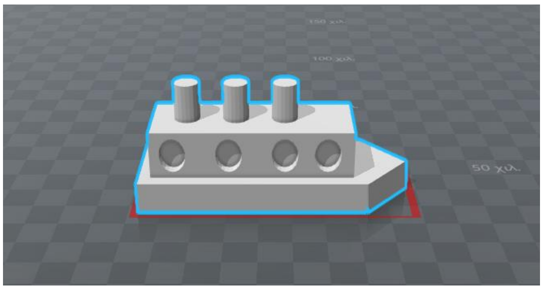
Other tasks for practice:

Now that you are familiar with this process, what about trying to make the 3D model a piece of emmental cheese?

The boat project

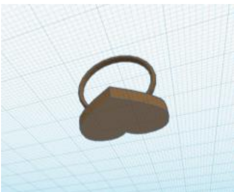
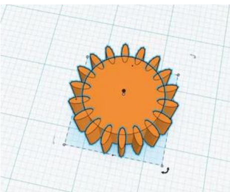
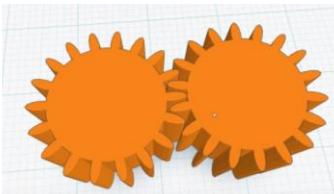
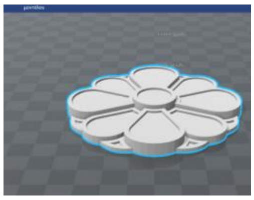
Let’s create the 3D model of a boat



Extensions: Try to write your name on the boat!

Feel free to work on your own ideas, combining different shapes and shapes generators and to share on Thingiverse!

Examples of 3D designs made recently by young students:

Explore more on Thingiverse!

Useful external resources: http://www.3dvinci.net/PDFs/GettingStartedInTinkercad.pdf

Guidelines for Session 5 (Round 1)

A. Advanced Remote Interaction Skills Using RPi3 and Tablet Devices

1. *Using the Snap4Arduino to form remote control requests*

   As mentioned in previous sessions, by using the installed VNC client application, (under the “Internet” category of the basic RPi menu (top left)), it is very easy to connect to the RPi3 unit of your neighbouring team and work there using the Snap4Arduino environment or equivalent. This method, although very easy to understand, is using a large amount of computational power and bandwidth.

Fortunately, the Snap4Arduino environment provides direct creation of simple HTTP requests, thus allowing direct access/control of the GPIO pins of remote RPis or local. HTTP functionality in Snap4Arduino is provided through the “Sensing” category via the “http://” block (Figure 1). The path part of the given url defines the action to be taken.

a) Try to understand the meaning of the url: 127.0.0.1:42101/GPIO_18_ON and the one of the url: 192.168.100.115:42101/GPIO_18_OFF.

b) Try to turn on and off a LED connected between the GPIO18 and the GND pins of your RPi board by pressing two separate buttons in the Snap4Arduino environment. Change your code appropriately in order to control the LED on the RPi unit of your neighbouring team.

Figure 1: The “http://” block of Snap4Arduino

A very simple HTTP server like the one described here https://wiki.python.org/moin/BaseHttpServer can be combined with the RPi.GPIO python library (https://pypi.python.org/pypi/RPi.GPIO) to control the GPIO pins of interest the RPi board has. Actually, we have implemented such a version of an HTTP server, in python, to intercept the http requests. This server can be used by writing:

$ python httpserver-eC2L.py

The RPi3 GPIO specific pinout is available in https://sensorgnome.org/@api/deki/files/14074/=RPi2_Pinout.png

2. *Using the MIT App Inventor to form remote control requests*

Can we use our smartphones and tablets to create computer-supported artefacts?

Let’s explore in groups how this can be done via the App Inventor environment using its ability to generate HTTP requests via the “web” object.

a) For practice, repeat tasks 1a) and 1b) using the MIT App Inventor environment and the local GPIO pins or the pins of your neighbouring team (Figure 2).

