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

Deliverable D3.2 - M15

Description of Use Cases

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 731345.

PROJECT DESCRIPTION

Acronym:	**eCraft2Learn**
Title:	Digital Fabrication and Maker Movement in Education: Making Computer-supported Artefacts from Scratch
Coordinator:	University of Eastern Finland
Reference:	731345
Type:	RIA
Program:	HORIZON 2020
Theme:	Technologies for Learning and Skills
Start:	01. January, 2017
Duration:	24 months
Website:	http://www.project.ecraft2learn.eu/
E-Mail:	office@ecraft2learn.eu

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The University of Oxford, United Kingdom, (UOXF)
SYNYO GmbH, Austria, (SYNYO)
University of Padua, Italy, (UNIPD)
Technopolis City of Athens, Greece (TECHNOPOLIS)
Evothings, Sweden (EVOTHINGS)
Arduino, Sweden (ARD)
Ultimaker, United Kingdom (ULTIMAKER)
Linnaeus University, Sweden, (LNU)

DELIVERABLE DESCRIPTION

Number:	**D3.2, M15**
Title:	**Description of Use Cases**
Lead beneficiary:	**ZSI**
Work package:	WP3
Dissemination level:	Public (PU)
Type	Report (R)
Due date:	31.03.2018
Submission date:	31.03.2018
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Acknowledgement: This project has received funding from the European Union's Horizon 2020 Research and Innovation Action under Grant Agreement No 731345.	Disclaimer: The content of this publication is the sole responsibility of the authors, and does not in any way represent the view of the European Commission or its services.

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EXECUTIVE SUMMARY

This deliverable continues the work of Task 3.2 by establishing further use cases.

Thus this deliverable is a continuation of the previous work (M5 and M10, please see Annex), it neglects to repetitively outline the eCraft2learn's aims, definitions of terms or the methodologies used (see D3.2-M5 and D3.2-M10)[1] but focuses further on use cases that were collected from the increasing practice we gained during the lifetime of the project. Thus, in difference to the previous use cases that were rather based on examples from internet and partners descriptions at the beginning (M5), or based on research (interviews and questionnaires) (M10), this deliverable increasingly integrates the insights gained during the deployment work in the project. Therefore, the use cases were either adapted or expanded (i.e. robot use case) or new ones created, driven by insights from workshops and the first eCraft2Learn pilots in Finland and Greece (reports from facilitators, scanning of drafts and artefacts of students) and expert user groups.

The use cases reflect the different needs of teachers and students as well as ideas created by the teachers and aim to further define (or re-define) already existing and planned work or point out new ideas and requests that shall be used as input for further discussion on the development work in eCraft2Learn.

In total, 14 and two variations or adaptations of use cases were created, very different in terms of topic, focus and description in order to reflect on the manifold possible environment of usage.

[1] https://www.zenodo.org/search?page=1&size=20&q=eCraft2Learn

1 INTRODUCTION AND OVERVIEW

Use cases can support very much the understanding of how a product or a tool can be used. The use cases developed in eCraft2Learn are meant to foster this understanding and allowing insights on how a school class, a teacher or single students could handle different projects with the eCraft2Learn learning ecosystem.

Obviously all introduced use cases differ in terms of topic, persons, details of description etc. but they all follow a clear structure that has been developed in month 5 (see D3.2-M5)[2]. Whilst the first use cases were built rather on single experiences from partner institutions, literature research and practice reports (report based), the use cases evolved further as the project progressed. The development was driven by the analysis of the interviews with teachers and facilitators as well as questionnaires of students (research based). Thus the use cases of D3.2-M10[2] were orientated rather on the interests and the environment of the students and teachers. By time, the co-creation aspect increasingly became very vivid in the development of the use case scenarios, since several use cases were co-created with teachers in M10 already.

Just like the use cases differ, the history behind each use case differs. The use cases in M15 are as well co-created or launched by teachers, several are put or have been put into practice, either by single schools or within the pilots (experience based). Also, the presented use cases of this last version are influenced by the first impact interviews (three Greek and one Finnish teacher part of D5.5) that were performed. Thus, some use cases were adapted accordingly to the findings in the last month. Apart from the answers to the impact, the teachers were also asked for further improvements and ideas. Other use cases in this last version of this document were taken from practice examples and shall give ideas on further possible scenarios. The input for these ideas derived from the highly experienced user communities of the partners ARD and ULTIMAKER, checked and verified by the partners. Thus, the scenarios are performed already in practice and reflect ideas for further advanced usage within the eCraft2Learn ecosystem.

2 BACKGROUND AND INSIGHTS FOR USE CASES

Important at this point is to clarify the background of the use cases. As outlined, they reflect on different needs, interests and ideas of the end-users (teachers and students). Thus, the use cases contribute to the understanding of the usage of the end users, their environment, their way of teaching, learning and working as well as their preferences and –in some cases- also their ideas. On one hand, the use case descriptions aim to further define the needs in more detail or re-define already existing assumptions. On the other hand, new ideas or requests from the end-users serve as a source for discussion if these implementations are useful and feasible in the framework of the eCraft2Learn project. Thus, the use cases are not aimed to deliver a step-by-step curriculum to implement one or another activity, but they will influence the further development of the eCraft2Learn environment in respect to the pedagogical model (WP3) as well as the technical features in the UUI (WP4).

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[2] https://www.zenodo.org/search?page=1&size=20&q=eCraft2Learn

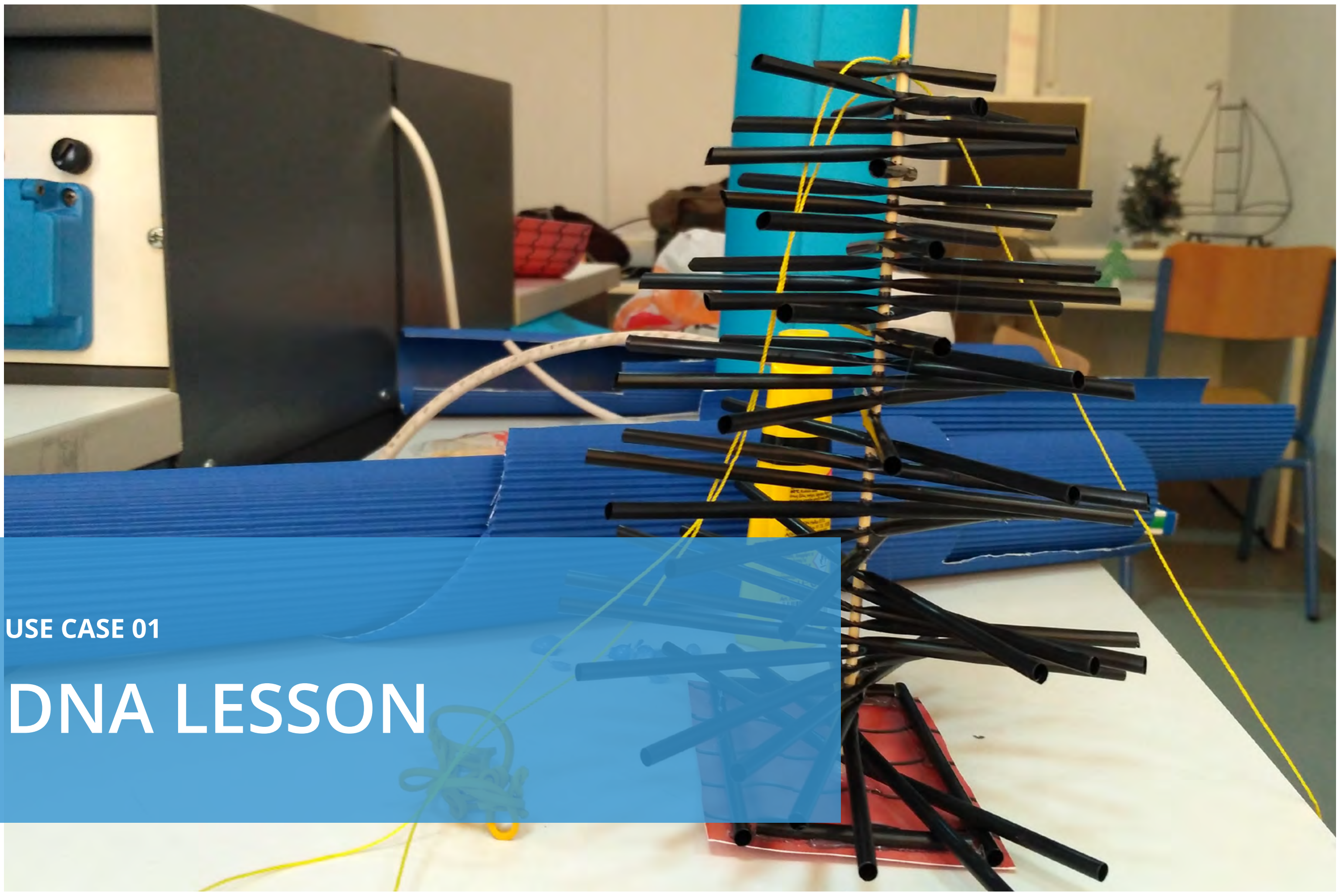
These scenarios might also serve as an influencing element for WP 2 (Managing open innovations and future use scenarios) - in specific D2.2 - where future use scenarios are developed.

This deliverable is not aimed to provide a report on the experiences and insights made, since this is covered by other deliverables. Still, for the understanding of use cases some points shall be explicitly mentioned here:

- The level of difficulty is in the eye of the beholder: while some activities might be simple for readers, it might hold very difficult components for others. Thus, the grade of complexity and difficulty is a matter of subjective value. Therefore, the following section has to be understood as a recommendation or estimation.
- The use cases can be applied to different age groups. Experience has shown that age is not the major factor for being able to perform these activities, but rather the individual ability and (pre-) knowledge of the learner as well as other factors like interest, curiosity, etc.
  Although the use cases are written for a certain age or school grade, the use cases and examples can work well with younger or older students.
- Many use cases mention a certain school grade where the activities are applied. However, school curricula differ in European countries, thus the use cases shall be understood as possible example but should not limit to a certain school level.
- The connection to the curricula is still an important issue for teachers. Therefore, the different subjects where the activities can be embedded are mentioned since they reflect a realistic situation. However, eCraft2Learn fosters cross-disciplinary teaching and learning and efforts have been made to emphasise this approach also in the use cases.
- The use cases aim to set a framework for discussion and advancements/development of the project but should not be used as a step-by-step guide to reproduce a certain use case. Thus the focus lies on the environment, items of consideration, possible pitfalls etc. and therefore avoids a too detailed practical or technical instruction.

3 USE CASES – M5

The following sections describe the use-cases developed in Month 5. The upcoming chapters present more developed scenarios of additional use-cases delivered in months 10 and 15. Each use-case was designed individually including images from project activities and referencing EU funding. The aim of the design is to use the pieces as factsheets for dissemination purposes at external events and online media channels seeking to reach out to the project stakeholders.



USE CASE 01

DNA LESSON

Primary Actor and Main Goal

She plans to teach DNA for the next week. She knows how to combine technology-driven hands-on projects with pedagogical concepts as she learned about in her professional development courses.

The topic is difficult and the students are not motivated to study biology. However, the use of technology may be attractive especially to the boys, but having students working in groups in order to enhance social interaction might also be attractive to the girls.

Moreover, allowing the students to discover the topic by themselves through a technological lens, being active, exploring and trying out, and producing interactive DNA models, the students learn more and become more interested in the topic. Teacher assigns the groups as she normally does in her classroom activities.

Age & Level

Susan, Finland
Science teacher
Teaches 15 years old

Susan, a Finnish secondary school science teacher, has a class of 20 fifteen-year-olds. Half of her class are female students.

Topic and Content

For the DNA lesson she decides to use 3D modelling, 3D printing, computer programming, and assembly instructions for electronic components and circuits. Her idea is to let the students build wireframe models of a DNA sequence.

During the development of the project the students will be learning and applying knowledge from electronic components (e.g., Arduino) assembly, 3D modelling and printing, programming, collaborative skills and presentation skills. Susan is planning for the development of the project to take 2 weeks (3 times a week sessions 1.5 hours).

Description of Environment and Possible Pre-conditions

Her school is pretty open for new ideas and projects, and there is a high trust in the teachers that the projects align with the curriculum. Still for security reasons, Susan needs to arrange the installation of the 3D modelling program with the IT coordinator from Happy Lab of the school.

The school also has a designated space where the 3D printing machines are, alongside available electronic components such as Arduino, Raspberry Pis, resistors, breadboards, cables, and recycled materials (e.g., cardboard, clothes, pet bottles, etc.) for the students to use

Preparatory Work

Susan knows well the people from Happy Lab, and they set up the 3D printer for her. The people there explain her in detail how the 3D printer works and also how she could solve issues that might appear. She also organizing the necessary materials that the students would need for building their 3D model.

Other Stakeholders and their Possible Interests

An IT teacher from the Happy Lab at school is happy to support Susan with any queries that she may have in setting up the project. She also offers support when needed during the working sessions.

Description of Activity

During the first session, the activity starts through ideation and planning. A group of students, Paul, Kelly, and Julian begin to work on their project on the DNA model. Susan supports the students with the 3D printing of the model's pieces from the wireframe models they made since a number of questions appear.

Also, during the creation of the model, there are a lot of errors to resolve at the beginning of the process to get the 3D model to print correctly. During the second session, they had to download drivers for the right 3D printer hardware model. However, once in a while, the printing process would fail, and they would have to discard the spoiled material and start the sequence again. User errors would also occur, such as miscalculations of scale between the software model and the printed result.The IT teacher offers assistance with the proper settings of the printer.

Kelly and Julian wonder what will happen if they will modify the model shape. Kelly changes the parameter of the X and the group starts to see interesting results they will ask to the teacher Susan.

During the third session, the students then assemble their pieces into a physical 3D model. The 3D-printed model give them a much different sense than the 3D computer images, because they could hold the model with their hands, rotate it directly, and combine their own model with other students' models.

In the fourth session, Susan asks the students to to give "life" to their 3D models by programming in them some functionalities. Susan uses the guidebook included with the STEAM "packet" to explain different ways they could vivify their physical models with Arduinos. Each group selects a project and start to work on it. To design the circuits, students are facilitated by paper template circuits, and examples of codes which are ready to be used and modified easily. This activity takes two sessions to complete.

For the presentation and sharing final session, Paul, Kelly, and Julian took turns explaining why they wanted to animate their physical models using LEDs in a particular way, and teaching their classmates how they did it. They then explain to the class how they programmed the Arduino for their project, e.g. how they solved the tricky part with creating a sequence to highlight repetitive structures, and how they overcome the 3D printing issues. This peer learning process continued with each group presentation.

Susan now feels the students would be able to understand more about DNA than before. The following day, she asks each group to present their model to the rest of the class, to discuss what they learned about how molecules form the famous double-helix structure.

Extensions

Paul, Kelly, and Julian explain how to highlight the different proteins that connected the DNA strands by assigning different coloured LEDs to each. They show that it was difficult to see that certain protein sequences were repeated. By lighting up the coloured LEDs, everyone could easily see the patterns. Protein sequences become even more evident when the LEDs associated with them flashed at the same time.

Failure and Condition

- Making sure that there is enough support available for all the learners/groups.
- Online communities should be introduced as a source of knowledge crawling
- The outcome of programming is not what is expected
- Sufficient material (technology)
- There is not enough time to complete the project due to- the knowledge level of the students.

Success and Condition

In just two weeks, Susan was able to foster student interest in DNA, while students learned how to use 3D models and printing, and how to program small circuits, including elementary programing statements such as sequences and loops. The students also gained experience in collaborating with each other, and in using software and hardware technology to realise ideas that began in their own imagination. Susan feels empowered by these tools, which facilitated the transformation of classroom roles and activities, and ultimately helped her achieve a progressive pedagogical approach in her classroom.

Failure and Condition

Time considerations for taking the project to completion. For instance, during the SciFest experience, there was one group, where one of the group members had to leave earlier and the other two were not able to decide how to continue with the activity. Their robot head was a simple one and it seemed that the two members were not happy about the result: it was not the product they designed in the first place.

Barriers/Facilitators

- The gender-based preferences – girls are more interested in social interactions
- Every learner is making something personally relevant
- Students with varied skills.
- Using the mixed-gender groups (different interests of males and females) to support the peer learning.
- Lack of previous experience of using different technologies.
- Creativity

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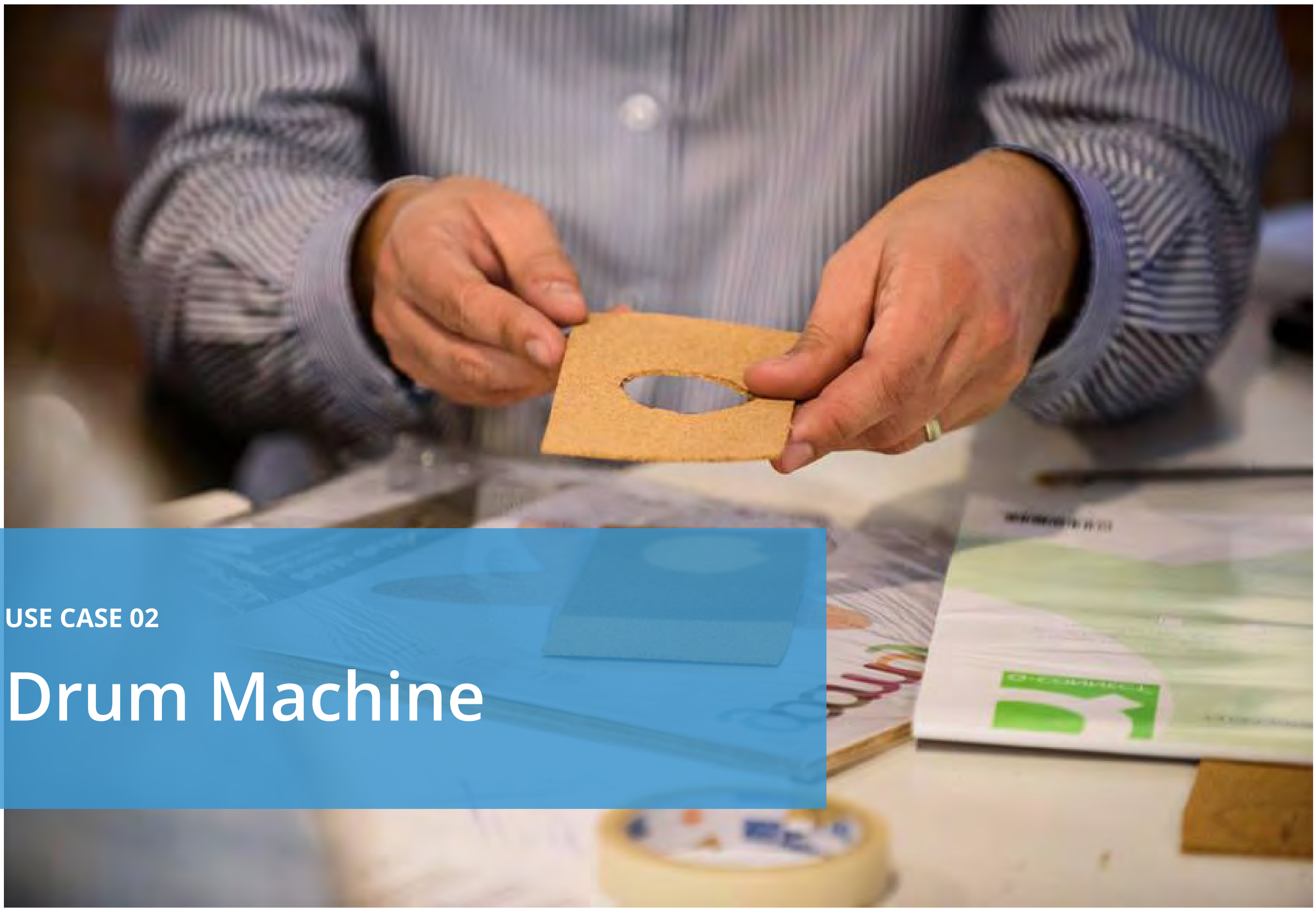

USE CASE 02

Drum Machine

Primary Actor and Main Goal

He is a substitute teacher in Greece, teaching for twelve years classes and has been asked to teach them about how sounds are produced by the modern music instruments.

Topic and Content

He starts by playing recordings of some instruments and explaining the various technologies that are used to make it. However, he notices that many of the students are getting bored. He asks: “Does anyone know how to make a drum machine?” The students laugh, joking about how they can download one from the app store with their mobile phones. They are expecting to be reprimanded, but they are instead surprised by Nikos’ reply: “How about we all learn how to make a drum machine ourselves, without our mobiles?” The students are very intrigued and do not really believe this is possible, but they are willing to give it a chance.

Age & Level

Nikos, Greece
Substiture teacher
Teaches students around
16 years old

Description of Environment and Possible Pre-conditions

Nikos has brought with him an eCraft2Learn case, with 4 project kits.The kits contain electronic components and simple instructions how use the components and STEAM projects examples.

Preparatory Work

Nikos knows well the kit, since he experimented himself with the tool some time ago.

Other Stakeholders and their Possible Interests

Nikos asks some help from the computer teacher of the school, especially because he wants his students to have access to the computer lab for Arduino programming and information searching activities.

The computer teacher of the school, who has little experience with Arduinos, finds the whole project very interesting and is offered to help by uploading the necessary web content, explaining the steps of this music project, to the school web site.

Description of Activity

He asks the students to form groups, and loans each group a kit.The students are interested, but some are worried this task might be too difficult for them, since they do not know about technology like Arduinos. He tells them not to worry, and asks them to take out a sheet of paper. "Your sheet of paper will become the buttons for your drum machine!" They think he must be joking, but they now feel very comfortable working on the project, since instead of a complicated circuit, they are focused on a piece of paper. He asks them to draw lines on the paper, dividing it up into "buttons", in any arrangement they would like.

He then asks them to take out of their project kits a few different coloured wires, and a handful of small sensors. They are instructed to connect each sensor to a different coloured wire, and to connect the free end of the wire to the series of pins on the Arduino board. Finally, he asks them to tape down each wire onto the piece of paper, so that there is one sensor in each square they've drawn. He also invites them to connect the small speaker from their kits into the Arduino's audio output connector.

Failure and Conditions

The students are following along, but they seem to be losing interest. Sensing this, Nikos decides to take an intermediary step.

Success and Condition

There are also LEDs in the kit, and he asks them to connect the LEDs to wires, and the wires to the other set of pins on the Arduino board. He knows from a previous project that there is software pre-loaded onto the Arduinos that connects the input and output pins. He now invites the students to "play" the squares on the paper, which trigger the lights, and the students are immediately engaged, for a moment. They quickly tire of making lights flash, but they still want to know more about how the Arduino works. And they really want to make the drum machine that was promised to them!

Extensions

At this point, Nikos tells them to plug the USB connector on their Arduinos into their classroom workstations, which have the Arduino coding environment on them. They load the software from the device onto their screens, and he explains to them what each line of code does, and what makes the LEDs light up. He then shows them how to add new lines of code that trigger a drum sound when the light is triggered. For the remaining time, the students play collaborative rhythms using drum sounds made by their paper and Arduino drum machines. Some of the students even get the idea that they can go back to the software and replace the drum sounds with sounds of their own voices. Now they are enjoying making music together, while having learned about music technology through an exploratory, hands-on approach.

USE CASE 03

Robot Building Workshop

Age & Level

Group of 20 students
Age 9-15 years old

Technopolis, a non-formal educational institution that fosters educational activities of new Technologies and STEAM. They would like to engage kids into some Robotics activities. Sofoklis, a facilitator from Technopolis likes the idea a lot and sets up a call for a workshop called 'We-build-Robots'. Sofoklis himself is very interested in technology and has built already robots for several years from many different materials. He and his colleagues are trained by an educational institution dedicated to enable people to hold STEAM workshops with kids. For this workshop, 20 students, aged 9-15, subscribed. Robotics is very popular amongst youngsters for the moment in Greece, thus it is not surprising for him that so many students subscribed. He expects that those that subscribed are very familiar with their mobiles including the different apps.

Primary Actor and Main Goal

From his previous experiences with students he knows that primarily the students are keen to play with "such a cool thing as robots" while their parents are happy to have some creative educational activities during the weekend for their kids.

Topic and Content

ASofoklis plans, to ask the students to assemble a robot, using lego pieces, blocks, rubbers etc. After that they shall use an Arduino kit, exploring different programs to make it work.

The "classroom" is divided in pairs of 2 or 4 kids each, depending on the use of tablets or laptops.

Sofoklis has decided that each group is working on the same project rather than each group taking over only a part of the project since he feels that the kids are more motivated if they are doing their own project from start till the very end. Also, all three objectives of familiarizing with crafts, the making and new technologies are tackled by all the students in that way.

Description of Environment and Possible Pre-conditions

The last times Sofoklis has performed the activity, each workshop usually took 6-8 hours divided in 2-hour sessions in subsequent Sundays. However, from the last evaluation Sofoklis received feedback from several parents, that they would prefer to have the kids there for 1, or 2 days so he decides to go for a 2 days workshop, 4 hours per day.

The course takes place in a vibrant, colourful open space venue, inside a lab consisting of one large table and some supplementary smaller ones to accommodate the whole group. Usually, the students find the venue exciting due to its particular shape and layout.

Sofoklis is not bound to any adaptation to a curriculum but there is a need for each workshop to be aligned with the strategic goals and educational program of Technopolis. Due to the fact that the workshops of Sofoklis is closely connected to STEAM, he is very much in line with the overall set goals.
Sofoklis has full support also in terms of raising awareness and participation in his workshop. For once there is a media plan, set up each semester, for the upcoming workshops. Press releases and invitations are sent to schools and to a subset of a large contact database. Also, printed booklets are made available as well as announcements through different (social) media channels.

Preparatory Work

For the workshop, Sofoklis needs an Arduino set and uses also Scratch and WeDo 2 for the programming. In case he needs other software, it is easy for him to install since there are no limitations of installation. He checks if the software is pre-installed and if the program runs also on the tablets. Also, Sofoklis buys the materials needed for the workshop.