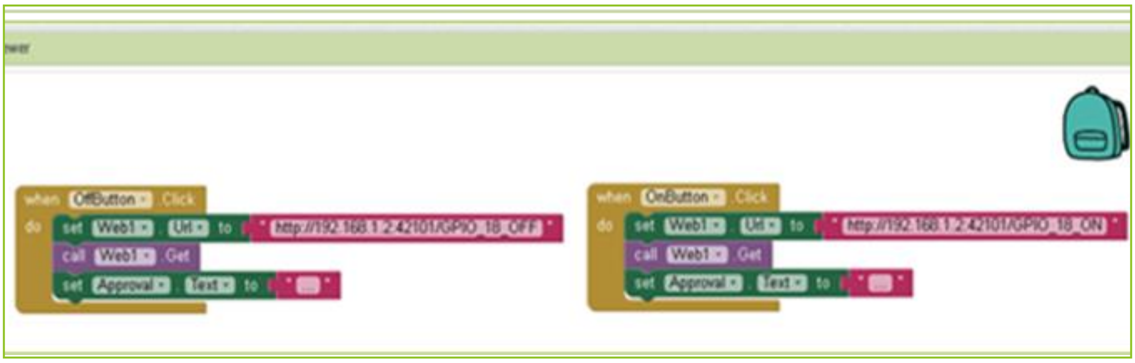


Figure 2: The "web" object of MIT App Inventor used to invoke HTTP requests

b) Under Sensors category select the AccelerometerSensor component and use it (when it is shaking) to turn on and off GPIO18 pin of the local RPi or the pins of your neighbouring team.

The small HTTP server code, written in python, is used to handle each request, exactly as in case 1 (the Snap4Arduino case).

App Inventor web site: http://appinventor.mit.edu/explore/

B. Indicative Examples of Artefacts to be realized by students

The following table contains indicative examples for artefact project creation by students. Let's discuss the projects and try to imagine the deployment of an eCraft2Learn task in the classroom!

The Lighthouse project	Arduino Uno / Arduino IDE Ardublock or similar Potensiometers, Leds, Photoresistors	Students, using paper/plastic bottles, will construct a lighthouse miniature having its light blinking at a specific rate and only at night (i.e when external light is low) Feedback through the use of team diaries.
The shy rabbit project	Arduino Uno /Ardublock or similar Angle servo, Microphone with amplifier, Some wire cables	Students are sketching a rabbit on a paper, they put it on an angle servo and move it up or down depending on microphone readings (i.e. a loud sound makes the rabbit to go down). Feedback through the use of team diaries.
The Sunflower project	Arduino Uno / Ardublock / Snap4Arduino / RPi3 Angle servo	Students are 3D printing a flower; they put it on an angle servo. The flower will be able to move around its axis according to photoresistor readings, in order to enjoy the sunshine. Feedback through the use of team diaries.
The scent-emitting flower	Arduino Uno / Ardublock / Snap4Arduino /	Students are 3D printing a flower; they put it on the top of a plastic bottle. They put a motor and a fan inside the bottle and a few drops of

	RPi3 Small electric fan, Photoresistor,	perfume. The artefact is programmed so as to create a scent emitting air flow whenever the light conditions are low. A photoresistor is used to distinguish between day and night. Feedback through the use of team diaries.
Sensor triggered sound invocation	a) Arduino Uno equipped with distance sensor and speakers. b) RPi3 unit plus an Arduino Uno as a sensor board.	Voice/sound message invocation on an RPi unit, according to luminosity or distance sensor readings. Snap4Arduino or Ardublock can be used. Feedback through the use of team diaries.
Remote triggered sound invocation – RPi3/WiFi implementation	RPi3, (it has Wi-Fi on board), speakers, Android tablet, Some wire cables	Students are shaking a tablet (or pressing buttons), thus invoking a sound to be produced by a pair of speakers connected to a RPi3 unit. Communication is done via the Wi-Fi interface, using the MIT App Inventor environment. Feedback through the use of team diaries.
a) Making a bug to move using a RPi3 unit and a tablet b) Making a bug to move using a RPi3 unit and the VNC environment	RPi3, (it has Wi-Fi on board), Servo motors with wheels and a motor driver circuit, Android tablet, some wire cables Ardublock / Snap4Arduino / App Inventor	a) Students are 3D printing a bug-like shell and a chassis for a small robot. After that, they equip it with servo motors and a RPi3 unit and move it through the Wi-Fi interface of their tablet, using the MIT App Inventor environment. The control of the bug can be done using buttons created via the Snap4Arduino environment as well (on the workstation RPi3 unit). b) Same as in previous case but now students move the robot through the Wi-Fi interface of their workstation using a VNC connection to the remote raspberry (part of the artefact). Implementation may include Scratch or Snap4Arduino and an Arduino unit. Feedback through the use of team diaries.
a) Making a virtual bug to move using gestures/light b) Moving a real bug-robot using gestures/light	a) RPi3, Arduino, distance or light sensors b) Same as described above but now the focus is to control an actual bug-like robot Snap4Arduino	a) According to distance or light sensor readings a virtual bug-robot (in Snap! or Scratch) environment is driven. b) Same as described above, but now the bug-robot is real. Feedback through the use of team diaries.