Description of Activity

As students are doing research on components needed, Sofoklis starts off at the very first Sunday explaining the 20 students some basic understanding of terms such as "voltage", "current", "motor", and "sensors".

He asked the students to determine what their robot should do. With the given materials, one group decides to build a wheeled robot, that will act as a 'wheeled butler' carrying things in a small box. The students should determine the route of the robot towards a specific location by writing commands for moving forward, backward, left or right respectively. Sofoklis is summarizing with the students what materials they would need for their, driving' dustbin. The students are following a step-by-step printed direction. Although Sofoklis sees that they are sometimes struggling, he lets the students solve their issues themselves. Encouraging them to think creatively requires sometimes quite some patients from him, but he makes them also stop at various points and check together their robot from time to help ensure they have configured things properly before moving on to next steps. Thus, while constructing the students repeatedly try it out in the room. During that process, they realize that their initial programming in Arduino is leading the robot in the wrong directions. They re-program their device again and again until they are satisfied and personalize by adding eyes on it. At the end of the workshop they present their 'butler' in front the other students, using it to carry some candy bar paper to the bin.

Success and Condition

At the end of the 2 days' workshop, all the groups were able to finalize their robots. Sofoklis had the impression that students had fun and joy by creating their own robots. Some even asked if they could to do more and come again for creating an even more advanced robot.

Failure and Conditions

Only one student was not able to take part in the finalization of his robot since he had to leave earlier at the last day. Unfortunately, his robot never worked and the student left fairly unhappy.

Barriers/Facilitators

At the end Sofoklis ask the students if they have other ideas for workshops and what they would find interesting. He experienced, that the interest and curiosity of students as well as parents is limited because they are just not used to/ not familiarised with makers and the option they would have. Thus, they don't really know what to wish for. However, after this workshop, he was able to collect many different creative ideas from the students in all kind of areas not only technology, but also including art and other sciences.

Extensions

Sofoklis discusses with the students how the butler robot could reach the target more easily. They suggest to modify the algorithm of the robot in order to intercept remote commands via a Bluetooth interface.

Variations

Students are asked to propose different applications for their robot. So, they suggest to cover it with a shell made of colour paper in order to look like a ladybug. So, its route to the target becomes more amusing. The girls that are following the lessons find this alteration from butler to ladybug very artistic and pleasant.

4 Use Cases – M10

4.1. Variations/Adaptation - building Robot

Revision History

Date	Author/contributors	Description of change
April 2017	Andrea Alessandrini	First Scenario: Robot Building Workshop (Greek School)
May 2017		SciFestival - actual application of use case
June 2017	Hanna Nygren, Andrea Alessandrini, Margit Hofer	Reflection interviews with Hanna Nygren (observer) and Andrea Alessandrini (workshop facilitator)
October 2017	Calkin Montero, Hanna Nygren	Revision of original scenario based on the feedback of participants and interviews
October 2017	Margit Hofer	Slight corrections and final version

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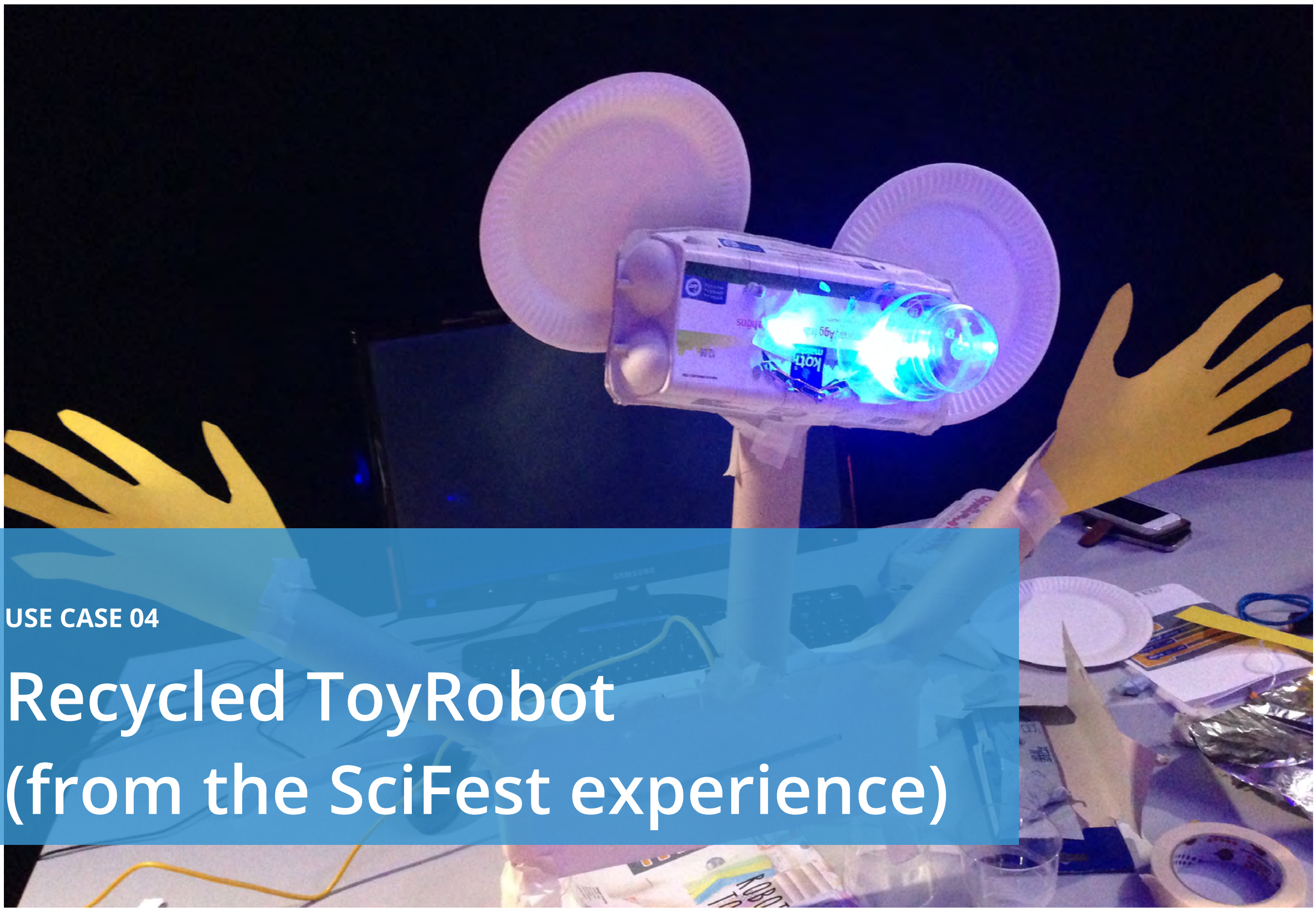


USE CASE 04

Recycled ToyRobot (from the SciFest experience)

Age & Level

SciFest is a scientific faire, that attracts thousands of visitors every year. There are companies, schools and departments from university who are running the workshops, experiments or presenting showcases and their products/services which is related to science, engineering, technology, arts and crafts, mathematics, and other subjects taught at schools. One of the workshops of SciFest was dedicated to creating recycled robot heads (and bodies!) out of cardboard boxes, plastic bottles, and other available, easy to find everyday materials. Idea of the workshop was to engage not only kids who are enthusiastic about technology, but also kids who are interested in arts and crafts. Sonja also observes that 10-16-year-old kids can take part of this workshop. For more advanced students, there is the opportunity to choose tasks that are more challenging. Robots are very familiar, especially for boys, but hardly in any place, have kids built up a robot head from the recycled materials. Some kids are also familiar with programming, but Sonja notices that especially it is hard to engage girls and some boys for this activity; they think that it is boring. Therefore, Sonja thinks of modifying her idea to let the kids in her club to use their imagination to create/bring to life their own version/conceptualization of what a 'robot' is by making their own Recycled ToyRobot. This could attract the interest of a wider group of boys and girls. The workshop was about making and hands-on activities, with the aim of attracting a wide variety of girls and boy (e.g., those who are not so interested in technical activities such as programming). This was to emphasise that robot building is more than programming. Sonja, an after-school crafts and arts club instructor, is very interested in handcrafts and she likes to make things by herself, because then what she makes is personalised and has her signature. She is not interested in ready made products and has not had interest in programming. She wants to teach her club kids to be creative and that they can recycle things for creating something new. She and other colleagues from the club are observing and participating in the RoboHead workshop in SciFest, involving themselves in a short hands-on activity to understand how this workshop could be run with the kids at the club.Sonja also observes that 10-16-year-old kids can take part of this workshop. For more advanced students, there is the opportunity to choose tasks that are more challenging. Robots are very familiar, especially for boys, but hardly in any place, have kids built up a robot head from the recycled materials. Some kids are also familiar with programming, but Sonja notices that especially it is hard to engage girls and some boys for this activity; they think that it is boring. Therefore, Sonja thinks of modifying her idea to let the kids in her club to use their imagination to create/bring to life their own version/conceptualization of what a 'robot' is by making their own Recycled ToyRobot. This could attract the interest of a wider group of boys and girls.

Primary Actor and Main Goal

The primary actors will be the instructor (Sonja), the students (boys and girls). Instructors are concerned about the feedback they receive from the parents (secondary actors). Parents are little bit concerned about programming, because kids are playing with the computer for long periods of time. However, parents appreciate that the SciFest activities that they have the opportunity to see (and test if they wish) are more than just programming with the computer, more creative activities are performed.

Main goals of the Recycled ToyRobot scenario are to boost kids' creativity, problem solving and team skills as well as to demystify the use of technology while keeping in mind ecological perspectives (using recycle materials for building new toys/things/robots). Furthermore, girls enjoy being creative using crafts and arts, as well as some boys, too. Technology could be attractive for boys more than for girls, but it might be that when integrating crafts and technology, all kids can find that there is something they are keen to make/create and enjoy.

Topic and Content

In the Recycled ToyRobot activity, kids are asked to plan and design their own version of what a robot/toy is, using recycled materials, such as paper rolls, boxes, plastic yoghurt mugs. An interactive part of the toy, such as the eyes, will be made using LEDs (light-emitting diodes), which will be programmed to blink at a certain rate. At the beginning of the activity, the kids are given the instructions, they form groups and are introduced to the five stages of craft- and project-based learning (ideate, plan, create, program, share). They are also asked to follow the instructions about how to make the LEDs blink. There are 3-4 students in each group and each group has their own PCs and Arduino kits at the table as well as different recycled materials, pencils, glue, scissors, colour paper, foil paper, etc. Each group is designing their own version of a ToyRobot and how the eyes of the robots will blink or how lights in the eyes are on or off.

Description of Environment and Possible Pre-conditions

Kids can perform the activities within 1.5 hours (however 3D printing is not included to this activity). The feedback received from the students that participated in the SciFest version of the activity indicates that some students wouldlike to involve 3D design and made the robots more professional looking. This implies that the activity could be set to be developed in longer time (2 days or more), so that kids really have a chance to carefully design and take longer time to make/create their ToyRobot. The robot building activity originally took place at SciFest, an inspiring environment, where the students can get comments and feedback as well as ideas from the audience and professionals visiting the event. There could be open place for everyone to join in, use the materials and get instructions and help when necessary. The activity is based on STEAM subjects, which serve well the curriculum of schools. However, more students might be interested when receiving the information about the workshop. Using social media and school network more efficiently could help to reach the wider audience.

Preparatory Work

For the activity, an instruction manual of the steps to follow when using the virtual programming environment (Snap4Arduino) needs to be prepared.

Also, during the workshop, an Arduino Uno board connected to a Raspberry Pi3 computer was set up, as individual work stations for each group. When other software is needed, if there are no restrictions of installation, it is easy to install. The instructors should check that the necessary software are pre-installed and the programs run. In addition, recycled materials as well as crafts materials should be collected and made available during the activity development.

Description of Activity

The instructor starts with a short introduction about what kids are supposed to do, what the process is and what the materials and tools to use are. The students are asked to form groups of 3-4 students and take a work station (Arduino board connected to a Raspberry Pi PC) and start working. In the SciFest version of the workshop, one group designed a square robot head, where the robot eyes are blinking one after another. Another group designed an elephant robot head - big eyes were supposed to be 3D printed, where the LEDs are set in the middle. Since there was not 3D printing available, the students set for using cardboard to create the eyes of the elephant. Students planned themselves, which recycled materials they need.

They also decide what part they need to 3D print for the head. Students are dividing the tasks among themselves, and when the group member struggles with a task, the other members are ready to help: they seem to solve the problems by themselves. Instructions are following the processes and especially in 3D designing and printing students need more guidance, because it is new for them all. Some problems with properly printing the 3D design meant that they needed to try printing again after adjusting their design. The instructor is helping by not giving direct answers but leading the group to check their design in order to print it correctly. At the end of the activity, the groups present and explain their creations for everyone else to see.

Other Stakeholders and their Possible Interests

Parents who provide positive feedback to their kids. Creative designers and makers with a positive attitude. Results also might interest companies and investors who might appreciate to have inspirations from young people.

Success and Condition

At the end of the workshop/activity, all groups are asked to present their creations to all and asked feedback about the implementation. Teachers experience that they have not seen the students working so well together and being so engaged on that kind of learning process. Even the girls were excited about the hands-on activities and arts and crafts and their ToyRobots look well designed and carefully made. As the groups got more experience they started to talk about how they could design and make more advanced ToyRobots, which would be more complicated and high-design product that reacts to voice, movement or light changes in the environment.

Failure and Condition

Time considerations for taking the project to completion. For instance, during the SciFest experience, there was one group, where one of the group members had to leave earlier and the other two were not able to decide how to continue with the activity. Their robot head was a simple one and it seemed that the two members were not happy about the result: it was not the product they designed in the first place.

Barriers/Facilitators

Barriers

Are the groups working well?

Grouping makes difference, to get students to work well with each other and make sure that they have time to work on their ToyRobot.

Is the given time sufficient for the workload?

Tracking the time is important. The students need to understand that the amount of time they have and the workload will be in good balance.

Do the students have the information they need to succeed?

Role of the instructor/teacher/coach

A limitation arises if the students do not have any idea about how to build a ToyRobot and creativity is missing. The instructor is to intervene: how to guide them to be free of the limits set by their own mind set.

Facilitators

Motivation

Some students were keen on the idea that they can create and make a real product by themselves.

Peer networks and Internet Information finding, a powerful tool to fuel creativity.

Extensions

From the robot head workshop to the ToyRobot activity the robots can advance towards becoming more interactive and reactive to changes in the environment. For instance, creating a robot alarm to wake the person up when it is day time; a robot guard to sound an alarm whenever someone trespasses a forbidden room; a talking robot that reacts to the close presence of people; etc.

Variations

Some students would like to design projects with the LEDs lights embedded to the accessories of clothing. Students started to think also how they could for example help the elderly people for having them the robot with blinking eyes, when their phone is ringing in the other room.

4.2. MY COOL FLASHLIGHT SCHOOL BAG

Revision History

Date	Author/contributors	Description of change
20 July 17	Hofer, M. B. Fischbacher	Initial draft of Scenario
27 July 17	B. Fischbacher	Adaptations
3 August 17	Hofer, M, Voigt C., Unterfrauner E.	Discussion of scenario; testing with Arduino board
4 August 17	Fischbacher B.	Integration of feedback and change.
20 September 17	Ehrndal, M.	Some additional tech content

USE CASE 05

Flashlight School Bag

Age & Level

Veikko, Finland
Student
12 years old

Veikko is a 12 years old student in Helsinki. He goes twice a week to swimming training, likes techno music but he is also fond of online games and computers. With the age of 10 he got for Christmas a Lego robot and with the help of his father – an engineer – he managed to get the robot going.

Primary Actor and Main Goal

At school he acquired some basic programming skills already. Veikko also has a younger sister that just started school. Since they live a bit outside of Helsinki, both have to leave early in the morning to go to school. Especially in winter it is still dark when they leave home.

Topic and Content

Veikko has an innovative teacher who launches different projects. This month the teacher got some Arduino boards to launch different projects. He understood that with Arduino you can programme many different things and combined with sensors he can create many things with different functions.

Description of Environment and Possible Pre-conditions

Veikko's teacher has asked them to build pairs and agree to a small project they would like to create. Veikko and his friend Pekka would like to do something of real usage that goes beyond playing or fun. Veikko and Pekka elaborate a plan to 'pimp' school bags: since they are leaving so early from home it is difficult for cars to see school kids in the dark, especially when there are no reflectors attached to the cool bags any longer (which leads often to discussions with his parents). Thus, Veikko and Pekka decide to build a sensor for the school bag that would start flashing on his school bag once the light becomes low.

Preparatory Work

The teacher asked them to prepare a sort of 'concept' that outlines the idea behind, the usage, the materials and skills as well as knowledge they will need a.s.o. Thus, Veikko and Pekka start to investigate which components they would need and establish the list materials, the sensors, the LEDs they would need, a.s.o. The boys also consider the different circumstances for the design (ie. snow and rain on the sensors and the Arduino board, ...). They hand over their written plan to the teacher and discuss with him the outline.

Description of Activity

Four days later, the teacher has ordered the needed Arduinos and each of the students have brought additional materials with them. Veikko has brought his old school bag for testing since he is not sure how to attach the LED lights, if he would need to make some holes in the bag, a.s.o.

The teacher helps him plan how to mount the LED lamps on the bag, and also reminds the students they need to insulate the component legs to avoid a short circuit. Before they start building, the teacher helps the students to test the photo sensor with one LED, as a 'proof of concept'. They search online for how to connect the components on the breadboard, and use an Arduino example sketch that reads analog values and maps them into the range suitable for LEDs. They learn about statements, and how to set a threshold for the lights to turn on. After the core concept has been prototyped, the teacher asks the woodwork teacher to help the students solder the parts together. The teacher has helped them draw a circuit on paper to aid them as they solder everything together.

Once everything is connected, it won't light up. The students are very disappointed, and are not sure what to do next. The teacher tries to cheer them up, and shows them a systematic approach to troubleshoot the error. They use the serial monitor to make sure they are getting values from the sensor, and that the threshold is properly set. After that, they upload a code to light up the LEDs only. They don't light up, and one of the students suddenly finds it's because they have not properly insulated the LED legs. Once the whole circuit has been properly insulated, all the technology is working as planned.

Other Stakeholders and their Possible Interests

As Veikko tells in the evening what he has done at school his sister also would like to have some flashing LED lights installed on her bag.

Veikkos realizes that the lights might need improvement in terms of design if used by smaller kids so that all the components are hold within one case. By creating this, the Arduino construction would be more stable than his initial installation and design. Thus, he designs a case in the 3D printing programme TinkerCAD.

His teacher allows Veikko to use the 3D printer at school to improve his project. During the creation of the case, there are a lot of errors to resolve at the beginning of the process to get the 3D model to print correctly. However, once in a while, the printing process fails, and Veikko has to discard the spoiled material and start the sequence again. Finally, Veikko managed to have the case printed and installs the Arduino in the case.

Success and Condition

One week later Veikko is allowed to take his LED lights home for his sister. Together with his mother, they only need to sew a Velcro stripe on the outside lunch box case of his sister schoolbag. Veikko connects the cable with the components in the case, turns off the lights and immediately the LED lights start blinking.

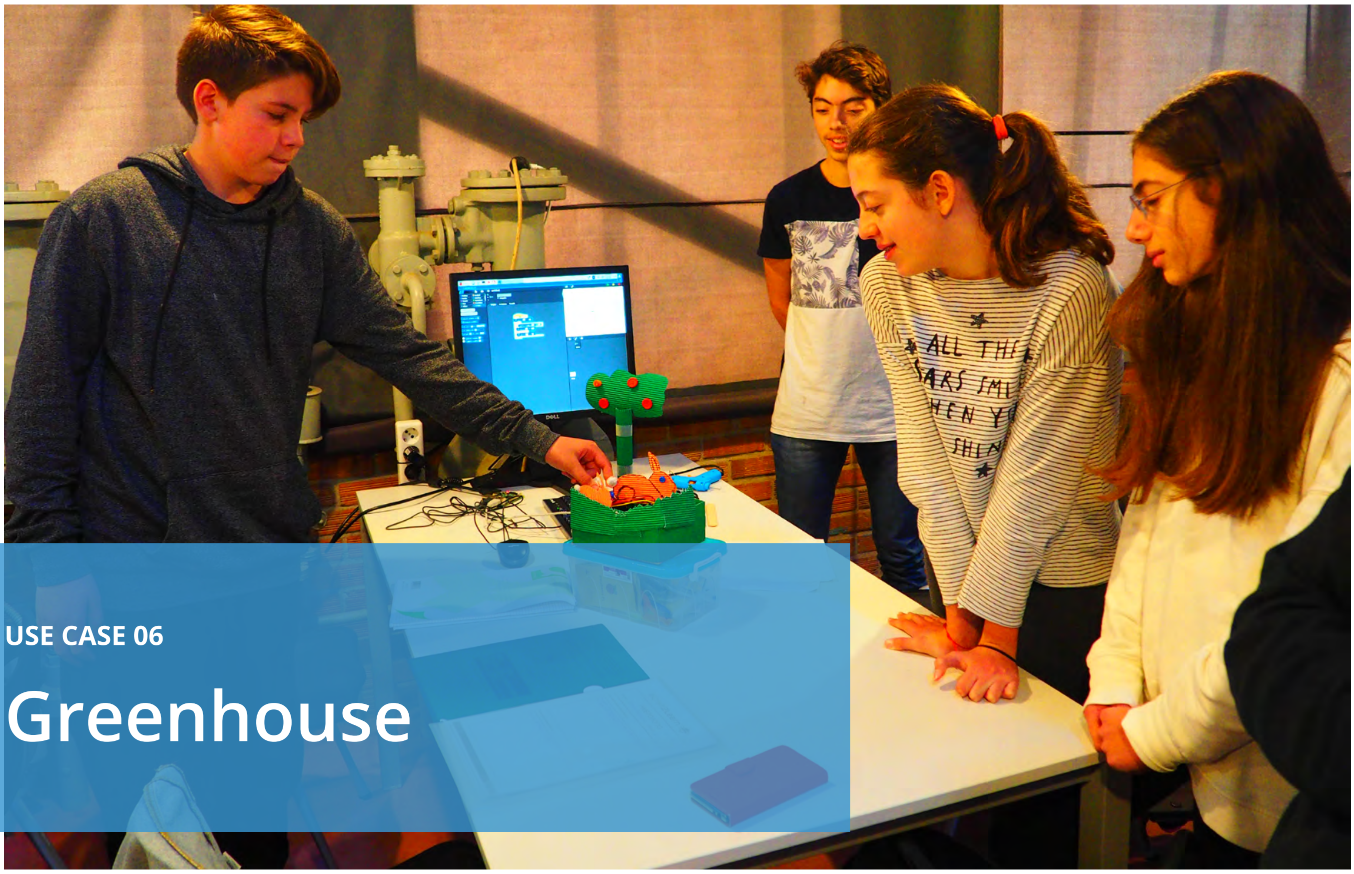
Variations

This type of scenario, where learners try to find the solution to a problem relevant to their everyday life has the power to engage them in a completely different way.

4.3. Greenhouse

Revision History

Date	Author/contributors	Description of change
20 September 17	Ehrndal, M.	Initial draft of Scenario
24 September	Hofer, M.	additions
27 September	Hofer, M.	Final version



USE CASE 06

Greenhouse

Age & Level

Jenna, Finland
Student
13 years old

Jenna is a 13-year-old student in Helsinki. She cares deeply about the environment, and loves to take care of plants and animals. Her favourite school subjects are all related to natural sciences, and she is an independent learner who reads a lot about things she finds interesting in her spare time.

Primary Actor and Main Goal

At school she has been introduced to programming and basic electronics, but since she didn’t understand it instantly it affected her self-confidence. Jenna, having a perception of herself as a fast learner, is starting to think this is not her subject. She has also noticed that some commonly low performing students in her class seems to excel at these subjects. She wants to prove herself, but at the same time relate it to her interests to make it more motivating and meaningful for her.

Topic and Content

Jenna’s teachers, one technology teacher and one math teacher, want the students to work more cross curricular. This is the first year that they try to involve electronics and programming in their work together, and none of them have much experience.

Description of Environment and Possible Pre-conditions

The students are asked to work in pairs to realize their projects. Jenna wants to work with her best friend, Aina. They share similar interests, and as they have been introduced to Arduino and programming, they have also asked their parents to buy electronics to that they can learn at their own pace at home. Soon, Jenna and Aina agree that they want to build an automated greenhouse.

Preparatory Work

The teachers are not sure how to help them, they have only bought some kits with components and are not sure their idea can be realized. Most students have much simpler ideas, that the teachers can help to realize. Aina's father, who works in IT, knows about Arduino and Raspberry Pi, so he decides to help the girls order the material needed. He is later contacted by the teachers, so that he can share his knowledge on where to find components and educational resources with them.

Description of Activity

Once the material has arrived, Jenna and Aina have a systematic approach towards testing them and putting everything together. As per Aina's father's advice, they split their problem into small parts, and test the solutions separately. Since they are both independent learners, they can find most information needed to build and code the core parts of their project by themselves. They test the light sensor first, to learn what values they receive in different light conditions. They then try the temperature sensor, and explore different way to build your own humidity sensor. Aina's father helps them to filter the captured data to make the values more stable.

Other Stakeholders and their Possible Interests

After spending some time realizing their spare time project, they decide to bring it to school to show it to their teachers. The teachers are impressed, and have Aina and Jenna present their project to the class. They also try to understand what resources and knowledge will be needed for themselves to support similar student projects to be created in school.

Success and Condition

The teachers learn that Aina and Jenna were able to build a more complex project not only because they had Aina's father as a support, but because they came into the project with no idea of how feasible it was. They were also able to realize the project independently as they did it at their own pace, driven by their own motivation and interest in the final result, and since they were both independent learners. In the end, Jenna and Aina had as much electronics knowledge and skills as the high performing students in the same subject.

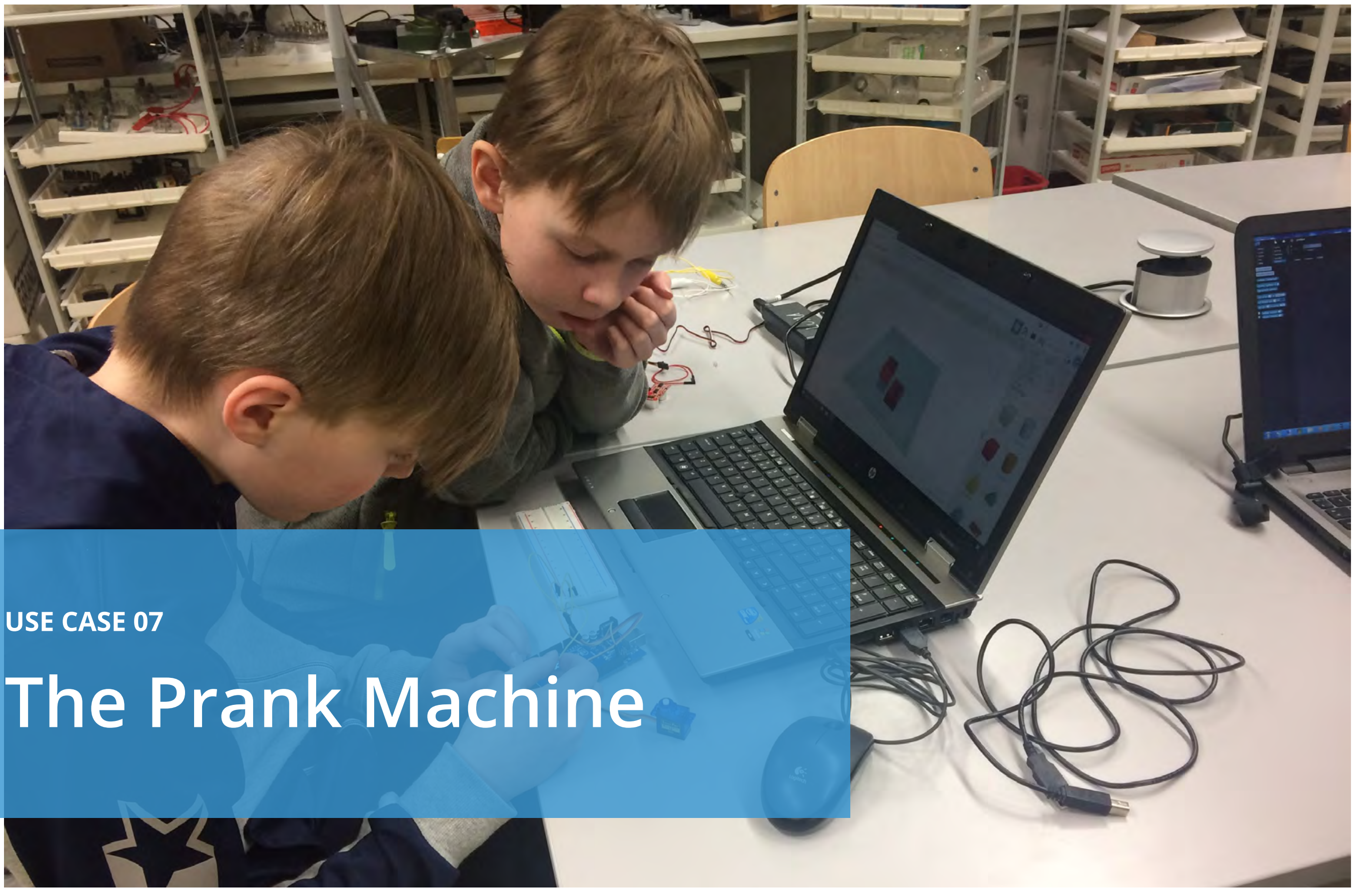
Failure and Conditions

Without Aina's father helping out, the girls would not have had the support needed to finalize their project. The challenge for the school would be to make this visible, and provide the appropriate support. Jenna and Aina would perhaps not have had the opportunity to understand that they were as able as their other classmates in regards to hands-on technology. The eCraft2Learn systems ability to put the learners in direct contact with experts would make this scenario possible for more students.

4.4. PRANK MACHINE

Revision History

Date	Author/contributors	Description of change
20 September 17	Ehrndal, M.	Initial draft of Scenario
24 September	Hofer, M.	additions
3 October	Hofer, M.	Final version



USE CASE 07

The Prank Machine

Age & Level

Elias, Finland
Student
14 years old

Elias is a 14-year-old student in Helsinki. He has a hard time concentrating in the classroom, and has started to skip some classes to hang out with friends around town. His main hobby is playing online video games with his friends. Since he has a lot of experience that he is also good at sharing, he is the leader of two MMORPG guilds. He has his own game oriented YouTube channel, and has gained around 200 followers since he started a year ago.

Primary Actor and Main Goal

His technology teacher has started to introduce the class to Arduino. To her surprise, Elias who has stopped attending her Physics class, is excelling at Arduino and electronics. Although he is dyslexic, he seems to have little trouble programming in the Arduino IDE.

Topic and Content

As Elias's teacher had the students create their own technology projects, she noticed Elias' ideas were standing out, but seemed very complex to carry out. She still wanted to find a way to support his enthusiasm. Since he learned so fast, she made him and another one of his classmates, mentors for the other students.

Description of Environment and Possible Pre-conditions

The teacher plans it so that her students can come up with concepts 6 months before the deadline in December. Although she does have a small lab with basic electronics components that she started to build up two years ago, she knows final projects often meant materials had to be ordered. Since some components had to be ordered from China, sometimes with weeks of shipping time, she made sure to collect material lists as early as possible.

This year, as she had started to collaborate with the woodwork teacher, she had a bigger budget for materials, and planned on buying some soldering irons, wire strippers, as well as a laser cutter. After some lessons learned from the previous year, they had decided to collaborate later in the project, to make sure everything got finished in time for Christmas.

Preparatory Work

The teacher asks the students to prepare a sort of 'concept' that outlines the idea behind, the usage, the materials and skills as well as knowledge they will need. As Elias is planned to help out with a range of his classmates projects, he also agrees to simplify his own idea.

While other classmates are planning to create functional projects, Elias wants to create something fun. His teacher had something different in mind, but decides to avoid discouraging Elias, now that he is finally enthusiastic about a school topic. Elias wants to create a prank machine, so that he can film his prank victims for his Youtube channel.

His teacher helps him discard offensive pranks as well as pranks that are too technically complex for the time at hand. In the end, the idea is to create a machine that senses when someone comes close to the school Christmas tree, and that triggers the song 'Last Christmas' at the same time as the Christmas lights start to animate in disco-like patterns.

Description of Activity

As students are doing research on components needed, some have to change their concepts based on technical limitations and material cost. One project planning to use five servo motors and three ultrasonic sensors is completely discarded. Although it is expensive, Elias wants to order an mp3 shield for his project. His teacher knows that the best way to easily control several LED lamps is through using an addressable LED strip, so she helps him order addressable LED christmas lights.

As the ordered materials arrive, the students prototype and test them to learn more about the components they are planning to use. Elias is quite disappointed as he notices the mp3 shield uses so many pins on his Arduino board that he can't fit the other components and functions he wants in his project. He decides to use two Arduino boards, and brings the one he has personally brought to school.

Starting out, he tries out the mp3 shield with a special code library he has found online. Once he gets it working, since he found there to be few pins and power left for the sensor he had planned, he decides he will craft his own push button to trigger the song. The teacher helps him find tutorials online, and makes sure the textile teacher can allocate some time to help out ordering materials and sewing the button. Elias then finds resources online for how to connect and control the addressable LEDs he has ordered. He uses a PIR sensor to trigger a light animation when someone was close to the Christmas tree. The e-textile push button is made to be a carpet in front of the christmas tree.

Other Stakeholders and their Possible Interests

As Christmas break is approaching, Elias has his Christmas prank installed in the school's main hall. One day he decides to film the reactions, and edits a compilation of the best reactions. With the consent of the ones depicted, Elias then shares the compilation on his Youtube channel. It is spread locally in the school, giving him more followers, and it is suddenly shared on a famous blog authored by a "Maker".

Success and Condition

After some time, Elias starts to explore a new identity as a Maker. He contacts the blogger, and continues to expand his network as well as work on more advanced projects.

Failure and Conditions

It is being challenging for the teacher to evaluate the student projects according to the learning goals. Since the student projects are not framed by neither theme/topic nor technical solution, the variation of outcomes might make them challenging to realize and evaluate.

Variations

The brief given was kept open, but could have been tied to specific technical solutions or related to certain theoretical topics.

4.5. AIR POLLUTION BOX

Revision History

Date	Author/contributors	Description of change
18 July 17	Hofer, M.	Initial draft of Scenario
23 July 17	Hofer, M.	revision
24 July 17	Fischbacher, A.	Discussion, second revision
25 September 17	Ehrndal, M.	Revision of content
3 October	Hofer, M.	Final version integrated

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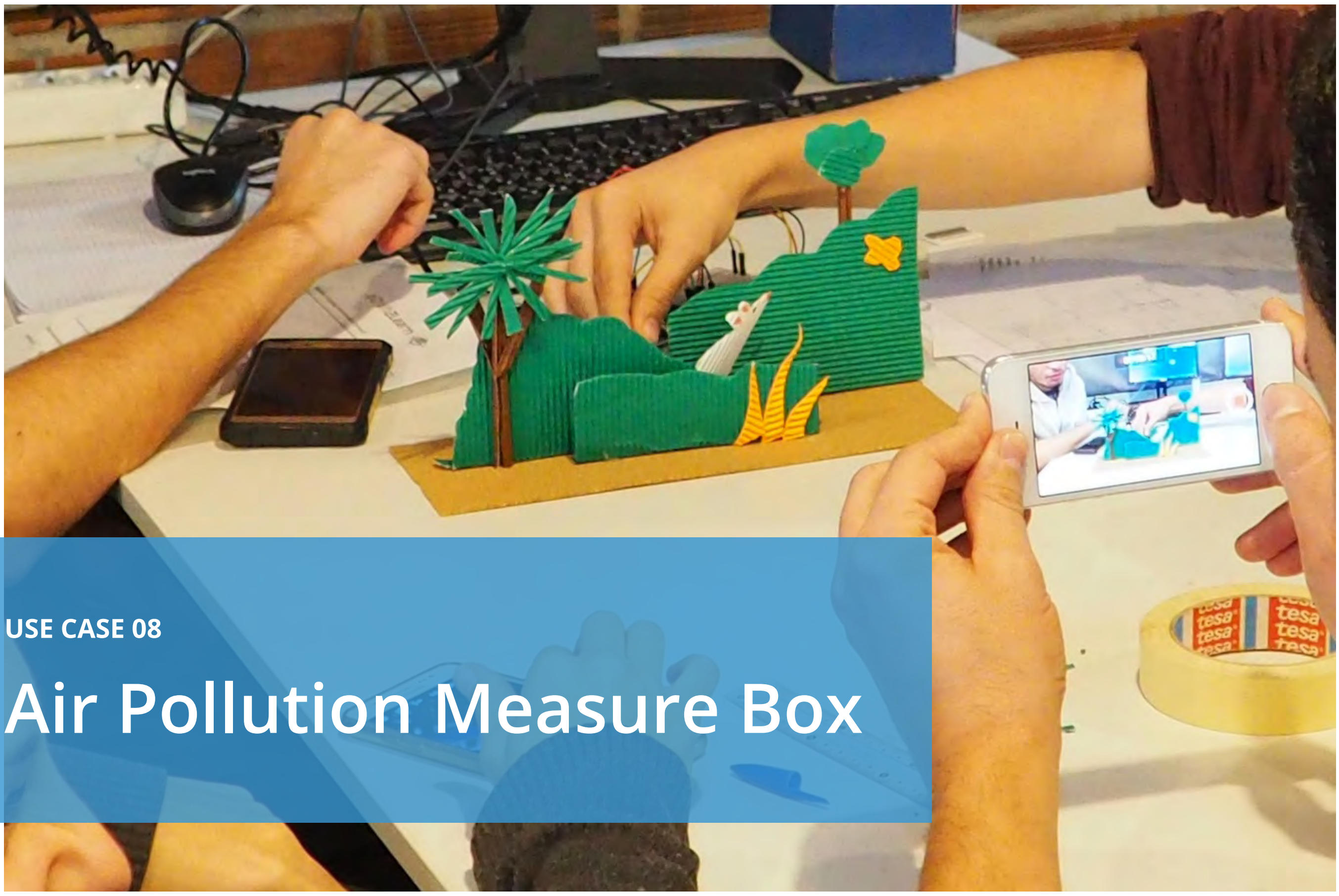


USE CASE 08

Air Pollution Measure Box

Age & Level

Anna, Austria
Teacher for Biology, Maths & Physics
39 years old

Anna, 39 years old, is a second-grade student teacher for Biology, Maths and Physics in Austria. The new system of 'Neue Mittelschule' is meeting very much her personal way of teaching. A personal attitude of her being as teacher is to enable and empower students and connecting theoretical knowledge with practice. Thus, she is balancing her teaching a lot with different teaching methods and pedagogical approaches. She also tries to foster team work amongst the students since she is convinced that this is a core skill for the next generation. She tries hard to integrate the obligatory curriculum plan with the student projects, and is getting better at this every year.

Primary Actor and Main Goal

Anna lives on the countryside in the mountains. Since ozone pollution is higher in the mountains, she plans to raise the awareness of her students towards air pollution. Last year she had everyone collaborate on the same project, but this year she wants the students to be freer to come up with their own ideas. She decides that all projects need to incorporate some specific technical components, and that they need to bring awareness of the invisible concept of air pollution.

From previous projects she knows that most of her 14-year-old students only have very basic skills in electronic or even programming, but all of them are very capable to handle different programmes. Some of them did amazing crafting the year before. As for herself, she has to confess that her abilities in programming or crafting is limited thus she is aware that she would need very clear and detailed instructions to get started on a project. Some time ago she talked to her colleague Mike who teaches IT in the class and he was willing to collaborate in case she finds an appropriate project that fits also to the IT curriculum. Together, they agreed all students would need to technically incorporate at least one sensor input, and any type of output. Apart from that, the students would be free to innovate.

Topic and Content

Searching on the internet, she discovers the eCraft2Learn platform and decides it's the perfect tool for her students since it supports team work. It provides her a frame for how to plan for her current as well as future student project assignments.

Reading on the instructions, she understands that she will need to provide prior to the project, some theoretical background knowledge to air pollution but since these fit well with the current school year curriculum she continues reading the other teachers experiences that have been shared on the eCraft2Learn platform.

Description of Environment and Possible Pre-conditions

Anna and Mike start by looking through the electronics and tools inventory from last year, to sort out all broken components. This takes longer than expected, and Anna decides that next year she will do this as soon as the term has ended.

After they have spent some time researching what materials and tools to purchase for the pollution theme, Anna calculates the related costs for materials needed. After making sure the cost falls within the yearly budget, Anna pays a visit to the local electronics store in the outskirts of the town. She spends the following days sorting components into compartments boxes, and makes sure to label all components and resistor values. She learned this from last year, as all components and resistors quickly became a mess.

Mike makes sure to update the computer rooms software with the latest version of the Arduino IDE. He also makes sure all students have access to the eCraft2Learn platform that has been installed in the classroom.

Preparatory Work

wo weeks later Anna starts with the educational content preparations. She decides to give some first initial input before starting the project in order to allow the students to gain a broad context of pollution, talking about atmospheric ozone, carbon dioxide emission, methane gas, and other substances that affects air quality.

Starting out, she wants all students to follow instructions to connect an Oxygen(O2) gas sensor, to read the values with an Arduino. This ensures individual assessment. For the project, she and Mike then give them the exercise to use incoming sensor values, from a gas sensor of their choice, to control an LED, a motor, a Piezo, or any other component. This, along with an explanation of what their code did, was the minimum technical solution and deliverable they needed to implement in order to pass Mike's IT class learning goals.

Anna, on the other hand, was more interested in the biological pollution aspect, as well as the introduction of mathematical concepts such as < (smaller than), and >(bigger than) being used in the conditional statements. Other than that, she is also interested in how well they are able to collaborate and execute a project in groups, and plans to have the students keep a log of what they are doing. She later finds this type of activity tracking is partially integrated into the eCraft2Learn system.

She books the IT room and the crafting room in accordance with Mike, gets the o.k. from the headmaster and organizes the needed materials (Arduino boards, jumper wires, breadboards, gas sensors, and various other electronic components).

Description of Activity

Anna gives her students the task to learn about air pollution. She splits her students into eight small groups, and ask them students to list causes, solutions, and to locate what gases are polluting the environment, and how. The students are told to work in groups to visualize the findings in one poster, and are then paired with another group to present their findings. The paired groups are then instructed that they now work together, and that they are supposed to create an interactive system that can detect one or more types of air pollution, and then carry out one or more actions(outputs). The teams brainstorm, present their ideas, and are given feedback on them based on relevance, usability, and feasibility. The concepts students have created are;

• A sensor box that opens a window when CO2 levels are too high
• A fart (methane gas) sensor that makes a Piezo beep as a threshold is reached
• An Ozone map (built to represent ozone levels in different areas around the school)
• "Bach's air" - a portable instrument made out of sensors. The different inputs are transformed into tones for different instruments or music loops.

Anna and Mike meet the teams one by one, to help them iterate their ideas, and to understand what tools and materials they will need to complete the projects. After a few days, the 4 teams meet in the drafting room. Anna and Mike have brought the materials each group needs, meaning the practical part of the project has begun. Students take on different roles in the teams, and to ensure everyone are actively involved, they meet with the teams and have them describe their work. every week. The teams are encouraged to solve the problems they stumble upon on their own, and during the weekly support meetings they mainly get hints and links to relevant resources. They can also book Mike for an hour to help out with the soldering of the circuits.

Most groups have similar problem, such as dealing with gas sensor warm-up time, and setting appropriate threshold values. Some groups want to build their electronics into boxes, and get help from the wood crafting teacher. Anna and Mike decide to plan for her to be on board for the projects next year.

After five weeks it is time for final presentations. The students are asked to give a background description based on their initial research, demonstrate their prototype, and to talk about what they've learned throughout the process. One group of students are not finished, and their prototype is only half done. They are asked to present their project later, and are told they cannot get the top grade for their project.

Other Stakeholders and their Possible Interests

As the wood craft teacher is contacted by the students to help them build cases for their electronics, she starts to imagine ways to incorporate these types of projects in her curricular activities. She starts to think about complex mechanical structures, as well as product design angles.

After discussing her thoughts with Mike and Anna, she decides that a laser cutter and an Ultimaker 3D printer should be purchased for next year. They also agree to collaborate more the following year, and have at least three cross curricular student projects that can be executed in a similar way.

To ensure their hours can be scheduled in synch to make this happen, they talk to the school principal. The principal is positive to this development, and encourages the teachers to present this at the next teacher meetup so that it can inspire other subject teachers to do the same.

Success and Condition

One week after the project is over, the last student group is able to demonstrate their prototype and get their grade. They are asked to write a post mortem to reflect on what they could have done different to deliver on time. In the end, all four teams were able to conduct research, create concepts, realize their ideas, and present their project and share what they learned to the class.

Failure and Conditions

Anna and Mike learned that their schedules needed to be more in synch, that they lacked the time, knowledge, materials and tools to build the electronics into physical objects. It was hard to keep track of the students' individual contributions to the teams, and this was something they wanted to improve for the following year.

Extensions

Some students started tinkering after school, and would create interesting devices at home.

Variation

The brief given to the students could be made more defined or open depending on the topic. The themes and topics could be varied as well.

5 USE CASES – M15

5.1. THE LIGHTHOUSE

Revision History

Date	Author	Description of change
Oct 2017	EDUMOTIVA	Initial idea, concept, instructions and guidelines
Nov-Dec 2017	Used by pilot 1 in GR and FI	Testing, implementation of input from teachers and observers for revision
Jan 2018	M. Hofer	Adaptation for use case
Feb 2018	Rene Alimisi	Further adaptation according to feedback from teachers
Mar 2018	Review	Finalization, comments

eCraft2Learn

USE CASE 09

The Lighthouse Project

Age & Level

Paola
Ischia, Italy
Science teacher
Teaches 13-year-old students

Paola is an Informatics science teacher in Ischia, Italy. She teaches 13-year-old students whose interests differ a lot in science and ideas as well as motivation for the lessons at school. For the project days, she would like to do some electronics with the kids since one of her colleagues showed her what he did with an Arduino Board in another class. She realized that the students were very excited about this way of learning. Thus Paola considers to do something similar. But since it is the first project of this kind for her, she searches in the internet for rather simple ideas that she can realize with her class even though she is a beginner. Paola has understood that her students are more motivated if she finds something that has a connection to real life.

Primary Actor and Main Goal

At the eCraft2Learn portal she finds a recommendation from a teacher to build a blinking light house. For her teaching in informatics it would be a first simple step towards programming & Do It Yourself electronics for students. She also likes the fact that the students will craft something by themselves.
She enthusiastically realizes that this project offers opportunities for:

1. exploration of primary concepts in electrical circuits and basics in programming
2. construction and expression of creative skills (i.e. by making drawings from observations to analyse the structures of the buildings, looking online at collections or photographs of built structures)
3. reflection & discussion (i.e continuity and change of lighthouses over time/ technological and scientific developments over long periods, maritime history and more).

Topic and Content

Still she is aware that she needs quite some preparation as well as doing some testing before, in order to be able to support the students if necessary. She is also aware of the fact that the steps of a project like this cannot be explicitly foreseen and no matter how well-prepared she is, it might be needed to work with the students and all together to find solutions to emerging problems.

Through this project the students will perform hands-on activities and will be able to construct simple electrical circuit and do the Arduino wiring. They will also understand basic programming concepts (loops, conditional-statements) in Snap4Arduino or any other programming environment that will be selected). They will understand the role of sensors and how to use them in accordance to the project scenario and to read values from an analog input. In addition, the students will practice their crafting and soldering skills.

Description of Environment and Possible Pre-conditions

Before she starts with her own testing of the project, Paola discusses the project with her colleague and what issues they need to consider. For once, her colleague recommends her to block several hours since 45 minutes are far too short for the project unless more sessions are foreseen (i.e. 3 x 45 minutes) Her colleague further explains that it is important to allocate time for hands-on activities and craft-making as a tight schedule may limit students' creativity. Based on her colleague's experience the implementation of the project-based methodology takes time and it does not fit in a single session. Paola has already a plan on how to embed the lighthouse in the curriculum that she is bound to. She makes a list of materials that they will need for the project, and writes a short memory incl. the required connection to the curriculum (including the learning goals and how the students will reach them) to the headmaster for information. Usually she is quite independent with her curriculum, but since the school invested some of its budget for the Arduinos, she would like to contribute to the documentation of the usage and benefit.

Preparatory Work

Since the Arduino Uno Boards were already acquired by the school, there is only the need to get some more wires, breadboards, resistors, potentiometers, photoresistors, and LED pins.

In order to enable students' engagement into crafting, Paola equips also the class with scissors, rulers, silicone pistols, glues and other tools that can support the hands-on activities of the young "makers".

She decides to split the lighthouse lesson in two sessions, forming teams of three students each. As soon as Paola bought the materials, she borrows an Arduino and tests with her colleague the lighthouse project. She realizes that there can be quite some pitfalls but with the help of her colleague she does well with the testing.

In order to scaffold the students without indicating a specific pace of working in the project, Paola prepared a worksheet where key steps and tips were documented. She also identifies useful external resources that can be used to familiarize the students with the tools/technologies that can be used. She enthusiastically realises the circuits on Tinkercad are very good resources for introducing her students in electrical circuit design and showing them the basic wiring actions in their Arduino boards. She makes a list of such resources and further enriches it with videos and web links.

Description of Activity

For the first session, she introduces the kids to the lighthouse project by questioning 'What is a Lighthouse and what is the exact usage of a Lighthouse?'. She also asks the students to discuss within their groups in a lighthouse without a keeper how the flashing light is turned on when it is getting dark? How it is turned off in daylight?

The students are invited to note down their answers after a search in the internet and to start setting up a plan for a lighthouse. The students are then encouraged to make a list of (recycled) materials that can be used for the lighthouse construction and they are advised to take this material with them to the school the next day.

For the last task, she starts familiarizing them with the tools that are going to be used using the list of resources that she has prepared. She encourages the students to hold in their hands the Arduino boards and using the selected resources guides them in exploring 'what is what' (pins, boards, gates, wires, breadboards, resistors, sensors etc.). The students get a first idea and start thinking of the resources that are going to use to construct their lighthouse. As for the next day, Paola has following step-by-step tasks for the students (which are also documented in their worksheets):
"Create your lighthouse with materials and devices available in the lab. Take a photo of your model and upload it to your group folder."

She also asks them to make the lighthouse to blink (to alternate from on to off state) every second.

Paola gives them the tip to use a LED in series with an 1kΩ resistor as well as to open Snap!4Arduino to program their lighthouse. While for some students it is easy to use Snap!4Arduino, others need some more support. But having done so, also the other students understand the basic principles and are able to do some small programming.

As a second step she asks the teams to let the lighthouse blink at different rates by modifying the on and off period duration.

And she launches the question on how read and inspect analog values from the pinA0 of the Arduino Uno board.
Several students have problems with this, thus Paola helps them by pointing out to connect the A0 pin to the ground / 5 Volt / 3.3 Volt pin (each time) using a wire.

As a next task the students are asked to connect (instead of a potentiometer) a photoresistor / 10kΩ resistor to the pin A0 of the Arduino and write down the corresponding values for daylight and darkness conditions.

The classroom is very bright, thus the students use different materials like jumpers, boxes, etc. for covering their photoresistor. This is important, because the next task that Paola gives to the teams is to make the lighthouse to blink only at darkness.

For Paola it is important that the students are able to present their work to their peers, no matter if they completed the project or not. She encourages the students to present the current status of their work including challenges that they may have faced. Thus also for this project, she requests each team to prepare/make a short presentation to their peers.

Other Stakeholders and their Possible Interests

Paola and the students also record with a camera these presentations and share it in the internal folder of the school with other teachers and students. This is an excellent opportunity for students to demonstrate their work and process that was undertaken and reflect upon what worked well and what aspects should be improved or enhanced. They are also encouraged to talk about the challenges that they faced and the way they overcame them providing Paola with additional opportunities to gain an insight into their understanding of the underpinning technical and scientific concepts.