C: Free Project Ideas for Exploration and Practice
Use the tools and practices you prefer to plan and implement your own project or the main components/parts

Plan for initiating discussion in Session 1 (Round 2)

1) **The eCraft2learn methodology (ideation, planning, creation, programming, sharing)**
   As a trainer, how much of the following did you notice during the pilot workshops with the students:
   - How much was the above-mentioned methodology applied? Were there missing stages? Were there stages taking over the process?
   - What do you think should change in the 2nd round of pilots, when it comes to the methodology?

2) **Think of your role as a trainer in the first round of pilots**
   - Share your comments on your role as a trainer: what went well, what went wrong, what are your suggestions regarding changes for the 2nd pilot round?
   - Let's discuss! Share your comments/views on the following statements, documented by external observers (postgraduate students)

> 'There was no table, no books and no seat. [The trainer] was sitting with the children in the groups and if it wasn't for the age difference that helped us understand who is the teacher, we would have thought there was no teacher, at first glance'.
>
> 'It was also observed that the group put more emphasis in the construction of the object (lighthouse) than in the creation of the operational program and circuits, which were also included in the process'.
>
> 'In the part of the creation of both the circuit and the program, the role of the trainer in the specific case was that of sharing knowledge. The trainer created the circuit board and wrote the commands himself'.

Comment on the technical instructions given before each workshop and the children's worksheet

- How useful were they in practice?
- Would you suggest some changes for future workshops?

Guidelines for Session 3 (Round 2)

Study with your group the UUI resources for 3D printing entitled '*Introduction to 3D printing' (UUI educational resources)*. Have a look and then...let's move from theory into practice

- See/observe the 3D printer available in the eCraf2Learn lab: Can you distinguish the parts/components of the printer?
- Are the steps for three-dimensional printing clear to you?

Review with your group the UUI materials on 3D modelling in TinkerCAD (UUI educational resources). Get connected to the remote computer with VNC to work with TinkerCAD.

- Build a very simple model, such as a simple geometric shape or a combination, and place a letter on it. We need something simple to print it.
- Once you have finished building it, export it into an .stl file format.

Review with your group the UUI resources on Cura Quick Start (UUI educational resources).

- As you are connected remotely with VNC, open the Cura and enter your model (.stl file). Edit it for printing. Pay attention to the required printing time.
- Read the simple instructions before you start printing.

Let's print each group's work and observe the printing process

Possible problems in 3D printing that you may face:
Study the UUI materials entitled *Other 3D printing Problems Troubleshooting*
Blocked nozzle or under extrusion
Print not sticking to the bed
Warping
Caked nozzle
Leaning prints or shifted layers
X,Y,Z switch broken error message

Useful resources:

3D Printer Dummies Guide (available in the UUI)

Top 10 solutions (https://ultimaker.com/en/resources)

Guidelines for Session 3 (Round 2)

1) Study the UUI materials on Snap4Arduino and A.I. To find more detailed information, visit the link https://ecraft2learn.github.io/uui/index.html, providing your name and location (e.g. Athens informal pilot site) and browse through:
    - Educational Resources (top right) -> Troubleshooting -> eCraft2Learn Components -> Snap4Arduino ή in AI Snap! Programming blocks
    - Educational Resources (top right) -> A.I. -> AI programming in Snap!