The artefacts (meaning the Lighthouses) that were prepared are going to be presented in the open-day of the school that is organized the month after.

Paola also considers the participation in bigger events and this idea has been embraced by most of the students. She is aware that the participation in bigger events is a valuable educational and social experience for the students but it requires good preparation and support from additional teachers in order to handle challenges related to organizational issues, logistics, coordination and more (i.e. permission and approval for participation in external educational events from the school, the parents).

Success and Condition

All the teams were able to fulfil the given tasks and the variety of the different designs was astonishing for the students.

Failure and Condition

Although all the teams finished their lighthouse, Paola realized that for some students teamwork is more difficult than for others. While some teams found very soon solutions to work with each other, Andrea realized that other teams had rather difficulties to agree on the design, the planning, etc. Also she observed that one student seemed to be not be very involved in the project tasks, independently of the stage and the tasks (making, the design, the programming, sharing).

The project was completed by all the teams. Still Paola realized that some students mechanically connected the wires and the pins in the breadboard without being able to elaborate on their decisions. This was a good point for her to intervene and through prompt questions to help them understand the underpinning science principles in relation to technical practicalities.

Last, Paola realised that in some teams, some students were mostly involved into crafting or into electronics, or programming. Andrea was a bit alarmed. Both her guidelines and the ones provided through the worksheet encouraged all the students to be involved in all the parts of the project and decisions to be taken in a collaborative way. Paola kept an eye on how the role allocation is taking place without putting pressure to the students to undertake specific roles. She would like to see first how the role allocation will be shaped naturally in current and forthcoming project activities and she has already set up a plan on how to foster role rotation for the benefit of the team as a whole.

Barriers/Facilitators

Further reflecting, Paola realized that the time each team spend in the crafting stage varies and depends on their creative mood, interests etc.

Extensions

On the other hand, many teams and students were thinking on further applications of the Arduino board and the photoresistor like Christmas tree lightning, traffic lights, RGB Interior Car Lighting, wearable security cloths, blinkers for cyclists. In addition, the project scenario offers a smooth transition and opens the way to 3D modelling and printing tasks; Andrea realised that in the future she can invite the students to design and print the 3D model of the building of the lighthouse exploring more STEM principles and concepts.

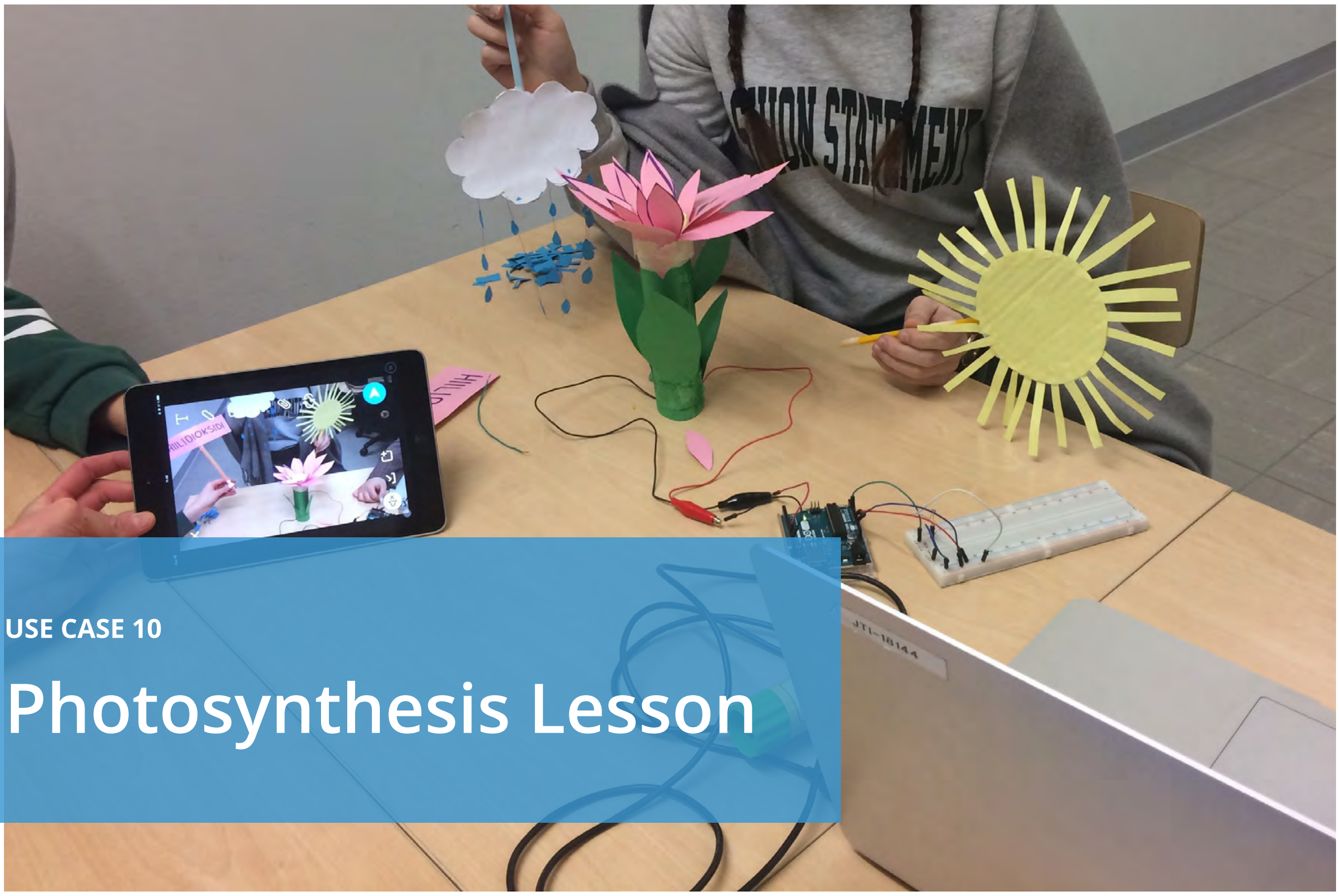
Variations

Concluding the project with the students, many different designs were constructed but obviously the functionality is the same: a led that blinks. Some students were inspired by online resources and tried to do the mock-up of a specific lighthouse. Some others started thinking how to add additional functionalities like sound while other students created also the surroundings (the port, the sea etc.). Thus, the project offered much flexibility.

5.2. PHOTOSYNTHESIS - SHOW HOW IT WORKS!

Revision History

Date	Author	Description of change
Oct 2017	Calkin Suero Montero (UEF) and Sari Nevalainen (formal pilot site teacher)	Initial idea, concept and instructions to carry out the activity
Nov-Dec 2018	Sari Nevalainen and Marjo Vornanen (formal pilot site teachers)	Used in 1st round of pilots in Finland - practical adaptation and deployment
Jan 2018	Calkin Suero Montero and Mareena Hyypiä (UEF)	2nd version revised based on observations and students/teachers interviews
2 Feb 2018	Sari Nevalainen and Marjo Vornanen (formal pilot site teacher)	2nd version revision and improvements
7 Feb 2018	Margit Hofer (ZSI)	Adaptation to style and format
25 Feb 2018	Mareena Hyypiä, Calkin Suero Montero (UEF) and Sari Nevalainen (formal pilot site teacher)	Final revisions by researchers and teachers



USE CASE 10

Photosynthesis Lesson

Primary Actor and Main Goal

In secondary school, the lessons are usually theory oriented. However, in this project Mikka and Iida want to combine biology subject matter with technology (which in turn helps the math teacher develop her subject matter) and emphasize students' active role and hands-on activities.

Mikka and Iida plan and ideate a project where students need to create a representation of photosynthesis using recycled materials for crafting as well as technical/electronic devices through the eCraft2Learn ecosystem.

Photosynthesis is a familiar concept for the students from their theoretical lessons. However, approaching it from the novel angle of technological tools application may be challenging. In the class, few students have used a computer programming application during their earlier school studies and for most of them technology used for crafting and making a physical artefact is unfamiliar.
When Mikka asks the pre-knowledge of students, they notice that students express concerns that the project will be difficult and that they have concerns to fail.

The teachers allow their students to self-organize into groups. They were wondering about the fact that the students decide not to form mixed-gender groups. Also, all the groups decided that they would distribute the tasks and defining roles for each team member (e.g. one is responsible of programming, other of documenting) and that these roles would change in each session. In that way, every student would have the chance to try each role. Mikka and Iida are fine with these arrangements and see the advantages in this settings the students decided: finally the students would not get bored or tired of being always in the same role.

Age & Level

Mikka, Finland
Biology teacher

Iida, Finland
Math teacher

Mikka, a Finnish Biology teacher and Iida, his colleague who teaches Math work in a secondary school, teaching 19 fourteen-year–old, 2nd year high school students (four boys and fifteen girls). At school, this group emphasizes Drama as their main study track. They both have done some projects already together.

Topic and Content

Ida and Mikka explain the student teams their overall task: to create a representation of the process of photosynthesis. The representation can contain a plant, for example, where it is indicated the impact of the elements needed in the photosynthesis process, particularly water, sunlight and carbon dioxide. The students should understand how each one of these elements affect the photosynthesis process and provide a suitable representation of it.

For the development of the photosynthesis project Mikka and Iida provide a variety of tools and recycled/craft materials that the students can choose from to use in their representation. The students use electronic components and circuits, computer programming, 3D modelling, 3D printing and craft materials (e.g. cardboard and playdough). During the project students shall enhance their technical, social and communication skills through exploration and collaborative work. Mikka and Iida plan the project to take 3 weeks (2-3 hour sessions once a week).

Description of Environment and Possible Pre-conditions

Their school is very open to the incorporation of new pedagogical and didactic ideas for teaching. The school principal gives freedom to the teachers to plan their subjects' projects in a manner the teachers consider most appropriate to implement. Mikka and Iida are guided by the national and local curricula and the content to be covered during one school year is vast. Thus, the task to be develop within the eCraft2Learn pilots has to align with the curriculum. Both are enthusiastic to integrate biology and mathematics subject matters to technology and arts.

Still, for safety reasons, Iida has to arrange the installation of the 3D printing program with the IT coordinator of the school. The photosynthesis project is held in the media classroom which has been designed to serve as a flexible space for teaching and learning. Tables, chairs and electricity plugs are easy to move and modify based on the needs of the student teams. There is an iPad storage cart in the classroom where students can take iPads when needed (e.g. for information search and 3D modelling). All electronic devices such as 3D printer, monitors, keyboards and mice are stored in one corner of the classroom whereas smaller electronic components such as Arduino, Raspberry Pi, breadboards, cables and sensors are stored in a cabinet. The equipment is assembled by student teams in the beginning of each session, taking only 3 to 5 minutes to setup. The school also has cardboard and recycled materials in the craft classroom.

Preparatory Work

The biology teacher gathers necessary materials for crafting.
The eCraft2Learn technical cores (i.e., monitors, Arduino, Raspberry Pi computer, keyboards and mice) are made available in for assembly before the sessions. Smaller electronic components (e.g., resistors, breadboards, sensors, etc.) are also available for use.

Description of Activity

The first two-hour session starts with orientation. Mikka and Iida introduce the project topic and start a discussion about photosynthesis. What does photosynthesis mean? What is needed for it to successfully happen? What is the result? Next, they introduce the equipment to be used. Their students get familiar with the technical core and the basics of electronics and programming through different hands-on activities and tasks including short introductions. These tasks start from easy exercises and progress towards more advanced ones. First task is to connect one LED to Arduino and program it with Snap4Arduino to light up. Next, students need to get the LED to blink. After the testing Mikka sees that the students understood the meaning of a digital pin, and the students are able to explore the analogue pins in the Arduino board. This is done by connecting a photoresistor to the LED circuit.

Iida provides a list of possible sensors that the students could use in their projects. The students are allowed to test and work with several sensors for some time. Soon they understand the principles behind the sensors. Now, students' task is to start ideating which sensors they could use and how for their project. Mikka and Iida poses a question how to represent photosynthesis using technology such as electronic components and 3D modelling and printing in the representations. Immediately the students ideate and plan how will their solution look like, what materials they need, which sensors they will use to model the different elements influencing photosynthesis. Iida realizes that the ideation part is challenging for the students who are not use to work in this manner. The teacher facilitates the process by asking students to find information about photosynthesis and by proposing possible concepts for the representation. All student teams decide to create a model of a flower.

During the second session, the teams start creating the models. Some teams use recycled materials, and one team decides to 3D model and print their flower. Simultaneously, some teams start creating and programming electronic circuits where students include the wires and sensors in the flower model.

The first hour of the third and final session is used for adding the final touches to the model. During the last hour students share teams' work by recording videos and explaining the functions of the representation to others. These videos and the instructions which each group made was uploaded in the UUI shared space. Automatically all the files show also up at the to school's Moodle plattform, dedicated for sharing and accessible also by other teachers of the school. During the following lesson, the biology teacher discusses with students about the project and asks the students what they learnt about photosynthesis.

Other Stakeholders and their Possible Interests

Curious what is going on in the IT room, other teachers and students are passing by the classroom and getting curious about the project. Also, some students uploaded their video presentation on their private facebook website and received many 'likes'.

Success and Condition

Mikka and Iida reflect on their project and they realize that the role of them as a guide and facilitator is vital for the students to work as main actors in the classroom, collaborating with each other. In just eight hours and by providing sufficient background knowledge, the students are able to create physical representations of photosynthesis using technological devices. The final models exceeded teachers' expectations by being creative and unique and students are proud of their work.

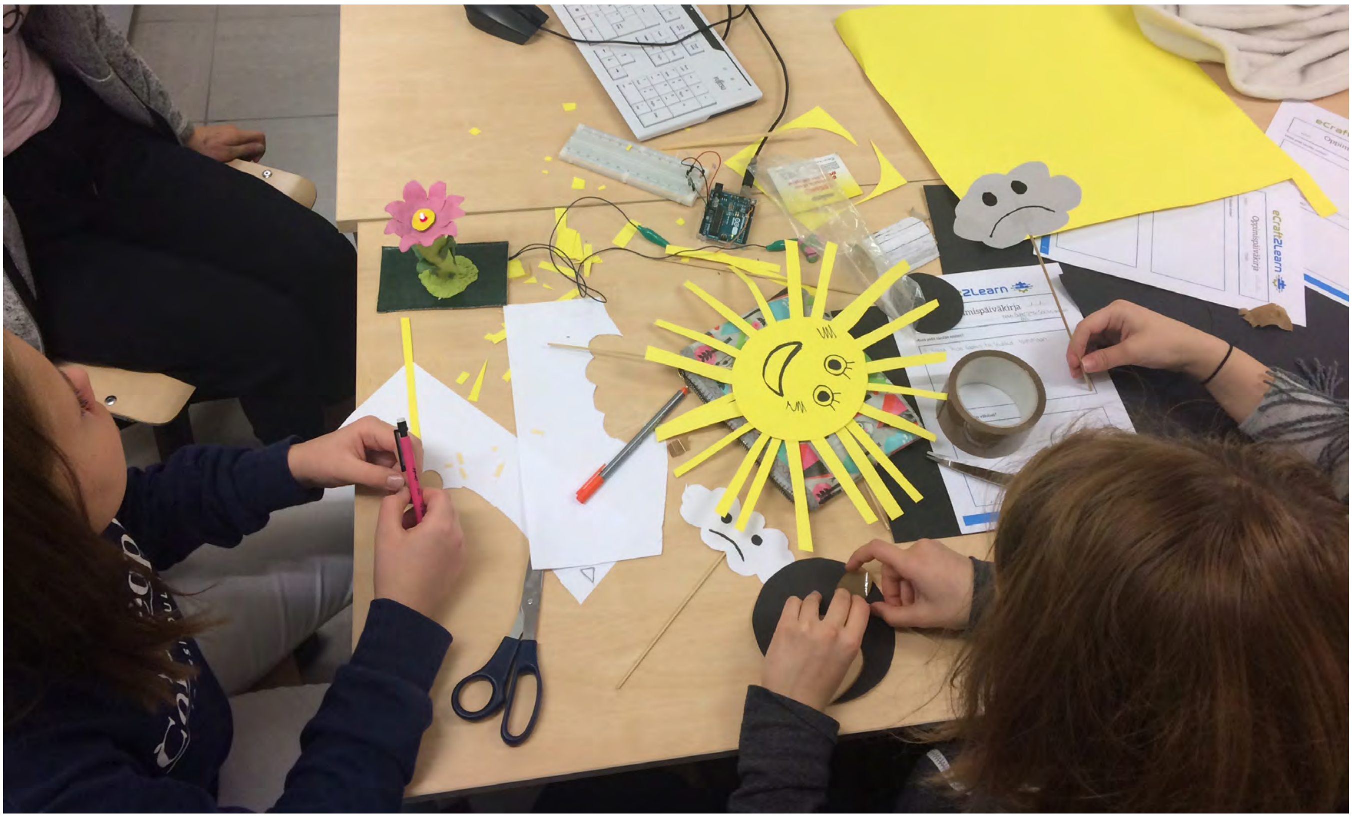
The students learnt how to program small circuits and how to use 3D modelling and printing by combining software and hardware technology. They also strengthened their knowledge about photosynthesis. Students shared ideas and combined different opinions into a joint vision of the final product. This helped improving the group dynamics of the class.

Mikka and Iida were able to give students positive feedback often and in real time which helped to engage and motivate students. Through the project students experienced technology as makers and this helped to diminish fears or doubts towards technology. The flower concept was attractive for girls to engage them in using technology as well. Both believe some students could continue studying the technological field in the future.

The role of a coach in the classroom is familiar for both teachers that carried out the photosynthesis lesson, they are not afraid of admitting they do not know everything. They agree that they are now more confident to implement this type of pedagogical process that integrates technology into the development of subject lessons. They are excited to implement the hands-on activities and project-based learning in their teaching in the future.

Variations

Mikka and Iida realize that the representation of photosynthesis can be much more than just a physical model of a flower. The variations are limitless. For example, a tree or a scale model of a greenhouse could be possible to create. Thus for further projects there are many different exciting options.



5.3. Pet Feeder

Revision History

Date	Author	Description of change
05 Feb 2018	Horton, S.	Initial draft
07 Feb 2018	Hofer, M.	comments and feedback
08 Feb 2018	Horton, S.	Amendments and additions

USE CASE 11

Automatic Pet Feeder

Age & Level

Group of students, Spain
17 years old

A small group of three Spanish students aged 17 are very close friends since they attended two years ago the same class. Although very different in personality, they discovered that they have similar interests like making and also 3D printing. They have followed already some of the TinkerCAD tutorials and 3D courses and printed some small personalised models that they designed in the tutorials such as a keyfob with their name on and a chess piece. The students have also already used an Arduino to make a light flash on and off at specific time intervals, sewing it on a bag.

Primary Actor and Main Goal

The girls share the common interest of loving animals. Two of them - Maria and Francesca - have dogs at home and like to spend time walking them after school. The other girl, Marla does not have a dog but has a cat and a guinea pig. All three girls love meeting up after school going to each other's homes for snacks and a drink and fussing their own and each other's pets and when the weather is nice taking the dogs to a local park where there is a large field that the dogs can run about on.

Although the girls all have access to technology at home and in school - they all have mobile phones and tablets, the girls are not particularly interested in school technology lessons.

Practical technology lessons in school often mean using hand tools and spending a long time trying to shape materials, get parts to fit and get a good surface finish.

Due to their lack of practical skills and limitation with the tools, equipment and materials, the products they made were not very creative or inspiring, as complex shapes are difficult to produce using the tools and materials they had access to.

However when they experienced 3D printing, although they only designed and 3D printed a couple of small items, this made them realise that they could use their creative skills to design something unique using a variety of shapes and forms and that the 3D printer would make it for them and produce a really nice finish. This opened up their eyes to the opportunities for making products as the technology allowed them a lot more creative freedom.

Topic and Content

The girls experiment with programming an Arduino building on their previous experience of switching an LED on at certain time intervals they adapt this so that the Arduino will rotate a servomotor at defined time intervals. They soon realise that this will allow them to produce an artefact with moving parts.

The girls want to produce a real product that solves a problem, they understand the value of using craft materials to explore their ideas and refine them to make a working prototype, but see the added value that using a 3D printer brings. The ability to 3D print solid parts in specific shapes and sizes combined with the Arduino would allow them to create a functional, usable product.

Description of Environment and Possible Pre-conditions

Their IT teacher, Jose, is fairly innovative and recently he has done some projects with students using Arduinos. He has seen already several activities with 3D prints in this context and even has one used already in the FabLab Barcelona. At some point he mentions in his class the 3D print, and Marla, who is usually not showing much interest, suddenly starts to talk about different options how a 3D printer could be used for the daily life and that it could solve several problems and issues of society. When asking which examples she would think of, several other students start to come up with ideas. Thus Jose is asking his students to think of possible projects till next week, how these projects could be addressed and to sketch a plan on how to produce these items.

At the same day, Jose gets in contact with the FabLab Barcelona and he is very fond of the offer to have a 3D printer borrowed for one week for a fairly small fee. He gets the recommendation from a FabLab team member to talk to some more experienced users in the lab to gain more experience on the 3D printer before starting the projects with the kids and to check out the Unified User Interface of eCraft2Learn.

Preparatory Work

One week later, the students' mind-mapped ideas. Maria, Francesca and Marla love their pets thus they decided to make something that would be useful for pet owners.

They decided to incorporate an Arduino controlled servo motor with 3D printed parts to make a pet feeder that can be used to feed pets at timed intervals whilst the pet's owner is away from the home for an extended period of time.Facilitated by their class teacher, the students gather and bring in from home a range of recyclable materials such as cardboard, food packaging and containers along with the craft materials, Arduino and electronics available in the classroom.

Description of Activity

The students experiment with programming an Arduino, building on their previous experience of switching an LED on at certain time intervals, they adapt this so that the Arduino will rotate a servomotor at defined time intervals.

They discuss and sketch several ideas, and then they experiment with the craft materials to test and refine their ideas. Finally they produce a design for a pet feeder which they think will work, it contains 3 separate food trays with a cover that covers up 2 of the trays, they want to rotate the cover of their feeder every 8 hours so that the next tray of food is uncovered for the pet to eat. This would mean that a pet can be fed at regular intervals for 24hrs without human intervention.

The students produce a prototype design from plastic food cartons and cardboard, however craft materials do not provide enough robustness for a working solution, so the three girls decide to use 3D printing to fabricate the feeder trays and cover. Using Tinkercad the students produce a 3D model of their design. They realise they need somewhere in the design to store the Arduino board, the wires and the design also needs to hold the servo motor in place which is attached to the rotating lid. They adapt their design to accommodate this by including a bottom casing that holds the trays and the electronics. The trays need to be removable so they can be washed and filled with food. They adapt the lid so that it has sides that fully enclose the bottom casing.

The Tinkercad designs were saved, then sliced using the Cura software prior to 3D printing. When all of the parts had printed the girls programmed the Arduino and assembled the model.

Other Stakeholders and their Possible Interests

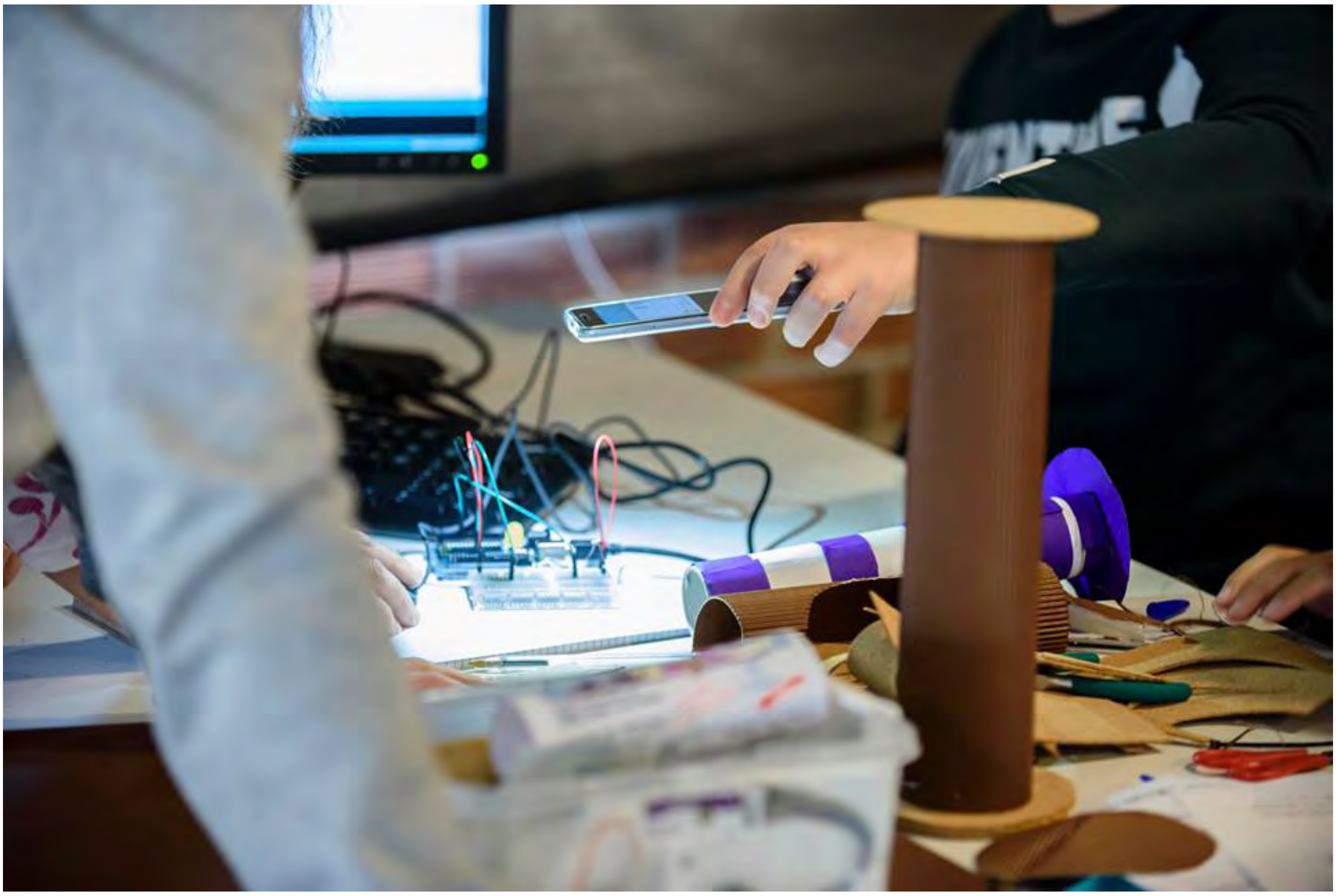
Finally the pet feeder works exactly the way the girls have designed it and they agreed that Francesca will take it at home to show it to her parents, handing it over to Maria one week after.

Success and Condition

All three girls are very proud of their product. And they realize how astonished their parents were with what they were able to design and build.

Failure and Conditions

They reported their parents exactly what issues they had to face and how they solved them (like one part was starting to wear down slightly and one hot end was clogged)



When the girls first attempted to print the casing they found that one corner of the model came away from the print bed and warped. They aborted the print, recalibrated the Print Bed and applied a thin layer of glue to the print bed. This solved the problem and the second attempt to print worked well.

Upon testing the assembled model, the lid was found to be a bit too tight to rotate smoothly and made a scraping sound as it moved. The girls watched a short video in the UUI that showed how to resize a model in Cura, then they resized their lid design in Cura to make it slightly bigger and reprinted it, the second print fitted well and moved much smoother when rotated by the servo motor.

Barriers/Facilitators

All three girls realized that the support of the teacher and the facilitator in the FabLab was great to have, since they gave valuable tips on how to proceed with the printing when they had issues.

Variations

As for Marlas pet, the girls decide to adapt it to the smaller size of her cat.

5.4. Aid for Grandma

Revision History

Date	Author	Description of change
07 Feb 2018	Horton, S.	Initial draft
12 Feb 2018	Hofer, M.	comments

eCraft2Learn

USE CASE 12

Aids for the Elderly or Disabled

Age & Level

Leon, Germany
Hamburg, Germany
16 years old

Leon is 16 years old and lives in Hamburg, Germany. He has some previous experience in 3D modelling and 3D printing gained from visiting his local FabLab. The facilitators at the FabLab are a small group of enthusiastic makers with a lot of practical experience under their belts but with no formal teaching experience. One of the facilitators, Paul is particularly helpful and Lean has built up a good relationship with him benefitting from his experience and advice.

Primary Actor and Main Goal

Leon is good at mathematics and technical subjects in school. He is interested in cars and cannot wait to learn to drive. He works at a local food takeaway on Saturday afternoons and is saving towards getting his own car.

Currently he is applying for an Engineering course at a technical college and ultimately would like to be an engineer at BMW. Last year he went on a school visit to the BMW headquarters in Bavaria and was amazed and impressed by the facility and location.

Leon visits a FabLab in his town most Saturday mornings to gain some additional skills, he knows that 3D printing is being used a lot in the automotive industry and thinks that by learning the technology will give him an advantage in future college and job applications.
At the FabLab he has taught himself the basics of 3D modelling. He started by downloading interesting models from Thingiverse to 3D print, but has progressed to designing and 3D printing a few small items for his home such as a stand for his mobile phone and a tealight holder as a birthday present for his older sister.

Topic and Content

Leon has a very close relationship with his grandma, she lives close to him and he visits her most days after school as his parents were out at work. His grandma has always had difficulty with movement in one hand due to a trapped nerve at birth, however as she has got older she has developed severe arthritis in both her hands and this has limited the movement of her fingers and restricted her ability to grip things.

Leon has noticed that his grandma finds it increasingly more difficult to do everyday tasks due to the limited mobility of her hands, he often helps her at home by opening bottles and jars for her, chopping vegetables etc. He wonders if there is another way he can help. He thinks he may be able to use the 3D printer and 3D design software at school to design and make tools and aids that will help his grandma to use her hands to complete everyday tasks.

Leon talks to Paul, one of the FabLab facilitators about the problem and asks if he thinks it would be possible to use the 3D modelling software and 3D printer to design and make something to help his Grandma. Paul thinks it is a great idea and offers his expertise to feedback on his ideas and designs before 3D printing, as he is also keen to not waste materials on printing designs that won't work in practice.

Description of Environment and Possible Pre-conditions

The FabLab in Hamburg is relatively new and contains a variety of making facilities and equipment. This includes:

- • a traditional workshop space with benches that contain wood and metal vices, a range of hand tools, a vacuum former, band saw, belt sander and lathe
- • a small electronics lab with soldering irons, electronic components, breadboards for prototyping and a range of programmable micro-controllers. This also includes a digital fabrication area with Raspberry Pis, a laser cutter, a PC and a 3D printer.

The small team of three permanent staff have different skill sets to assist the FabLab visitors, one is an electronics expert, one a former joiner who is an expert with the traditional workshop tools and machinery and Paul who is an experienced CAD designer and specialist in digital fabrication techniques. The team work different shifts so are not always all available at the same time, but Paul is usually at the FabLab on a Saturday morning when Leon visits.

Preparatory Work

Leon plans and then records a short video interview with his grandma, where he asks her a series of question about what she finds difficult. He shares this video with Paul, this helps them to understand the real problems his grandma faces and to generate ideas for bespoke 3D printed tools and devices that could help.

Leon also takes various measurements of his grandmas hands to help with his designs as he thinks these might be useful for determining the various size requirements for his designs.

Description of Activity

First of all Leon watched the video interview of his grandma and used the ideation tools in the eCraft2Learn UUI to record all of his ideas. He discussed various options with Paul and decided that the thing that would be the most useful would be to concentrate on cutlery. His grandma has difficulty gripping cutlery and finds it particularly difficult to cut meat, reluctantly she has had to change her diet to include things that are easy to cut and scoop up. His grandma did get some special foam grips that went onto the ends of her cutlery. These did help but the problem is they only lasted a week or two before they needed replacing and they were too expensive for his grandma to keep replacing. Leon decided to try and design and 3D print some special handles that would slot onto the ends of the cutlery.

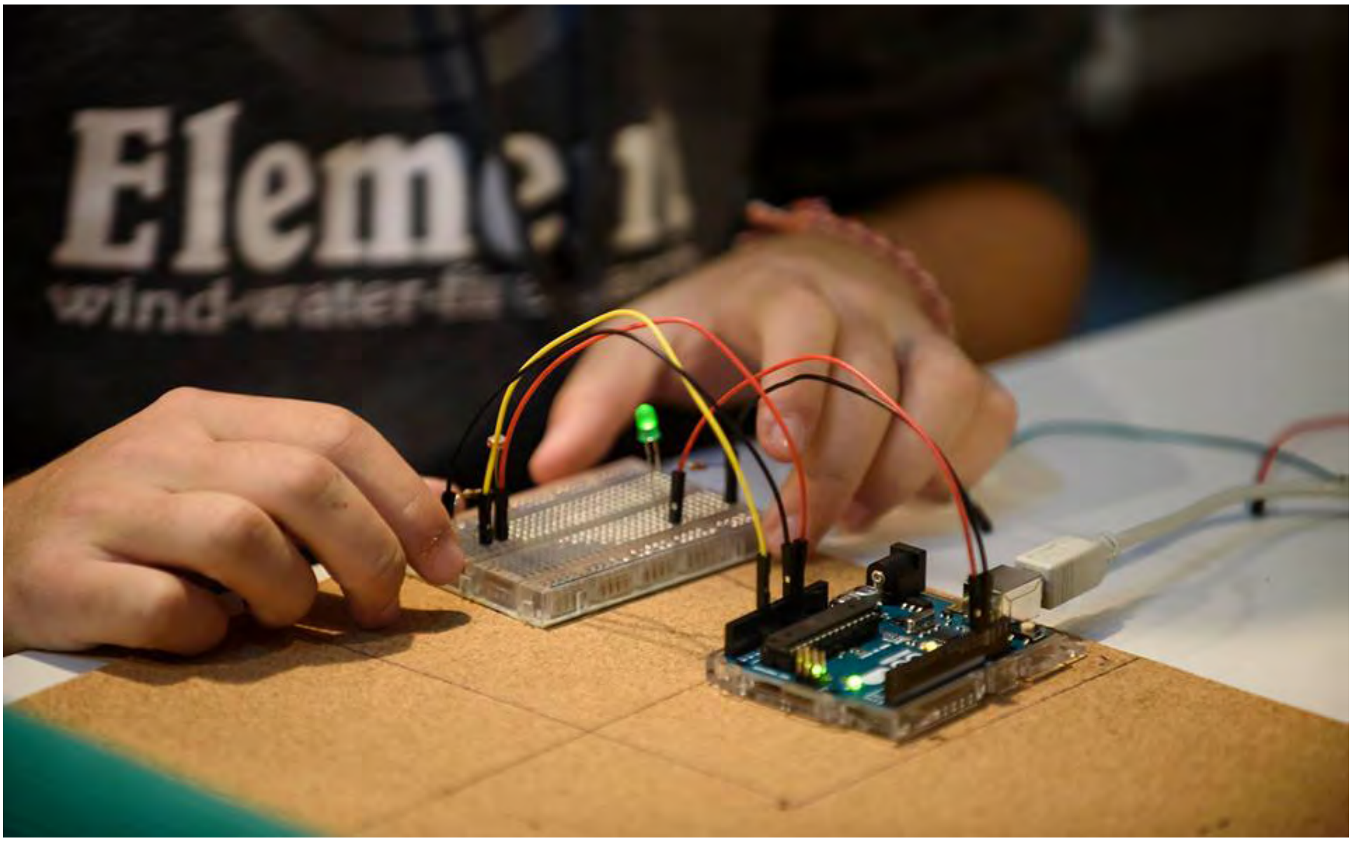
First of all Leon purchased some new cutlery with a cylindrical handle as he thought it would be easier to work with than his grandmas cutlery that had a complex shaped handle. He worked with his grandma to produce a prototype by using plasticine shaped around the cutlery to see what approximate size she would be able to grip. He also looked at how her hands wrapped round the handle to see where he would need to put grips. Using the prototype Leon then took measurements and started to draft up a 3D model in Tinkercad. First he made a basic large 3D cylinder the required diameter, he also placed a cylindrical hole down the centre for the cutlery handle to slide into. Then using the torus shape as a hole he made indentations into the surface of his object to add finger grips.

After a few tweaks to solve some object alignment issues he saved the design as saved the design as a .STL file. This file was opened up in the Cura slicing software. He realised that to minimise overhangs it would be best to print the handle upright on the printer, so he changed the orientation of the model in Cura. The file was checked and sliced then saved as a Cura Project and a .GCODE file for 3D printing.

A single prototype of the handle was then 3D printed and he assembled it onto the knife and gave it to his grandma for testing.

Success and Condition

Upon testing Leon discovered that his grandma's hand would slide down the handle sometimes, so he adjusted his design to include a raised ridge at each end of the handle to stop his grandma's hands from sliding.



This second iteration was a great success, so Leon printed 2 more and glued them securely onto a knife, fork and spoon so that they could be used permanently by his grandma.

He also decided to share his design as he thought other people with similar difficulties to his grandma might find it useful. In the Share area of the UUI, he selected Thingiverse and uploaded his model design to the Thingiverse community.

Failure and Conditions

When printing the first prototype, as it was a relatively tall print, towards the end it started to wobble and became detached from the print bed, this caused the print to fail. He wasn't sure how to stop this from happening again so he watched the Cura Build Plate Adhesion video in the UUI.

After learning about the two options he decided to add a raft as it provided more adhesion and was easier to break away from the finished print afterwards. Following this his second printing attempt was successful.
After Leon's success, he is now working on a kitchen knife design with two handles, one at each end so that his grandma can push down on both ends to chop vegetables.

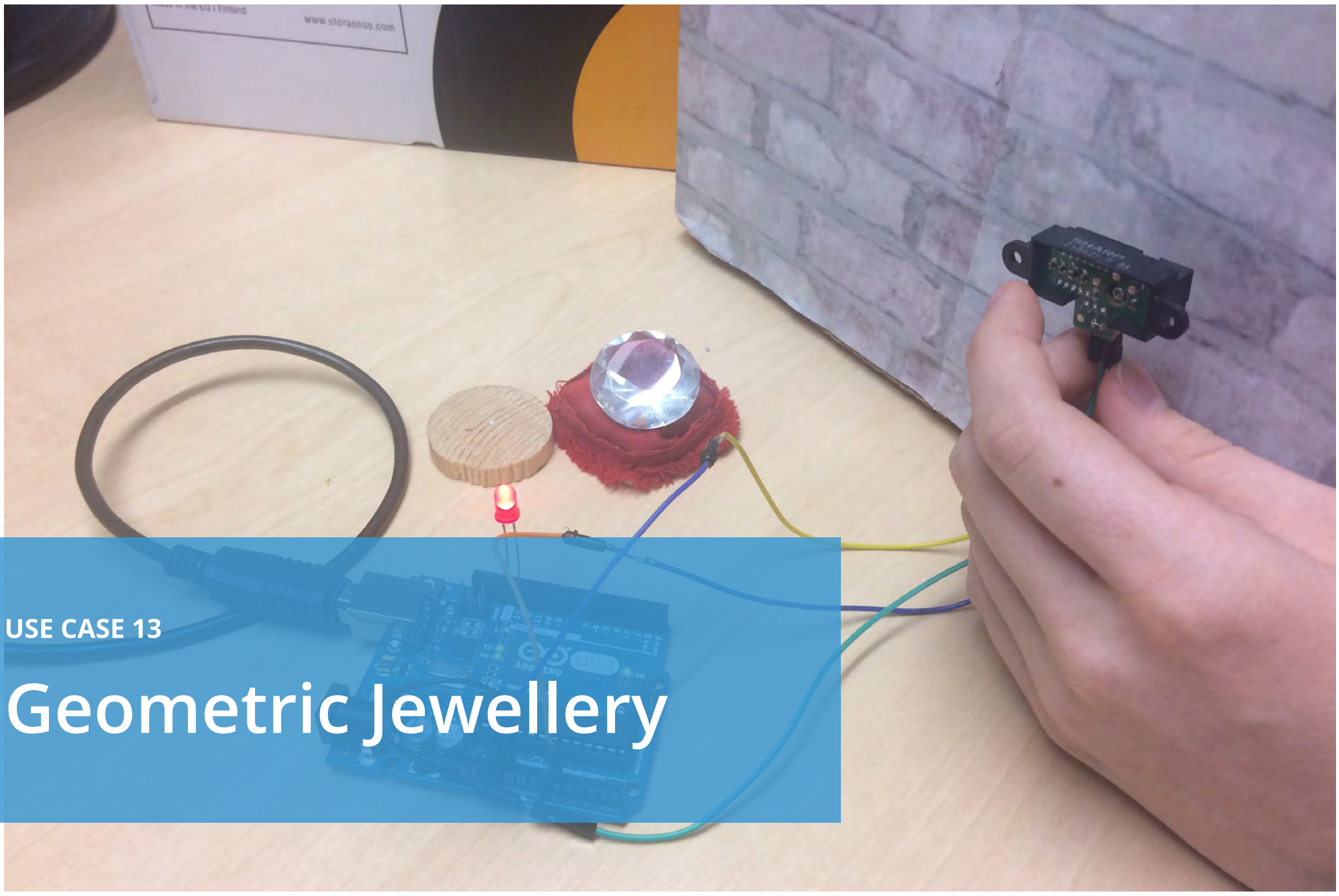
Variations

Leon's grandma is thrilled about her new aid and since it works so well for her, she shows it to her friends in her union for elderly people where she goes once a week and several other friends of her are wondering how he did this and are astonished how gifted her grandson is. One friend even asked her if her granson could find a solution for his crutch he tends to loose due to his Parkinson.

5.5. GEOMETRIC JEWELLERY

Revision History

Date	Author	Description of change
09 Feb 2018	Horton, S.	Initial draft
12 Feb 2018	Hofer, M.	Comments and adaption



USE CASE 13

Geometric Jewellery

Primary Actor and Main Goal

Sara lives in the suburbs of London, at the moment she is very busy planning her upcoming wedding. Sara is very active and likes to swim and cycle whenever she gets the opportunity.

Sara recently moved to a new school and is keen to make an impact, in particular she wants to increase the number of students (and in particular girls) who choose to study Computing at GCSE (General Certificate of Secondary Education) level.

To do this she wants to introduce some new projects for the 11-14 year olds that will engage them more in the subject, in particular she wants to introduce more physical computing, combining coding with other technologies in order to programme real artefacts rather than just coding animations and games.

Age & Level

Sara, United Kingdom
Computing Teacher
30 years old

Sara is a 30 years old Computing teacher who has seen many changes in the subject over recent years. At the beginning of her teaching career, she was just tackling ICT skills such as Word processing, spreadsheets and databases. Now the subject has evolved to be much more focussed on Coding so she has had to spend a significant amount of time in the last two years acquiring these skills herself in order to effectively teach her students.

Topic and Content

At a recent meeting with other local computing teachers, Sara was introduced to some new software called Beetle Blocks, this was very similar to Scratch: a blocks based programming software that her students use at Primary school. Beetle Blocks includes the ability to extrude a path and export the mode for 3D printing. Sara thought this would provide a brilliant introductory project for her 6th grade of 14 years old students as they would be familiar with the code but be able to actually make a physical artefact by coding the design. She also thought it would appeal heavily to the girls, as it is a very creative activity.

Sara decided to use Beetle Blocks for a geometric jewellery project, this would have a number of additional benefits in that way that it would help the students to consolidate the work they are doing around angles in mathematics, the jewellery prints would be relatively small and quick to print and it should engage the girls more than some of the previous coding projects.

Description of Environment and Possible Pre-conditions

The school computing suite is equipped with 20 PC's, with a reasonable internet connection. There is also class sets of Arduino Unos and MicroBits.

The Computing department does not have a 3D printer, but there is an Ultimaker in the Technology department. Sara speaks to them and finds that it is not used all of the time. As the 3D printing element of the project would only take place in the final week, she persuades the Technology department to let her borrow the 3D printer for a week in order to allow the students to 3D print their work.

Sara is hoping that once the Computing department experience the 3D printing and the positive benefits of this technology that she will be able to persuade them to invest in one for the department in future.

The Beetle Blocks software is cloud based so all that is required is for the students to access it through the UUI and log into their own student accounts.

The Cura slicing software has to be installed on the PCs. Students do not have the required permissions to install software on the PCs so the school IT technician was required to download and install the Cura slicing software onto each PC prior to the project commencing.

Preparatory Work

In addition prior to the start of the project, Sara created a set of student accounts in Beetle Blocks and prepared login detail slips for her students. Sara also created a few example Beetle Blocks designs and 3D printed them so that she could show students some possible project outcomes.

Description of Activity

To introduce the project to the students Sara first shows them some of the 3D printed examples she prepared - a ring, a bracelet and a pendent. She asks the students how they thought they might have been made, then explains that they have been 3D printed. In pairs the students are tasked with researching 3D printing and to find some other examples of 3D printed jewellery and fashion accessories.

The students share their experiences. Then Sara demonstrated the 3D printer printing one of the jewellery designs and explains how it worked.

Sara then introduces the students to Beetle Blocks, the students log into their students' accounts and follow a quick tutorial to learn the basics of the software. Sara demonstrates a few of the different programming blocks and the different outputs from them.

In pairs, students are then left to design an item of jewellery, Sara observes that the students work in different ways to achieve this. Some students sketched their ideas first then tried to find a way to program Beetle Blocks to produce their desired outcome. Others delved straight into Beetle Blocks, experimenting with different code sequences to see what effects they produced, then they edited the code and/or combined different code segments to create a design that they liked. Some students produced flat designs using only the X, Y plane however many of the groups managed to progress into using the Z plane to create more three-dimensional designs.

The students generally worked well in pairs as it allowed them to collaborate on the design, share ideas and problem solve together to debug and edit their code to get the design outcome they wanted.

Sara demonstrates how to export a design from Beetle Blocks as a .STL file and import it into Cura, she also points the students to the Cura tutorials in the UUI where they could learn about the various aspects of the software.

The students save, export and slice their designs. As the designs are all quite small, Sara asks one of the student groups to combine several designs onto a single build plate in Cura so that 5-6 items could be printed at the same time. This speeds up the printing process as Sara could start printing a set in the morning then another set in the afternoon, she does not have to keep returning to the printer to print the next design every 20 minutes. In all a whole class of 30 students, work was able to be printed this way in less than three days so that the students could take them home. Sara also prints duplicates of each design to keep for a classroom display.

Other Stakeholders and their Possible Interests

Following the project, the Art department is very interested to see the 3D printed Jewellery designs produced by the students. Viewing the end products instantly gave them ideas for how they could incorporate 3D printing within their art curriculum and design courses. This has opened up discussions between the two departments of how they might both make contributions from their individual department budgets to purchase a 3D printer that can be shared between the departments, as neither department would need all year round access to the printer.

The school leadership team has also expressed an interest in having the 3D printer on display at open-evenings, they believe it would produce a wow factor amongst potential students and their parents and may contribute to encouraging more students to apply for the school.

Success and Condition

The project was a great success as all the students, girls and boys were very engaged with it, they liked the challenge and the creativity of having to code their own design. Their coding skills developed much further as they were coding to solve a problem and get an outcome that they wanted. The additional benefit was that they were able to physically make their designs and had an end product they were proud of and wanted to take home.

Failure and Conditions

Reflecting the activity, Sara realised that there were two main problems that the students encountered, first of all if the students tried to scale their designs in Cura, this often didn't work very well and the model became faulty and would not print. Therefore, to bypass this ad hoc issue Sara encouraged the students to resize their models within Beetle Blocks by changing the "move block" distances until the model was the size that they wanted before exporting the .STL file. This way the model did not need to be resized in Cura.

Another issue was that as the prints were very small and detailed the print quality was not as good as Sara expected, with quite a bit of stringing. After consulting the Ultimaker user community forums that has been pointed at in the UUI, Sara tried slowing the print down, she did this by using the manual printer controls to changing the print speed to 50% and also reducing the nozzle temperature to 190°. This worked really well and the prints were a much better quality.

Barriers/Facilitators

Sara also consults the UUI learning analytics and is able to see how much time each pair of students used in the different phases of their work. This helps her also to understand in which phases the students need more support and or more explanation for future projects. As the designs were relatively quick to print and used very little filament, the cost to produce them is small. Sara realizes that the project could be extended into a business enterprise project with students printing multiple copies of a variety of designs and selling them at the school fair. As Cura gives the amount of material used per print, this can be used to calculate the production cost of each piece allowing students to determine their margins, selling price and calculate the profit. Students could take on management roles within the business, further building teamwork and collaboration.

Variation

Discussing the project with her colleagues, Sara has understood that this process has potential to be used for a range of different projects. One example would be to code and 3D print mathematical manipulatives such as 3D shapes or other designs to demonstrate mathematical principles for example transformations such as rotation and translation.

5.6. BLOOMING FLOWER

Revision History

Date	Author/contributors	Description of change
5 Feb.18	Johansson, M.	Initial draft of Scenario
14 Feb. 18	Hofer, M.	Revision

USE CASE 14

Blooming Flower

Age & Level

Sam, Finland
Student
17 years old

Sam is a 17 year old student in Helsinki. She spends most of her time drawing on her own, and likes to craft with her hands. If the class is not art or crafts related, she does not pay much attention. Although she has managed to hold a passing grade in most subjects.

Primary Actor and Main Goal

At school she has been introduced to programming, but don't see any point in using it, since she's not that into computers. But she knows that some other students seem to enjoy programming and they have made some interesting programs.

Topic and Content

The IT teacher, Mike wants all students to see how useful programming can be, even if not all students will continue with programming. This term the teacher has managed to get some Arduino kits for use in class. In the hopes of getting more students involved in programming.

Description of Environment and Possible Pre-conditions

The students are paired up and asked to build a project that could help the environment. Sam is put in a group with Alex, who is great with computers, but does not get along that well with Sam. The teacher picked the students to complement each other, which would be beneficial for the results and the students, who would learn from each other.

Preparatory Work

Mike has seen how many things you can make with an Arduino board, and therefor wanted open up for exploration during class and to show the students that there are many different solutions to any given problem. To achieve this the teacher supplied the students with several well explained examples and gave them the open-ended theme of helping the environment.

Description of Activity

When Sam and Alex start to build their project the approach the problem from completely different angels. Sam wants to make something with more of a nature-theme, but Alex aims to try to use a weather API. So while Alex is occupying himself with getting the weather API data readable by the Arduino, Sam is left alone to figure out how to make something on her own. Trying to come up with how to show a flower with lights, Sam happens to see one of the teachers' examples that showed how to make a servo-motor turn with a push button, and this looks easier to code than making several lights blink. Now she manages to build a small paper flower, where the bud will open up when the servo turned.

Around the same time Alex has managed to the weather data into the Arduino and makes a light switch on when the sun is shining. Sam seeing that Alex's code is a bit more complex code-wise than her own button, and Alex seeing that Sam´s flower looks much better than his single light, they decide to combine their projects into one.

This results in a final project that checks a weather API, with Processing, then filters out the how cloudy it is at that given moment in Helsinki, sends that date over the serial ports to the Arduino. There the program sees how cloudy it is and opens the flower accordingly with help of the servo. Hence, the flower opens gradually according to how cloudy or not cloudy it is at any given moment in Helsinki.

Other Stakeholders and Their Possible Interests

After showing the project to the teacher, and while the project itself ended up well, the teamwork was not what the teacher had in mind. Sam and Alex had work separately until the very end, but both students had worked out solutions on their own.

Success and condition

The teacher, knowing that most of the coding had been done by Alex, askes Sam to explain how she progressed from lights and buttons into the servo setup. This is where Sam showed that while her progress in understanding coding was not to the same level as Alex, she was able to work with the code and figure out how to solve problems and would adapt her ideas based on her coding level.