2) A.I. and local movements with your Raspberry.
    - Join the Snap! 4Arduino environment via the UUI. Connect a camera and USB speakers to your Raspberry.
    - Import (import option) the ai_basic_set.xml from the /home/pi/Documents/Snap4Arduino folder.
    - By right/left clicking on the speaker icon, at the top right of the Raspberry, choose the appropriate output device and desired volume.
    - Make your Raspberry say a phrase through the speakers (see example below).
    - Right-click on the camera icon, at the right top of the chromium, allow access to the microphone and select "Webcam C170, USB Audio-Default Audio Device" as the audio input device.
    - Connect an Arduino onto the Raspberry and connect with it through the Snap4Arduino interface.
    - Try to make a virtual figure that can move left/right and also a light or servo angle (connected to Arduino) that will show, each time, the respective direction (see example below).

Repeat the steps in Phase 2 but this time, connect the equipment onto another free Raspberry and connect to it via VNC. To save time, you can also go to another free Raspberry and take control of yours through VNC.

Notes:

- The Camera and Raspberry together require at least 1.5-2 Ampere, to work in a reliable manner.
- To work in a minimalistic way, you can control a Raspberry that has no screen and/or is charged by a power bank.
- The remote VNC control mode is not optimal from a technological perspective but is particularly beneficial from a pedagogical viewpoint.

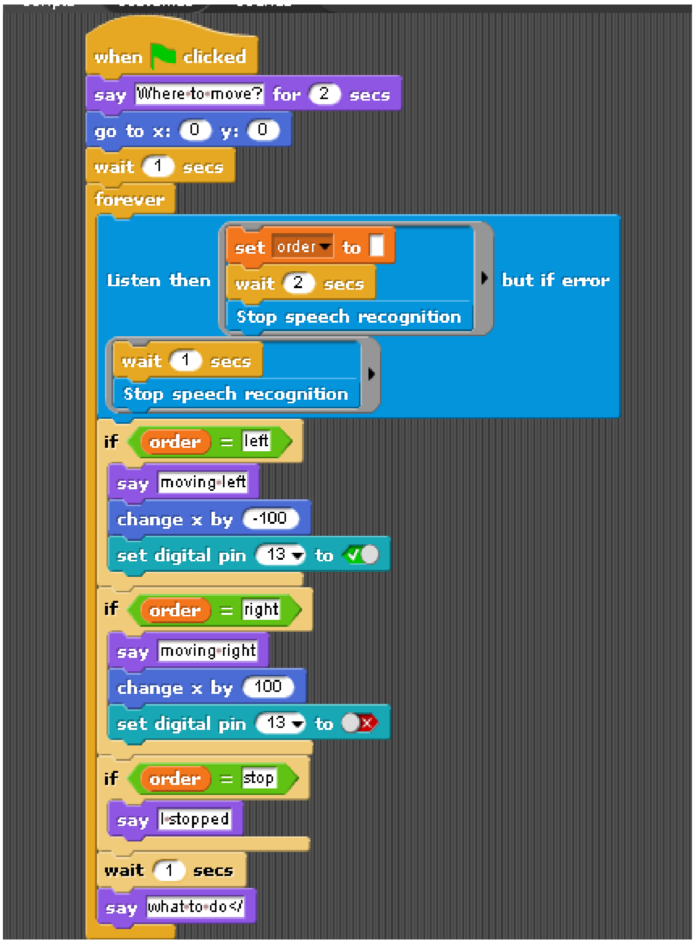
3) With the new tools that you have now acquired, think of some interesting scenarios for the children to create some interactive artefacts in a free way, discuss those with them and prepare them for the upcoming pilots.

Further useful materials

VNC, https://en.wikipedia.org/wiki/Virtual_Network_Computing
RealVNC, https://en.wikipedia.org/wiki/RealVNC

Examples: not complete on purpose / half-baked solutions - A.I. possibilities within a Snap4Arduino environment:

Listening:



Speaking:


when clicked
Speak (using Mary TTS) This is a demo of speech synthesis. with voice 1 at 1
volume
say This is a demo of speech synthesis. for 2 secs

The Lighthouse project

- Using paper/plastic bottles construct a lighthouse miniature having its light blinking at specific rate and only at night (i.e when external light is low)

What do you need?

- Raspberry Pi3
- Arduino board
- LEDs (Stage 1)
- (photo) resistors (e.g., 1kΩ) (Stage 2)
- Paper/plastic bottle
- Glue
- Connectors (cables)