Failure and conditions

While the project and the goal to improve the students' knowledge of project did work out for Sam and Alex, the two did not work as a group to any greater degree. Therefore, they did not see the progress of each side, only the results. So in the case of Sam, she never really saw how Alex solved own his issues. If they knew better what the other part was doing, they could have avoided some delays and would not have been side-tracked, which might have resulted in better project.

Barriers/Facilitators

For further projects Mike realized that – apart from the technical preparation – some more things need to be considered and noted in his reflection sheet:

- "Not sufficient amount of material for all student groups (Solution: need to form bigger groups)
- Not enough work for all students (Issue: increase in students off-time)
- Not enough time to complete the project due to the knowledge level of students (Solution: provide more practical examples during the introduction)
- The teacher effect of the project outcome is too big by presenting examples (everyone creating a flower etc.) (Solution: the teacher could ask an open question to elicit and pick students' imagination: what would be your ideal representation?)
- Where to find information if a problem emerges (e.g. new sensor, new programming code) (Solution: the UUI will provide a space for FAQ and also to access and ask the community of experts (e.g., Arduino community, Ultimaker community, etc.)
- Identifying the knowledge level of students and providing enough support for all learners/groups (important to guide students' imagination to match with their skills and available resources such as time and equipment)."

He also realises that there might be several barriers he needs to take care of like a lack of previous experience of using different technologies as well as the fact that many students are challanged by working in teams due to different interest, communication skills, etc.

However, Mike figures that the students are quick to learn and understand different concepts. Many of his students are creative and not afraid to try and explore. Also the fact that the feedback comes fast (e.g. an LED lights up or blinks) increases the motivation but also creates frustration if it does not work. Finally, reflecting with other teachers about the project, he concludes that high trust between principal and teacher is needed but that these type of projects can also increases the good relationship between teacher and students.

5.7. Robot Competition

Revision History

Date	Author/contributors	Description of change
5 Feb.26	Johansson, M.	Initial draft of Scenario
25 Feb. 18	Hofer, M.	Revision and adaptation

eCraft2Learn

USE CASE 15

Robot Competition

Age & Level

Alex, Finland
Student
12 years old

Alex is a 12 year old girl from that goes to a small school in Helsinki, and she loves robots. She has seen video clips online of all kinds of robots and would like to build a robot one day.

Primary Actor and Main Goal

Her school does not have any subjects that are anywhere close to robotics, but her enthusiasm has reached one of the teachers. This teacher's son happens to be an engineer that has experience with building robots.

Topic and Content

Not wanting Alex's enthusiasm go to waste, the teacher has convinced the school to let his son Juri, an engineer, help out by running a small robotics class as an extracurricular activity once a week. A few other students, besides Alex, also joins the class.

Description of Environment and Possible Pre-conditions

Juri has managed to gather up a good assortment of components and sensors for use in class, and he found some suitable tutorials on how to build in the components with Arduino boards. To engage the whole class, he suggests that the class compete in a robot competition for 11 year olds and up. The class, and specially Alex, wants build a robot to join in the competition.

Preparatory Work

With the components and the tutorials, the class spends a few weeks on learning the basics on how you control motors and how to use sensors. Juri shows the class more details of the robot competition and the class decides join the competition with a dancing robot

Description of Activity

The competition rules are that the robot needs to be able to make an on stage act, without any human controlling it, but can interact with the audience. So Alex and the class chose to make the robot move differently depending of the type of noise the audience makes.

As the class is progressing, Alex spends more and more time with the project but finds it hard to figure things out on her own. Much of that which she can find online is excessively complicated for her. Even when Juri is helping, there is a limit to how much he can simplify while still getting any functioning results. Finally, she finds on the eCraft2Learn UUI a similar project with very detailed instructions that she is able to follow. Still she needs the help from Alex to attach the motors on the robot so that it can move. However, getting the robots movements to be controlled by the input from noise sensors became time-consuming for the whole class and when it was close to finished, the deadline for joining the competition unfortunately was passed.

Other Stakeholders and Their Possible Interests

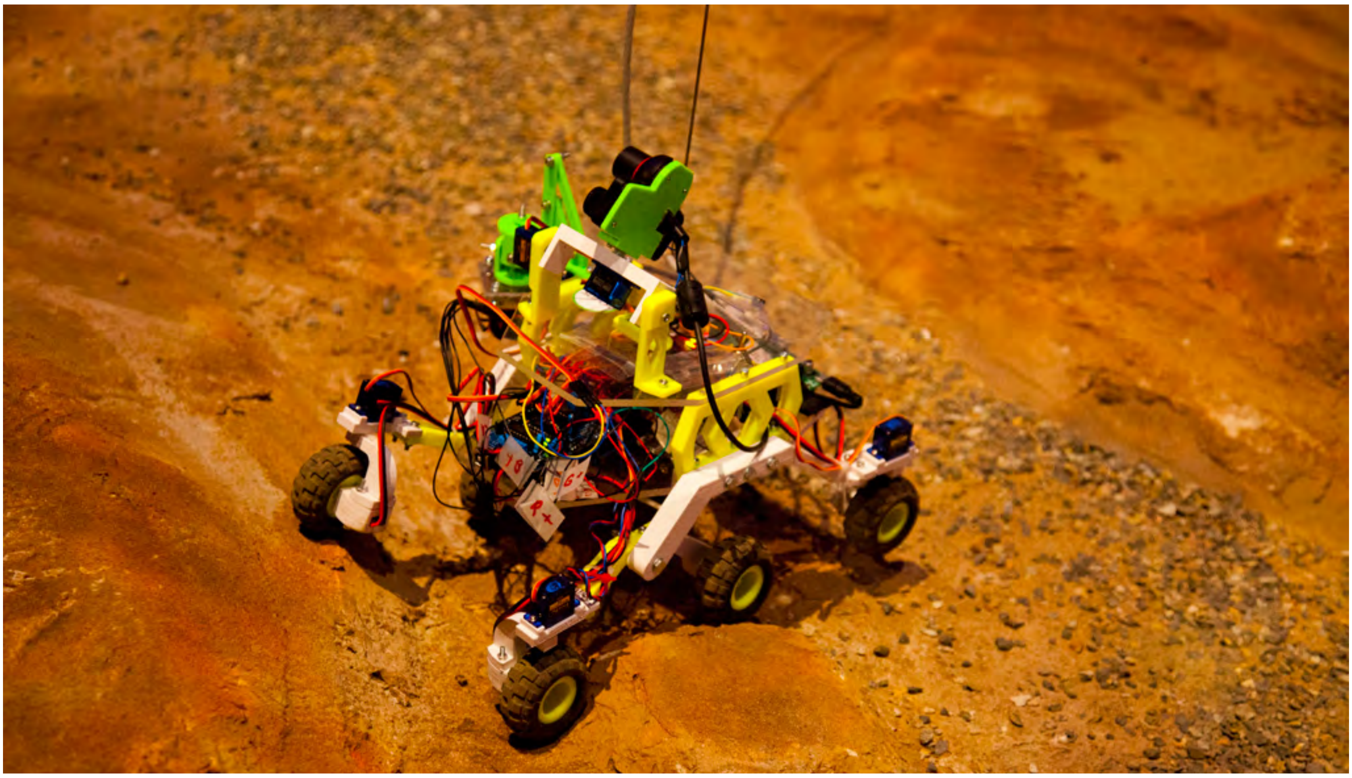
During the time the kids spent in the extracurricular activity, the school started to get feedback from the parents with kids in the robotics class. The parents were happy that their children were building robots, and they seem engaged with it. Alex's parents, however, were concerned that Alex spent too much time on the robotics class and too little on the normal classes.

Success and Condition

The robotics class was a success and the school wants it to continue the next year, but the school wants to make a syllabus to keep a better structure for the class. It is also important to document what the students have been doing in the class..

Failure and Conditions

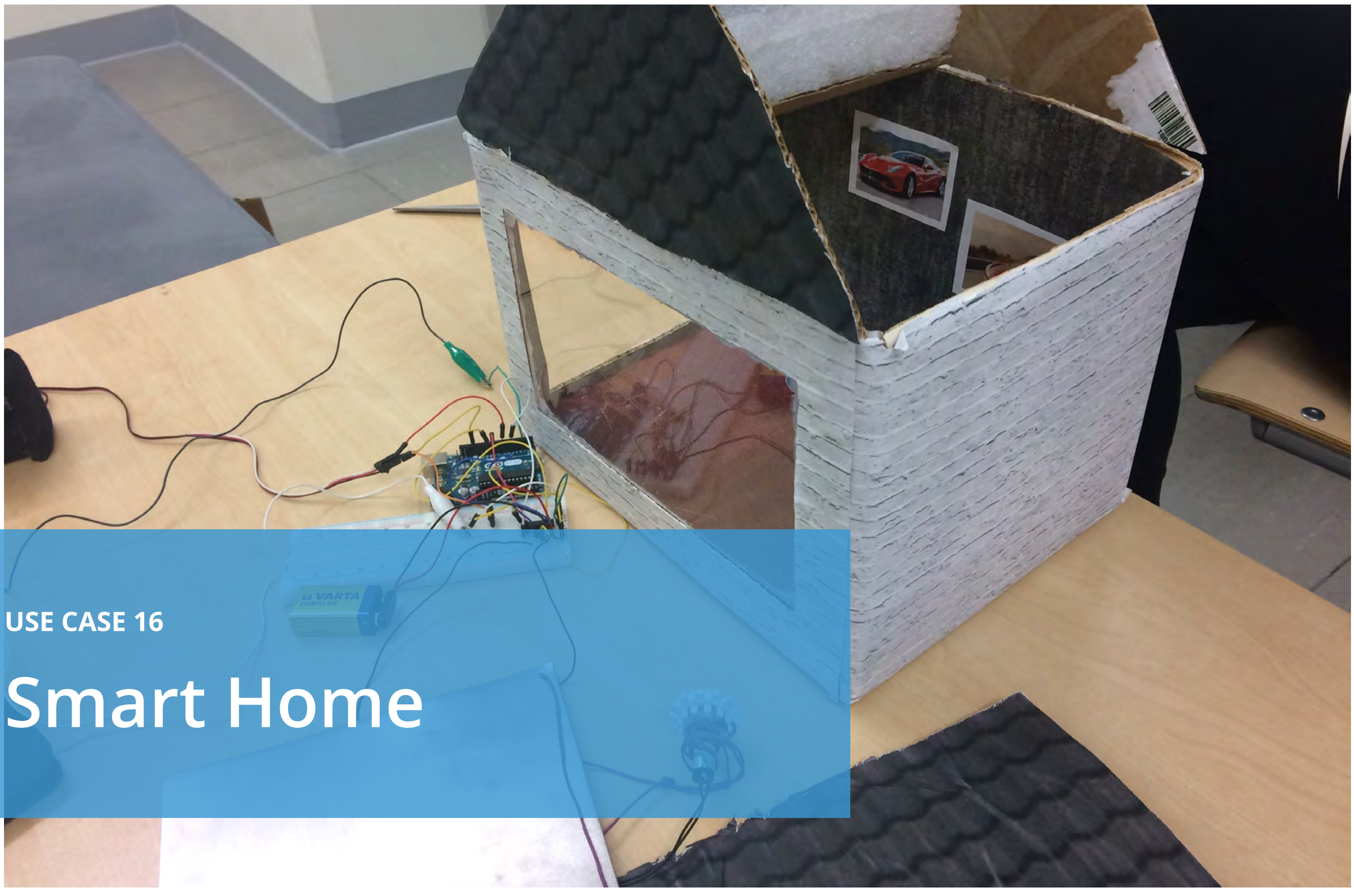
Although the students missed the deadline for the competition, the class was a success. The students were able shown that they are able to build a robot fitting the rules of the competition, but they were lacking the structure in the class and this made it hard for the students to progress evenly.



5.8. SMART HOME

Revision History

Date	Author/contributors	Description of change
20 Feb.18	Johansson, M.	Initial draft of Scenario
2 Mar 18	Hofer, Voigt	Review, comments



USE CASE 16

Smart Home

Age & Level

Kim, Finland
Student
14 years old

Kim is 14 years old boy from Helsinki. He is good with computers and knows some basic programming. However, the school he goes to does not have much for him do with computers.

Primary Actor and Main Goal

He has learned how to use graphical programming, but he feels limited by it and has a hard applying it in real-life situations. He wants to do more practical fun things, like hacking household appliances or building robots.

Topic and Content

The teacher wants the students to gain some insights into new technologies and has asked the students to pick a technology of their choice and make something with it. For example something that uses or inspired by any of the following technologies: IoT, Speech Recognition, Artificial Intelligence etc.
The teacher has access to many electronic components, but has not mastered programming well. Therefore, it will be up to his students to learn more advanced programming on their own.

Description of Environment and Possible Pre-conditions

The students are working alone, building their projects and are told to document their progress weekly. Kims father has a device that can control the lights in their home using voice commands. Kim likes this and would like to build something similar.

Preparatory Work

The student has access to the eCraft2learn platform, which has good tools for documentation, examples on how to use graphical programming, and tools to combine graphical programming with Arduino Boards. One of the last mentioned tools is a AI block for Snap that can recognize words.

Description of Activity

Kim tests his father's speech recognition device and wants to make something like that. He starts with adding servos on top of some light switches, making code that will switch them on and off. He tries to figure out how a speech recognition device works. It is too difficult, but the AI block in the eCraft2learn platform is manageable for Kim.

Kim has problems getting the AI block to recognize whole phrases and ends up compromising and uses one-word commands.

Other Stakeholders and Their Possible Interests

The end of the term is approaching and Kim seems to have spent a lot of much time investigating his father's speech recognition device and not enough time working on his project. The teacher is worried that Kim will not finish his project in time for the presentation and asks if he needs support.

Success and Conditions

Kim spends most of his time testing and trying to understand how the speech recognition device works, this results in his project coming out as a rough but functioning draft. It functions thanks to the AI block and manages turn on different lights using the servos. Kim has shown that he understands the technology well for his age and that he would be capable to advance his project further if he had more time.

Failure and Conditions

Kim managed to investigate and find out more about that technology he picked, but he had clear problems with finding his work-method. If Kim would have had access to a good source of info about speech recognition devices, where he would be able to build a speech recognition device himself would have been really helpful for Kim.

Barriers/Facilitators

This is what both, Kim and his teacher figured out when discussion about Kim's work.

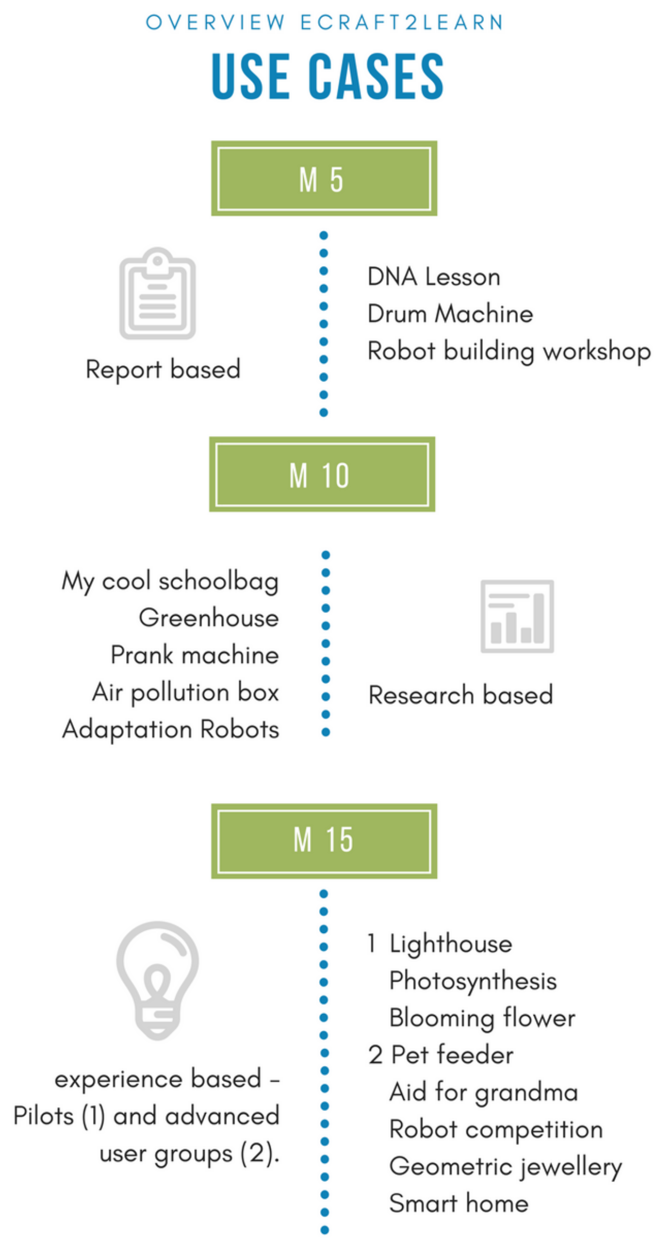
The teacher understood that the students need some guidance (some more than others) and that asking for help once a student is stuck is for some students tricky. While others managed well to find solutions to their identified problems, Kim was too much observed by identifying the problem and finding a suitable solution for it. Thus, the importance of guiding and coaching is essential.

He also realizes that the topic was too broad set. Although it would have limited the creation of the students, a limitation would have allowed the teacher to prepare some more material that would have been supportive for the children.

6 SUMMARY

Our past efforts resulted in very different use cases and several descriptions of personas that showed a high variety, though not exhaustive, collection of issues that are important to the teachers and students that might use the eCraft2Learn environment. These use cases outline a variety of factors, such as learning environments, personal interest, technical issues, pedagogical efforts etc. In total, we have developed 11 personas (in M10) and 14 use cases (see Graph 1) including two extensions and improvements from the very basic use case of building a robot.

Graph 1



Starting with use cases that were rather based on examples from internet and partners descriptions at the beginning (report based) by month 5, followed by use cases that based on research like interviews and questionnaires in month 10, the final use cases increasingly integrated the insights gained during the deployment work in the project (experience based). Therefore the use cases were either adapted or expanded (i.e. robot use case) or new ones created, driven by workshops and insights from the first eCraft2Learn round of pilots in Finland and Greece, co-designs by teachers as well as by the first impact interviews with teachers. Some more advanced use cases were developed by user groups that are very experienced (Arduino and Ultimaker) in order to give input for further working with the eCraft2Learn UUI.

As mentioned the use cases aimed to deliver a basis for further discussion and (re-)finement for advancements and development of the project by outlining different needs, preferences, abilities but also concerns from the environment of the users. Of course a major part outlines the advantages they might experience alongside possible issues they might face from a personal, technical, pedagogical and also organisational perspective. Thus, the scenarios aimed to 'translate' experiences from partners, opinions of facilitators and opinions of teachers and pupils into living stories to allow the eCraft2Learn project developers to easily to understand the environment and conditions where the eCraft2Learn ecosystem is deployed. Based on further discussions if ideas and needs can be met in the given framework, ultimately the developers can improve and adapt accordingly the UUI. At the end, many factors need to be taken into account if and how ideas and requests are integrated, but certainly the use cases can serve to set focuses on features of the UUI and the pedagogical model. Although these use cases reflect the environment and needs as of today, they can be used as a starting point for future scenarios of WP2 (i.e. by reshaping certain aspects – which would create a totally new scenario).

7 Annex

Semi-structured Questions for participatory approach

Aim:

Aim of the questions is to identify needs of the end-users (teachers and students) for co-developing the UUI of eCraft2Learn.

The questions shall give some 'introductory hints' in which directions you might ask for. Pl. feel free to continue asking questions that relates to the aim of the session.

A) Questions to pedagogical Model:

- Is the model applicable to your day-to-day teaching? Can you integrate it well? If so, how?
- Do you see some stages more relevant than others?
- Do you think you and/or your colleagues can apply it to other subjects as well?
- Does the model fit within your curriculum?
- Where do you see the benefit of the pedagogical model?
- Is there anything you could think of that would support you by implementing the model?

B) Questions to UUI:

Important comment: I would not do a classical ‚usabilty' testing, since this everybody can do, rather using the teacher to ask him for useful functionalities of the UUI:

- Does the UUI provide sufficient functionalities?
  - Which ones do you find most useful? Which ones can be neglected?
  - Are there some more functionalities that you would like to see included? If so which ones?

- Does the UUI provide sufficient guidance towards a curated set of tools?

- Is the data analysis helpful for you? If so, why/why not?

- Does the UUI help you in your teaching?
  - If yes, how?
  - If no, why not? What needs to be changed?

- Does the UUI has an added value for you? Which one?

- Do you have any further ideas that would improve the UUI and support you in your teaching?

eCraft2Learn

Digital Fabrication and Maker Movement in Education

Making Computer – supported Artefacts from Scratch

Deliverable D3.2

Description of Use cases (M5)

This project has received funding from the European Union's Horizon 2020 Research and Innovation Programme under Grant Agreement No 731345.

PROJECT DESCRIPTION

Acronym:	**eCraft2Learn**
Title:	Digital Fabrication and Maker Movement in Education: Making Computer-supported Artefacts from Scratch
Coordinator:	University of Eastern Finland
Reference:	731345
Type:	RIA
Program:	HORIZON 2020
Theme:	Technologies for Learning and Skills
Start:	01. January 2017
Duration:	24 months
Website:	http://www.project.ecraft2learn.eu/
E-Mail:	office@ecraft2learn.eu

Consortium: **University of Eastern Finland**, Finland, (UEF), Coordinator
Edumotiva, Greece (EDUMOTIVA)
Mälardalen University of Sweden, Sweden (MDH)
Zentrum für Soziale Innovation, Austria, (ZSI)
The University of Oxford, United Kingdom, (UOXF)
Synyo GmbH, Austria, (SYNYO)
University of Dundee, Scotland, (UNIVDUN)
University of Padua, Italy, (UNIPD)
Technopolis City of Athens, Greece (TECHNOPOLIS)
Evothings, Sweden (EVOTHINGS)
Arduino, Sweden (ARD)
Ultimaker, United Kingdom (ULTIMAKER)

DELIVERABLE DESCRIPTION

Number:	**D3.2**
Title:	**Description of use cases**
Lead beneficiary:	**ZSI**
Work package:	3
Dissemination level:	Public (PU)
Type	Report (R)
Due date:	31.05.2017
Submission date:	31.05.2017
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Version Control

Version	Date	Person in charge (Organization)	Changes	Quality Assurance
1	8 March 2017	ZSI, Hofer, Voigt	first draft	Organisation
2	28 April	UEF, Montero	Input use case Finland	
3	5 May	Voigt	Revision	
4	8 May	Loukatos (Edumotiva), Manika (TCA)	Final use cases inclusion	
5	22 May	ZSI, Hofer, Voigt	First version for review	
6	31 May	UNIPD, Emanuele Menegatti	Final revision, minor comments	

Acknowledgement: This project has received funding from the European Union's Horizon 2020 Research and Innovation Action under Grant Agreement No 731345.	

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EXECUTIVE SUMMARY

This report is the first one of a series of reports establishing different use cases. Thus, this report is divided into a first section that outlines the methodology on how different use cases are established and a second part that describes some first initial use cases. All use cases will go through a consolidation process. Further use cases will emerge during the lifetime of the project and existing use cases will be amplified by different methods.

1. INTRODUCTION

Deliverable 3.2 provides a first conceptual, methodological and practical framework for the eCraft2Learn project use cases. This first deliverable is based on initial desk research and work by WP3, WP4 and WP2. Thus, the first part brings the use cases in the context of these workpackages and outlines the methodologies for establishing use cases for eCraft2Learn technologies and processes.

Whereas deliverable D3.1 builds the pedagogical backbone, this deliverable puts its focus on possible application scenarios, integrating feedback from potential users. This document presents also the first version of the delineation of scenarios and use cases and will serve as a living document to be refined in an iterative way along the project from April 2017 (M4) till March 2018 (M15). The first co-created use cases describe use cases established via desk research and the expert knowledge of project partners, who provided initial insights into the usage of eCraft2Learn and possible outcomes.

Thus, the structure of this document reflects these two vital points - methodology and use cases - by outlining first the aims and objectives (section 2), the framework (section 3), followed by the methodology for creating the use cases (section 4), context screening (section 5) and the first three seeding use cases (section 6). Chapter 6 gives also an outlook for the next possible use cases to be delivered in month 10. Chapter 7 summarizes the findings.

The eCratf2Learn craft- and project-based learning methodology

The eCratf2Learn craft- and project-based learning methodology consists of five stages (Figure 1) aimed at learning through projects and producing a computer-supported artefact. Inquiry-based learning usually starts with students posing questions, problems or scenarios, and the process is supervised by a 'coach' (teacher acting as a coach). In inquiry learning approach, students identify study issues and formulate questions in order to develop their knowledge or solutions. This process is usually intrinsically argumentative whereby the students create questions and obtain supporting evidence to answer these questions. Project-based learning is based on the inquiry-based learning approach, but instead of building the arguments the students work around projects, which guide students' activities. We add the design thinking method as a hands-on counterpart in order to enhance maker activities and promote a producer view with the students. The five stages which are integrating project-based and design thinking methods are the following: 1) **ideation** through exploring the world outside the classroom, virtually or concretely and defining the problem, 2) **planning** and collecting the information for making the project plan, 3) **creation** of a computer-supported artefact using do-it-yourself technologies, 4) **programming** through using high-level programming language and 5) **sharing** and presenting what has been created and getting feedback from the professionals of the field.

The eCraft2Learn ecosystem deploys a craft- and project-based methodology. Via the web-based eCraft2Learn working platform, learners, teachers (coach, facilitator) and experts, are enabled to work collaboratively, open, playful and non-judgmental environment that supports learners' creativity. Learners are encouraged to walk around and collaborate freely with other students and to share ideas and solutions with peers and teachers.

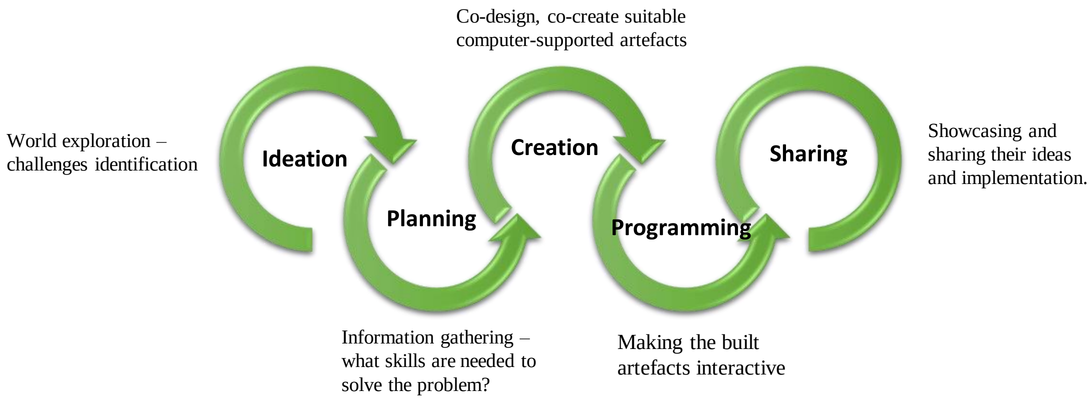

Figure 1: Five stages of craft- and project-based learning methodology

2. AIMS AND OBJECTIVES

With the rise of the maker movement (Anderson 2004), a new way of constructing interactive, digitally enhanced devices by young students, emphasizes learning by constructing not only mental models, but also personally meaningful artefacts. The new digital fabrication technologies, that are accessible to many, have gained importance for education and are entering into schools and spare time activities (Katterfeldt 2015).

In this environment which mixes the new maker movement, open innovation, pedagogy and technology, the gist of the idea behind the use cases is that they help to focus on the intended user of the eCraft2Learn services, rather than on the technical challenges of how to develop those tools and services. Thus, the likelihood that we develop tools and services that are actually useful for and usable by the target user increases.

Thus aim of this set of deliverables (two further versions in month 5 and 10) is also to reflect on the diversity of the end-users, captured in a combination of use cases, user stories and design claims, including – in the second and third version - the description of personas[1]. It puts its focus on possible application scenarios and integrating feedback from stakeholders.

As outlined in the DoA of eCraft2Learn, the use cases will be developed particularly for providing also insights into:

(1) Preparation, planning and logistics of - formal and informal - learning units,

(2) Orchestration of subsequent learning events and

(3) Impact (like empowerment of learners), especially in formal settings.

Thus, this deliverable takes the stakeholders of the project a step forward to outline on a more practical level the implications, needs and organizational necessities on the maker movement, the pedagogical perspective (ie. What learning model will be chosen? or How do we operationalize the open learning or the making?) as well as technical perspective (ie. Which tools shall we include in

[1] All concepts will be introduced with more detail in chapter 4.

the portal? How do we need to design the technical solutions in order to be user friendly?).

Guiding principle for the development is a participatory approach that will include teachers, learners, researchers as well as programmers. Participatory design aims to tightly align technical development with the needs of learners and teachers. This process starts with understanding the learning situations of the pilots as a whole and related implications for technology design in general (e.g. use conditions, appropriate terminology, required support and embedded guidance), creating some first use cases - D3.2 in month 5. It also forms the basis for discussion of the local development teams that will be established. The frequent exchange between end-users and developers, as well as the qualitative (interviews) and quantitative (questionnaire) data will further elaborate the use cases - D3.2. in month 10. Focus of D3.2/month 15 will be the usage of design instruments such as self-drawn mock-ups, photo diaries to capture learning processes and workshops to create a shared understanding of the needs.

It thus does not attempt to examine the detailed workings of individual cases, but instead to draw out from these the main elements which can be used to better understand the impacts they are having on the technical development and the pilots.

3. Design Framework: Conceptual models, practice and open innovation

3.1. Pedagogical Design and First Conceptualisations

The objective of this chapter is to firmly link the use case descriptions provided in this deliverable to the e-Craft learning methodology provided in deliverable 3.1. In a sense we can say that the pedagogical framework in D3.1 is domain-specific (theoretical approach) and here we approach the task-specific level (integrative approach).

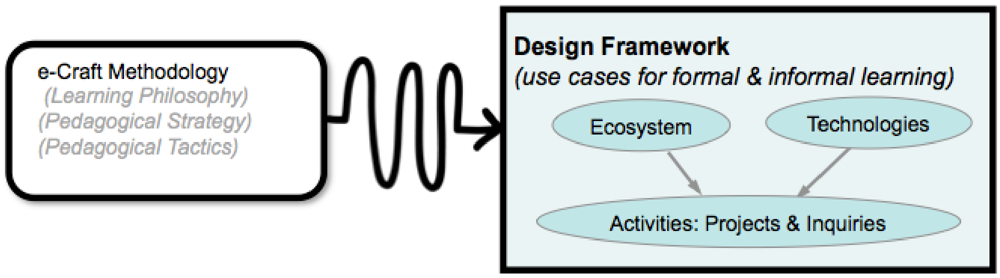

Figure 2: Methodology informs design framework

The figure above is based on Goodyear's (1999) generic overview of the relationship between pedagogy, the environment where learning is happening (i.e. the ecosystem) and technology. Goodyear argues that theory and implementations are closely intertwined, and that implementing a methodology or pedagogy is seldom a straightforward process. Rather it takes some reflection in order to figure out how to implement the principles of a methodology under the (often restraining) conditions of a particular school or maker space where the learning should be facilitated. This reflection is also represented by the iterative approach this deliverable is following as we start with candidate use cases which are then fine-tuned and tested under various conditions (small groups and workshops, classrooms or larger events in maker spaces).

The above figure introduces two new concepts (beside the terms used in D3.1) which will be briefly conceptualised, so that their scope and implications for future development work becomes clear.

Ecosystem: Higher education goes beyond the acquisition of knowledge and is to "inspire and enable individuals to develop their capabilities to the highest potential levels throughout life, so that they grow intellectually, are well equipped for work, can contribute effectively to society and achieve personal fulfilment" (Ramsden, 1998). Taking on an ecosystem's perspective implies a look at the bigger picture of learning as a whole-person activity (Motschnig-Pitrik, Kabicher, Figl, & Santos, 2007). Elements of educational ecosystems include (Dillenbourg, 2008):

- Funding for learning materials and needed IT infrastructures;
- Redefining learning objectives in light of new competencies gaining importance (creativity, communication, (autonomous) problem solving, entrepreneurial spirit, ect.)
- Training for teachers;
- Remodelling the role of teachers;
- Redesigning (physical) learning spaces;
- Integrating physical learning materials (e.g. electronics or 3D-printed ones) with their software counterparts (e.g. simulations);
- Orchestrating the flow of learning (e.g. the interaction between explanation, practice, exploration etc - or the five steps model suggested in D3.1).

The list above doesn't claim to be comprehensive or complete in any sense. However, it should be clear that successful use cases need to consider (and discuss) more than the functionality of a tool and its intuitiveness when being used or installed. In most cases, eCraft2Learn technologies will enter existing ecosystems - with the exception of learning spaces created during the time of the project - here the ability to integrate our technologies with existing plans and objectives of teachers and learners may be as important for the successful adoption of technologies as the bells and whistles of the technology itself.

Technologies: Research concerning the influence of technologies such as radio, TV or computers abound and have a long history (Russell, 1999) and since traditional technologies persist (email, discussion forums, wikis), 'newer' technologies such as Raspberry Pies, Arduinos or 3D-printers need to find their niches or offer a strong value proposition without presenting too much of a burden in terms of purchasing, learning and maintaining the technology. Nonetheless, one lesson learned persists, since a plethora of factors influence learning, strong determinism needs to be abandoned and studies should emphasise the effects ‘with’ rather than ‘of’ technologies (Jonassen, Carr, & Yueh, 1998). A comprehensive description of available technologies can be found in Deliverable 4.1, hence in this section we limited the discussion to the meaning of technology for designing use cases. In fact, we can expect an increase in complexity as more and more technologies enter the classroom. This trend is partially addressed by the project's development of a unified user interface.

Learning activities: Learning can happen in innumerable ways. A frequent way to distinguish types of learning activities are content-specific learning activities on one side and engaging, learner-centred activities on the other side (Boud, 2006). The two types of activities are not mutually exclusive, however, they imply different approaches to teaching and guiding learners. Whereas the former favours an upfront design of processes, the latter requires a design that allows for variations of activities to emerge. Characteristic of the discussion around learning activities is the notion of 'ideal learning'. For example, scripts are frequently used to elicit certain actions that are conducive to successful learning (O’Donnell, 1999). Put differently, scripts are meant to increase the occurrence of pedagogically desirable activities and to decrease the amount of ‘unproductive’ interactions (ibid). Hence learning designs include specifications of an ideal process, prescribing what should be done, in what order and by whom, using what resources (Kobbe et al., 2007). However, whereas such a structured process is still viable for ***non-formal learning*** (learning that takes place through a structured program of instruction, but does not lead to the attainment of a formal qualification or award), it's less suitable for ***informal learning*** (learning not intentionally accessed by the learner, and thus is neither structured nor institutionalised) (Clayton & Smith, 2009).

We challenge the question on what elements do we need to find answers to in order to build valid and vivid scenarios to be used as a first initial idea generation for the target groups. Based on the elements from the ecosystem as well as the input of WP 2 and WP 3, we divided the questions in three pillars, namely the stakeholders, the environment as well as topics. The questions serve the purpose to give guidance to the different methodologies, although not all questions need to be addressed in all methodologies, due to the different settings of the methodologies (ie. P2/Q2 - support for students will be provided by Technopolis experts, thus this question is obsolete for the questionnaire of Technopolis).

3.2. Design Questions

Digital technology is radically changing the way people live and work. As a consequence, it is introducing the need for changes in the landscape of education and training. The goal to create an ecosystem that will allow users to build computer-supported artefacts in both formal and informal learning contexts requires the close view to today’s environment of learners. Today we understand that learning takes place outside as well as inside of classrooms. Technology enables us to learn on demand. Connecting virtually to, collaborating with, and learning from other individuals in real-time, independently from location is todays learning practice. Huge repositories of data, that can easily be filtered to exactly find the information needed, changed todays learning.

Although limited in terms of today's needed ecosystem, much research that has been done in the last decade of integrating ICT. The lessons learned from this research can serve as a starting point to formulate questions that could provide an orientation to create use cases. A key school factors that can be connected to school improvement approaches are the degree of ICT training (e.g. Galanouli, Murphy, & Gardner, 2004), ICT-related support (e.g. Lai & Pratt, 2004), and cooperation between-schools (e.g. Triggs & John, 2004). Baylor and Ritchie (2002) conclude that ICT training has an important influence on how well ICT is embraced in the classroom. This implies for the research design of D3.2 to include questions on the stakeholders' pre-knowledge, their abilities as well as their networks where they can find support or even training (other stakeholders). While ICT training is clearly useful, continuous support is an issue that concerns many teachers and facilitators to a larger extent. William et al. (2000) argue that mechanisms need to be put in place to ensure that teachers have adequate access to support, also in the organisational level. Dexter, Anderson, and Becker (1999) conclude that successful implementation depends upon goals shared by different actors and at different organisational levels. Setting clear goals and defining the means to realise these goals, is a crucial step towards actual integration (Bryderup & Kowalski, 2002). In addition, Kennewell et al. (2000) confirms that a good ICT plan should also comprise an assessment and evaluation approach. This fosters an iterative approach in planning and monitoring the integration.

Many studies have confirmed the barriers to the integration of technology in education and in particular in science education (e. g. Blanskat et al 2006; Gomes, 2005; Osborne & Hennessy, 2003) which lead to the conclusion that neglecting factors like individual preferences, pre-knowledge, planning of the activity and an adequate pedagogy can be pitfalls for integrating digital use in learning environments.

Considering all this experiences and items from the last decades of integrating technology in schools, as well as the learning environment (Fraser 2012, Bader 2000, Kremer 2005, Kremer and Sloane 2001) and ecosystems, we formulated guiding questions and structured them into four pillars.

3.2.1. Pillar one: Designing for Diverse User(s)

P1/Q1: Who are the users/stakeholders?

P1/Q2: What are the preferences of these users/stakeholders in technology, pedagogy and general interest?

P1/Q3: What (pre-)knowledge do the learners and the facilitator(s) or teacher(s) have? (i.e. coding skills, problem-solving skills, project working skills, collaborative skills, communication skills, presentation skills)

P1/Q4: What are their interests and hobbies they have?

P1/Q5: What is their aim/goal?

P1/Q6: What is their (youth) culture they are embedded (norms, values, practices)?

P1/Q7: How do they define their role(s)?

3.2.2. Pillar two: Designing Supportive Environments

P2/Q1: How long shall/can the activity take?

P2/Q2: Who can give support to the learners/teachers? (Other persons or organisations including e.g. trainings)

P2/Q3: How can 'traditional' pedagogy embed Maker movement and Open innovation?

P2/Q4: How does the environment in and outside school look like?

P2/Q5: What are the technical requirements?

P2/Q6: What are organizational requirements (ie. curriculum adaptation, whom to inform, …)

P2/Q7: How can we stimulate the production and sharing of knowledge?

P2/Q8: What material is available/ need to be organized?

P2/Q9: What are the organizational and technical limitations in schools (ie. is it allowed to install software on school PC's, is it necessary to be compatible with already used software)?

P2/Q10: Are there compatibility issues at school? If yes, which ones?

P2/Q11: Is project based learning possible or does it require integration in the curriculum?

P2/Q12: Are mobile applications appreciated and useful for the user group?

3.2.3. Pillar three: Designing Pedagogical Guidance

P3/Q1: What are the topics/projects that users would like to perform?

P3/Q2: Are these topics embedded in projects or curriculum? If yes, how?

P3/Q3: What are the learning objectives by students/teachers?

P3/Q4: Are there any other topics or subjects evolving out of the original activity?

P3/Q5: Has the user developed variation(s) of his/her original plan?

P3/Q6: Is the activity itself and/or its outcome shared with anybody?

3.2.4. Pillar four: Designing Formative Evaluation

P4/Q1: How would you measure if an activity was successful?

P4/Q2: How would measure if the activity has failed?

P4/Q3: In what ways would you measure if students have reached their learning goal?

P4/Q4: Where do you see barriers or facilitators to .... <insert objective> ?

P4/Q5: How can the user's creativity be evaluated?

P4/Q6: How can the user's participation be evaluated?

These questions will be used to facilitate the construction of the use cases.

4. METHODOLOGY FOR DEVELOPING USE CASES

A challenge that we faced in writing the first user cases (month 4 and 5) was presented by the fact that the eCraft2Learn project is in many ways still at an early phase. Creating vivid use cases requires the participation and engagement of actual users, and much of this work is scheduled to take place in the months to come. A major component of the eCraft2Learn project concerns engaging end users. It is in the course of this time that we will be receiving a great deal more input and feedback from the stakeholders, much of which will result in revision or fine-tuning of current user cases and additions of new ones, stories which at this time we cannot yet anticipate. The first three use cases that are presented in this deliverable (section 6.1 - 6.3) are based on the experiences of several partners of the consortium and research evidence and feedback from facilitators. The use cases presented in this deliverable are intended, therefore, as base material for the subsequent project stages in which it will be further developed via engagement with end user and in close relationship to the agile development of tools that meet real-world needs of the stakeholders.

Following the description of possible methods to ensure the sound generation and development of use cases:

- case research;
- use cases, user stories and design claims;
- stakeholder interactions;
- personas.

4.1. CASE RESEARCH METHOD

Many well-known case study researchers such as Robert E. Stake (1995), Helen Simons (1980), and Robert K. Yin (1984) have written about case study research and suggested techniques for organizing and conducting the research successfully. Their work has been used to organize the first use cases that draw upon six proposed steps that should be used:

a) Determine and define the research questions
b) Select the sources and determine data gathering and analysis techniques
c) Prepare to collect the data
d) Collect data in the field
e) Evaluate and analyze the data
f) Prepare the report

In the process of developing the use cases/user stories and design claims, we will apply this structure also to the personas.

4.2. USE CASES, USER STORIES AND DESIGN CLAIMS

4.2.1. CASE SELECTION PROCESS

The conceptual framework of the methodology proposes a number of dimensions as deductive tools derived from three pillars: desk research and expert knowledge, qualitative and quantitative research and participatory design methods. Consequently, the production of use cases are guided in subsequent eCraft2Learn WPs in order to ensure that a range of different types are examined within the scope of the project and based on evidence from the literature, rather than this being an ad hoc random sampling decision. Random sampling would not be possible as we do not know what is the whole spectrum of all use cases, so cannot be sure we can sample across all possible occurrences.

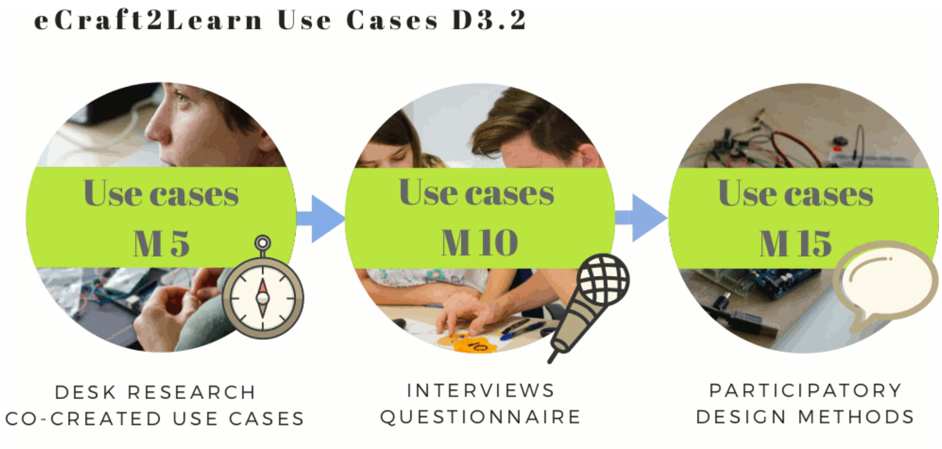

Figure 3: Stages of Use case reports

	Use case M5	Use case M5	Use case M5
Methodology Used	• Context screening / participatory research • Desk research	• Participatory workshop • Virtual exchange platform – participatory design • Interviews • Questionnaire	• Virtual exchange platform – participatory design • Participatory workshops

Table 1: Methodologies used in three phases

As outlined, the use cases will be established and evolved by a triple helix of methods, using interviews (qualitative), questionnaire (quantitative) and (co-creation) workshops (qualitative) data sets and subsequent participatory methods involving users.

4.2.2. USE CASE

Use cases excels at bringing us to an understanding of a complex issue or object and can extend experience or add strength to what is already known through previous research.

Use cases or scenarios describe what the user wants to do, what kind of goal she tries to accomplish (goal or task based scenario). Further information on the single steps he/she may be taking to fulfil a task is optional. In the context of software development, a user story consists of a sentence in the everyday language of the end user that captures what that user does or needs to do. It is the short, simple description of a feature told from the perspective of the person who desires the new capability. With this description, a development team can identify the user, an action and a request and it thereby serves as the basis for defining the functions which a software system must provide, and it facilitates requirements management.

Formal introduced by Ivar Jacobson (Addison-Wesley, 1992), use case analysis is an important and valuable requirement analysis technique that has been widely used in modern software engineering since its formal introduction by Ivar Jacobson in 1992. More recently, the concept has been developed further into a more general technique for requirements analysis and user interface design. Our use cases are aiming to identify, clarify, and organize requirements that a facilitator or learner is confronted with when interacting between a system in a particular environment and related to a particular goal.

In order to understand what is there to be varied in a use case, we need to describe the structure of a use case. One format described in Carroll (1996) includes

- Users' motivations
- Derived goals
- Design adopted (based on a design claim)
- Resulting experiences

4.2.3. USER STORIES

A user story captures the 'who', 'what' and 'why' of a requirement in a simple, concise way, often limited in detail by what can be hand-written on a small paper notecard. It is usually necessary to give the user stories more body in the form of extra details or requirements that do not fit into the very concise format of the user story.

The quality of a user story can be determined by its adherence to the following criteria: independent, negotiable, valuable, estimable, small and testable. These criteria for a good user story were first formulated and given the acronym “INVEST” in 2003 by Bill Wake.

In his article Bill Wake describes the requirements that each criterion represents as follows:

- **I**ndependent: the user story should be self-contained, in a way that there is no inherent dependency on another user story.

- **N**egotiable: User stories, up until they are part of an iteration, can always be changed and rewritten.
- **V**aluable: A user story must deliver value to the end user.
- **E**stimate-able: You must always be able to estimate the size of a user story, i.e. what it will take to build the user story.
- **S**mall: User stories should not be so big as to become impossible to plan/task/prioritize with a certain level of certainty.
- **T**estable: The user story or its related description must provide the necessary information to make test development possible.

4.2.4. Design claims

Design claims will have an essential input for the technical development of the eCraft2Learn system.

To describe a design claim, Carroll (1994) suggests the following format: *"IN <situation> <a feature> CAUSES <desirable psychological consequence> BUT MAY ALSO CAUSE <undesirable psychological consequence>"*. Stressing the inherently psychological nature of a design claim refers to the explanation component within the claim, as it is not the 'intention of the designer' that may cause the consequences, but underlying psychological probabilities. Hence design rationales are a means to go beyond the 'empirical testing and iterative design approach' most development projects are currently relying on.

4.3. Timeline for creating use cases

<u>Period 1 (M1 - M5):</u>

The first use cases were established by a first context screening (chapter 5) by the consortium experts. In close collaboration with the partners, the first three use cases were developed (pl. see chapter 6). This development of the use cases has been guided by different discussions and activities around technical solutions for the pedagogical model (D3.1).

In preparation for the second period, a questionnaire was developed by Technopolis City of Athens to allow a broader insight into a broader than single interviews would allow.

The questions were selected in accordance to the three pillars, precisely collect data from the users themselves (pre-knowledge) and their interests (regular visitors), their preferred topics (content) as well as preferences towards the length of the activity (environment), which is - for the non-formal education of special interest.

The questionnaire was also designed to be very short thus the need to cover all topics with very selective questions was seen as a precondition for the distribution (pl. see Annex 1). A pre-test ensured the correctness and understandability of the questions (Given 2008, Kaplan 2004, Rasch 2006).

During the period from April - August 2017, parents that visit Technopolis with their children will fill in the questionnaire. In addition, the questionnaire will be distributed during the Athens Science Festival (28 March 2017), which will also increase the number of completed questionnaires.

Obviously, the expected results relate to the targeted user groups (teachers, students and parents in Greece) and have restrictions when extending them to the entire population. Still, the findings will give indications and preferences that could serve well for further understanding of needs to address in the eCraft2Learn ecosystem.

The results will be thoroughly analysed in August and – together with the outcome of the interviews – presented to the consortium members. This quantitative information that will be gained will contribute to a firm basis for the next advanced use cases.

PERIOD 2 (M6 - M10):

Based on the initial questions of the three pillars, up to 5 interviews will be conducted during May and September 2017. These interviews will form the basis for further use cases as well as for some personas that will set an increased focus on the users and their needs, preferences and environment. Personas are a powerful tool for communicating the needs of different types of users and for prioritizing which users are the most important to target in the design of form and behaviour of a tool.

As a first step a selection of the most relevant questions will be done and (if appropriate) re-formulated, since not all of the questions from the pillar fit for (all) the interviewees. This will result in a semi-structured interview guideline that will be used by the partners to translate and perform the interviews with their selected interviewees (Flick, 2006 and Flick, Kardoff, & Steinke, 2005, Helfferich 2005).

After translation of the answers, ZSI will analyse the interviews and present the consortium the gained insights (proposed for the 2nd consortium meeting). As for now it is expected, that this analysis will be of high relevance for several WP's such as WP 2, WP 3 and WP 4 since these three workpackages give major direction to the concept of the eCraft2Learn system.

In addition, it will allow advancing the first three primal use cases. These advanced use cases will reflect increasingly the real-life scenarios for the eCraft2Learn system.

PERIOD 3 (M11 - M15):

As by the progress of the project it is expected that an increased number of learners and facilitators will share experiences and collaborate, supporting the development of the eCraft2Learn environment. Thus, the third phase will draw its use cases from materials of end-users that are engaged in the participatory design process. We will use design instruments like self-drawn mock-ups or photo diaries and will offer workshops and meetings as well as virtual tools for exchange and communication among users, technicians and educational scientists. This will support the technical development to increasingly adapt the eCraft2Learn environment to the specific learning experiences made.

4.4. DEVELOPER AND LEARNER INTERACTIONS: PARTICIPATORY DESIGN

Participatory design aims to tightly align technical development with the needs of learners and teachers. This process starts with a thorough analysis of learning situations as a whole and related implications for technology design in general, e.g. use conditions, appropriate terminology, required support and embedded guidance. As such, participatory design has two main components:

- the work of local development teams. The local development teams should include the expertise of teachers, learners, researchers as well as programmers.
- the updating of the projects consortium about milestones reached

According to the DoA, members of local development teams will be in close contact on a bi-weekly basis, however in practice development work will most likely be driven by development milestones so that local development teams are likely to need short but more frequent interactions. The same applies to the updating of the project consortium as a whole. Most discussions on technological directions are conducted with everyone in CC, in addition at certain points the state of development is captured in a summary page (Google Drive). Since partners are members of several workpages, not filtering communication too much at this early stage of the project seemed the most appropriate way.

However, at some point following up the different development streams around the most diverse technologies, crawling through emails becomes cumbersome. Hence in May 2017 we introduced Slack[2] , which is a platform developed to support the work of teams with easily to adapt structuring and notification mechanisms. It is still too early to judge whether this attempt will be successful or not. A huge benefit coming with Slack (see Figure below) is the preservation and transparency of past development decisions, which enables going back and referencing or changing past arguments.

[2] https://get.slack.help/hc/en-us

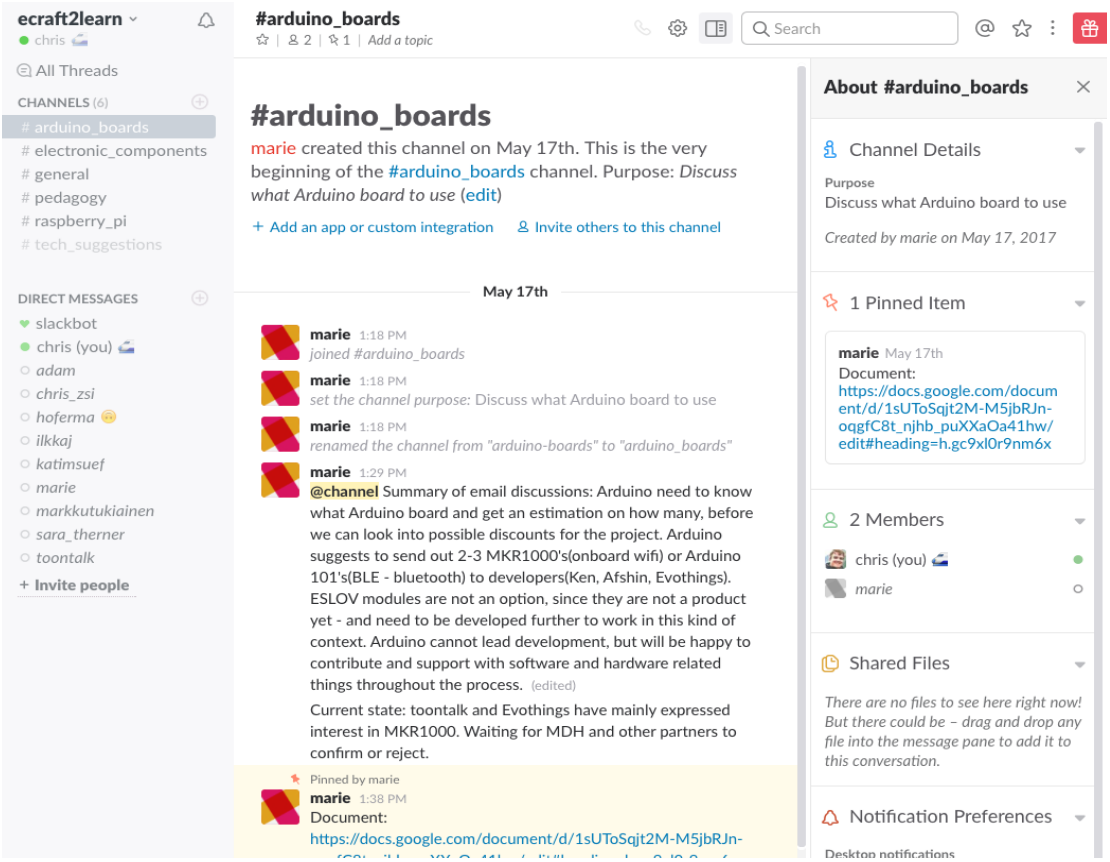

Figure 4: Screenshot of ecraft2learn.slack.com

4.5. PERSONAS

We will develop the personas for this project around the basic facts of their person – such as gender, age and profession - the relevant behaviours they exhibit in their daily life and the needs they have in order to pursue certain goals related to the topics of the eCraft2Learn project.

Personas help to:

- Determine what a tool should do and how it should behave. Persona goals and needs provide the foundation for the design effort.
- Communicate with stakeholders and developers. Personas provide a common language for discussing design decisions and also help keep the design centred on the user at all times.
- Build consensus and commitment to the design. Because personas resemble real people they are easy to relate to. Having personas makes it easier to be certain that everyone is on the same page and is using the same language.
- Measure the design's effectiveness. Design choices can be tested on a persona, providing a powerful reality-check for designers trying to solve design problems. This allows design iteration to occur rapidly and inexpensively at the whiteboard. This results in a stronger overall design that can then be tested with real people.

An added positive effect of personas is that for everyone involved in designing and developing the tools it is easier to be interested in and committed to the solution when one has the feeling of creating something of benefit for an actual human being. Personas are user models that are represented as specific individuals. They are not real people but are based on observations of real people. They should be based on facts that have been well researched with regard to the potential users of a product. Despite their depiction as specific individuals, personas are archetypes, representing a certain type of user. They are, however, not stereotypes: personas should be typical and believable, but must not represent biases and assumptions that are not substantiated by factual data (Cooper, A., Reimann, R. and Cronin, D., 2007).

In this context personas bring issues of social and political consciousness to the forefront. In developing personas particular demographic characteristics must be chosen with care.

One of the most critical tasks in the modelling of personas is identifying user goals and expressing them succinctly. User goals serve as a lens through which designers must consider the functions of an innovation, tool or product. All humans have motivations that drive their behaviours; some are obvious, and many are subtle. It is critical that personas capture these motivations in the form of goals. The goals of the personas are shorthand notations for motivations that not only point at specific usage patterns but also provide a reason why those behaviours exist.

5. CONTEXT SCREENING

The purpose of the workshop session held during the kick-off meeting was to identify and problematize the current situation of learning within schools and organizations in order to provide insights on how to best implement the eCraft2Learn system. The first understanding of the use cases allowed for cross-fertilization and idea generation through shared knowledge and experiences of the consortium experts.

The strength of the approach consists in its ability to bring together different actors, their knowledge, and expertise and apply it to solve complex problems, or as in the case of eCraft2Learn, design use case scenarios. The participatory approach aims to tightly align the (technical) development with the needs of learners and teachers. As defined by Galvagno and Dalli (2004) co-creation is “ … the joint, collaborative, concurrent, peer-like process of producing new value, both materially and symbolically.”

This process started during the co-creation workshop of learning situations/use cases as a whole and related implications for pedagogy, technology, the ecosystem, design in general (e.g. use conditions, appropriate terminology, required support and embedded guidance) and organisation of eCraft2Learn applications. The workshop created a first common understanding on how eCraft2Learn will be used by the end-users.

Based on the four pillars of design questions, three expert teams from pedagogy, technology, the maker movement and the school engagement (three teams, each team 4-5 people), were given the task to design a use case scenario. In line with planned the small scale pilot of WP 5, three locational settings were determined in prior: one use case at a Greek school, one in a Finnish school and one non-formal educational setting in Greece.

The concrete task was to choose one of the settings and discuss and exchange following items:

- Describe the environment and the “project”.
- Who are the stakeholders?
- What are their needs?
- Are there any drivers or barriers that would facilitate or hinder the implementation?

This workshop session revealed some first initial conditions for use cases that were developed further by the partners to the below presented use cases.

Initial use case: **Greek formal education**

Age group targeted	Existing situation: age 12+
Pre-knowledge of target group	Children using smart phones, although smart phone forbidden in schools, familiar to use touch screen; drag and drop skills, share photos, a.s.o. better familiar with smart phones than teachers. Greeks learn using computers at 13 and 14, continue till 15: processing spreadsheets, only some specialized schools learn programming (in technical schools).
Issue	Use of the tools is not connected with REAL live scenarios (rather abstract teaching); this is why low interest in some cases.
Other stakeholders	students, teachers, parents, policy makers, educational ministry and government.
Needs	Motivation (connection with real life scenarios), access to tools (more than PC labs), equipment Teachers need training, need continuous support, policy makers (need examples why they should support this), ministry (information to get convinced for change and improvement), government (awareness of multiple opportunities for new learning ecosystems for investments) in human capital (jobs for Greek citizens).
Barriers	Inexperienced not-trained teachers, existing structures (technical facilities, strict rigid curriculum that does not allow innovative teaching), misconceptions like ‚programming is hard / only for boys’ (connected with real life scenarios); time constraints. Permissions from usual curriculum.

Drivers	Flexible curriculum, curiosity, role models of well-known scientists or examples, cool scenarios, awareness of opportunity these skills create new jobs (easier to enter the labour market). Alignment with curriculum goals (but this is difficult); motivation

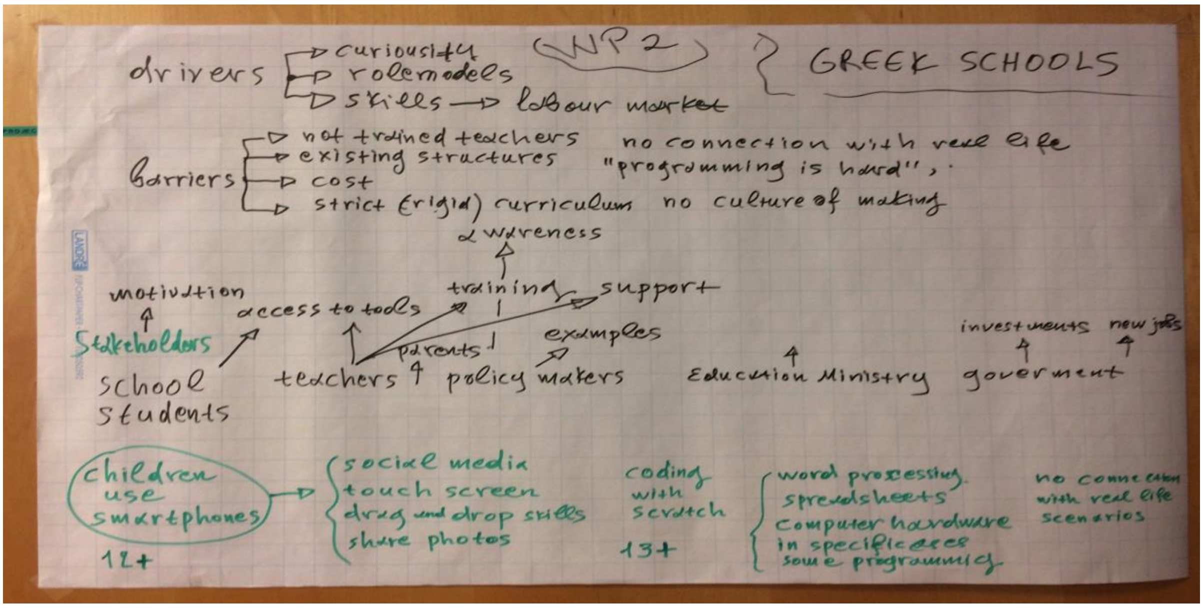

Figure 5: Greek use case school scenario

Initial use case: **Finnish formal education**

Targeted age group	Students 12+
Possible scenarios	Arduino: switching lights on/off, building car controlling it, Barbie robot, Biology 3-D printing
Other stakeholders	Students, teachers, parents (family coding clubs), champions (clubs), maker spaces, experts that one can ask
Needs	Involve teachers in planning, guidelines and recommendations, trained teachers, material (student), motivation (student), technology clubs, female dedicated projects (ie. Lilly pad), facility provision
Drivers and Barriers	Agreement/support from rectors, Convincing teachers, existing infrastructure (software), (money), involvement of family, informal scenarios, motivation, accessibility for special needs students.
Issues	Individually vs. collaboratively (how to give grades), involvement of maker

science fairs

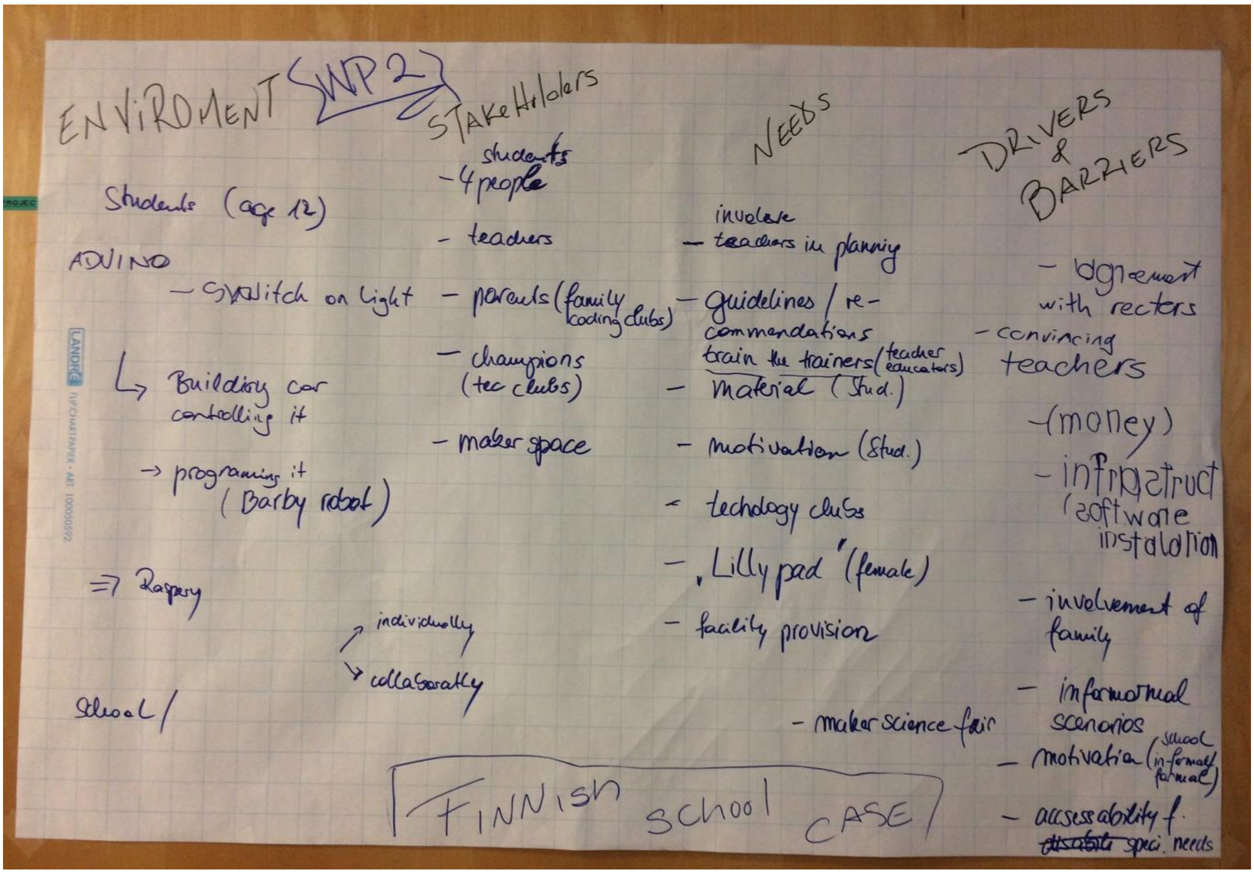

Figure 6: Finnish school use case scenario

Initial use case: **Greek non-formal education**

Learning environment and Pre-condition	Place have to be accessible, has to be inspiring (look), nice people, has to have components to make students motivation (how to motivate kids), Nice attitude, free time (alternative for playground).
Pre-knowledge	Very different levels of knowledge, abilities and interests
User groups	People should consist of educators, mentors and other peers and students, kids, something they can use (for good purpose)- connection to real life.
Issue	Parents (gate keepers), hard to engage typical parents (too technical, too difficult, ...), find another way to communicate (attractive).
Learning goal	What are the real goals of the project? Different way of learning: hands-on, collaboration, sharing, ... what are our priorities? Tools are needed, but not too many tools – being open to new innovative learning approaches

	Presenting something tangible eases the learning
Barriers	Problem: One-size fits all. Different interests, abilities; how do we accommodate that some do want to program, some do want to build, some are more into art.
Needs	Define roles; divide them by age, or by skills (what effects has that on the programming?), We need to narrow it down to make the project feasible. We need to know what it should not do. Creating the vision Transforming the role of teachers – he/she is not the expert!! Help teachers to change the role to facilitator.

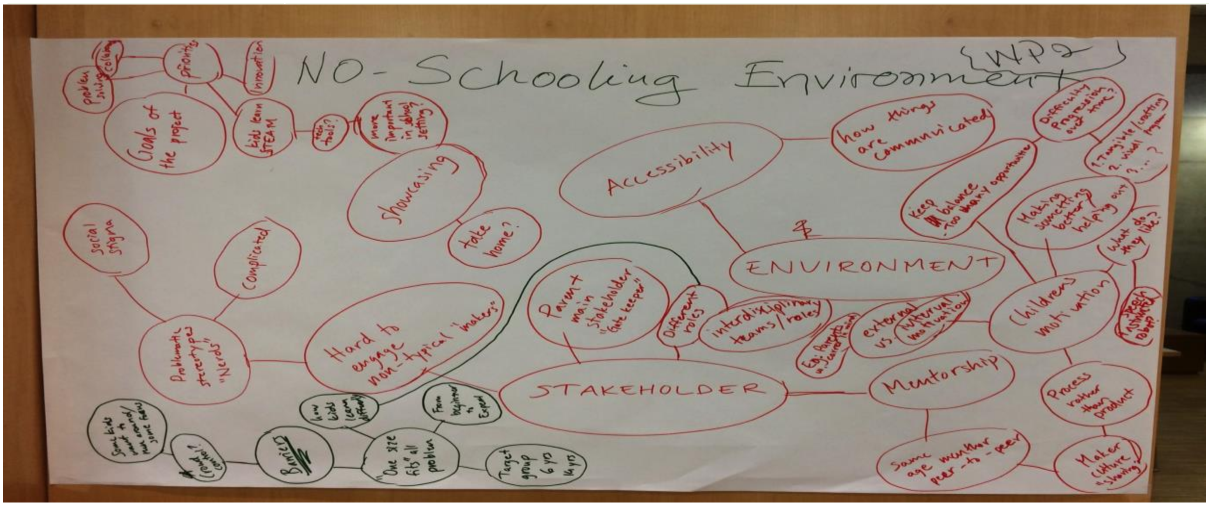

Figure 7 Greek non-formal use case scenario

By time, this initial group will be expanded by the formation of local development teams that will frequently exchange between end-users and developers. Once the pilot schools are selected the local development team will also include teachers, learners, researchers as well as programmers.

6. First use cases

Understanding the possible use, goals, topics and actors of the eCraft2Learn, use cases are an appropriate method to gain this insight. In order to ensure that the aspects that shall be considered (pillars) are addressed, a template has been created that serves the creation of different use cases (pl. see Annex 2). However, the intention of the template is not to restrict the use cases to a specific structure, but rather animate the writers to consider different questions and aspects. Thus, the use cases are written in a vivid and different way and structure, but contain major elements of each of the pillars.

6.1. Formal Education: DNA LESSON (Finnish school)

Name of use case	3D printing in Secondary school science class for Biology/DNA lesson
	USER – P1
*Age and Level	Susan, a Finnish secondary school science teacher, has a class of 20 fifteen-year-olds. Half of her class are female students.
*Primary Actor and main goal	She plans to teach DNA for the next week. She knows how to combine technology-driven hands-on projects with pedagogical concepts as she learned about in her professional development courses. The topic is difficult and the students are not motivated to study biology. However, the use of technology may be attractive especially to the boys, but having students working in groups in order to enhance social interaction might also be attractive to the girls. Moreover, allowing the students to discover the topic by themselves through a technological lens, being active, exploring and trying out, and producing interactive DNA models, the students learn more and become more interested in the topic. Teacher assigns the groups as she normally does in her classroom activities.
	CONTENT – P3

*Topic and Content	For the DNA lesson she decides to use 3D modelling, 3D printing, computer programming, and assembly instructions for electronic components and circuits. Her idea is to let the students build wireframe models of a DNA sequence. During the development of the project the students will be learning and applying knowledge from electronic components (e.g., Arduino) assembly, 3D modelling and printing, programming, collaborative skills and presentation skills. Susan is planning for the development of the project to take 2 weeks (3 times a week sessions 1.5 hours).
	ENVIRONMENT – P2
*Description of Environment and possible pre-conditions	Her school is pretty open for new ideas and projects, and there is a high trust in the teachers that the projects align with the curriculum. Still for security reasons, Susan needs to arrange the installation of the 3D modelling program with the IT coordinator from Happy Lab of the school. The school also has a designated space where the 3D printing machines are, alongside available electronic components such as Arduino, Raspberry Pis, resistors, breadboards, cables, and recycled materials (e.g., cardboard, clothes, pet bottles, etc.) for the students to use.
Preparatory work	Susan knows well the people from Happy Lab, and they set up the 3D printer for her. The people there explain her in detail how the 3D printer works and also how she could solve issues that might appear. She also organizing the necessary materials that the students

	would need for building their 3D model.
Other Stakeholders and their possible Interests	An IT teacher from the Happy Lab at school is happy to support Susan with any queries that she may have in setting up the project. She also offers support when needed during the working sessions.

*Description of Activity	During the first session, the activity starts through **ideation** and **planning**. A group of students, Paul, Kelly, and Julian begin to work on their project on the DNA model. Susan supports the students with the 3D printing of the model's pieces from the wireframe models they made since a number of questions appear. Also, during the **creation** of the model, there are a lot of errors to resolve at the beginning of the process to get the 3D model to print correctly. During the second session, they had to download drivers for the right 3D printer hardware model. However, once in a while, the printing process would fail, and they would have to discard the spoiled material and start the sequence again. User errors would also occur, such as miscalculations of scale between the software model and the printed result.The IT teacher offers assistance with the proper settings of the printer. Kelly and Julian wonder what will happen if they will modify the model shape. Kelly changes the parameter of the X and the group starts to see interesting results they will ask to the teacher Susan. During the third session, the students then assemble their pieces into a physical 3D model. The 3D-printed model give them a much different sense than the 3D computer images, because they could hold the model with their hands, rotate it directly, and combine their own model with other students' models. In the fourth session, Susan asks the students to to give "life" to their 3D models by **programming** in them some functionalities. Susan uses the guidebook included with the STEAM "packet" to explain different ways they could vivify their physical models with Arduinos. Each group selects a project and start to work on it. To design the circuits, students are facilitated by paper template circuits, and examples of codes which are ready to be used and modified easily.

	This activity takes two sessions to complete. For the presentation and **sharing** final session, Paul, Kelly, and Julian took turns explaining why they wanted to animate their physical models using LEDs in a particular way, and teaching their classmates how they did it. They then explain to the class how they programmed the Arduino for their project, e.g. how they solved the tricky part with creating a sequence to highlight repetitive structures, and how they overcome the 3D printing issues. This peer learning process continued with each group presentation. Susan now feels the students would be able to understand more about DNA than before. The following day, she asks each group to present their model to the rest of the class, to discuss what they learned about how molecules form the famous double-helix structure.

	EVALUATION – P4
Extensions	Paul, Kelly, and Julian explain how to highlight the different proteins that connected the DNA strands by assigning different coloured LEDs to each. They show that it was difficult to see that certain protein sequences were repeated. By lighting up the coloured LEDs, everyone could easily see the patterns. Protein sequences become even more evident when the LEDs associated with them flashed at the same time.

Failure and conditions	• Making sure that there is enough support available for all the learners/groups.
	  ◦ Online communities should be introduced as a source of knowledge crawling
	  ◦ The outcome of programming is not what is expected
	  ◦ Sufficient material (technology)
	There is not enough time to complete the project due to the knowledge level of the students.

Success and condition	In just two weeks, Susan was able to foster student interest in DNA, while students learned how to use 3D models and printing, and how to program small circuits, including elementary programing statements such as sequences and loops. The students also gained experience in collaborating with each other, and in using software and hardware technology to realise ideas that began in their own imagination. Susan feels empowered by these tools, which facilitated the transformation of classroom roles and activities, and ultimately helped her achieve a progressive pedagogical approach in her classroom.
Barriers/ Facilitators	• The gender-based preferences – girls are more interested in social interactions • Every learner is making something personally relevant • Students with varied skills. • Using the mixed-gender groups (different interests of males and females) to support the peer learning. • Lack of previous experience of using different technologies. • creativity
Variations	

Table 2: Use case Finish school

6.2. FORMAL EDUCATION: DRUM MACHINE (GREEK SCHOOL)

Name of use case	*Drum Machine*
	USER – P1
***Age and Level**	Nikos, has 10 students, who are around 16 years old.
***Primary Actor and main goal**	He is a substitute teacher in Greece, teaching for twelve years classes and has been asked to teach them about how sounds are produced by the modern music instruments.
	CONTENT – P3
***Topic and Content**	He starts by playing recordings of some instruments and explaining the various technologies that are used to make it. However, he notices that many of the students are getting bored. He asks: "Does anyone know how to make a drum machine?" The students laugh, joking about how they can download one from the app store with their mobile phones. They are expecting to be reprimanded, but they are instead surprised by Nikos' reply: "How about we all learn how to make a drum machine ourselves, without our mobiles?" The students are very intrigued and do not really believe this is possible, but they are willing to give it a chance.
	ENVIRONMENT – P2
***Description of Environment and possible Pre-conditions**	Nikos has brought with him an eCraft2Learn case, with 4 project kits. The kits contain electronic components and simple instructions how use the components and STEAM projects examples.

Preparatory work	Nikos knows well the kit, since he experimented himself with the tool some time ago.
Other Stakeholders and their possible Interests	Nikos asks some help from the computer teacher of the school, especially because he wants his students to have access to the computer lab for Arduino programming and information searching activities. The computer teacher of the school, who has little experience with Arduinos, finds the whole project very interesting and is offered to help by uploading the necessary web content, explaining the steps of this music project, to the school web site.

***Description of Activity**	He asks the students to form groups, and loans each group a kit.The students are interested, but some are worried this task might be too difficult for them, since they do not know about technology like Arduinos. He tells them not to worry, and asks them to take out a sheet of paper. “Your sheet of paper will become the buttons for your drum machine!” They think he must be joking, but they now feel very comfortable working on the project, since instead of a complicated circuit, they are focused on a piece of paper. He asks them to draw lines on the paper, dividing it up into “buttons”, in any arrangement they would like. He then asks them to take out of their project kits a few different coloured wires, and a handful of small sensors. They are instructed to connect each sensor to a different coloured wire, and to connect the free end of the wire to the series of pins on the Arduino board. Finally, he asks them to tape down each wire onto the piece of paper, so that there is one sensor in each square they’ve drawn. He also invites them to connect the small speaker from their kits into the Arduino’s audio output connector.
Failure and conditions	The students are following along, but they seem to be losing interest. Sensing this, Nikos decides to take an intermediary step.

Success and condition	There are also LEDs in the kit, and he asks them to connect the LEDs to wires, and the wires to the other set of pins on the Arduino board. He knows from a previous project that there is software pre-loaded onto the Arduinos that connects the input and output pins. He now invites the students to “play” the squares on the paper, which trigger the lights, and the students are immediately engaged, for a moment. They quickly tire of making lights flash, but they still want to know more about how the Arduino works. And they really want to make the drum machine that was promised to them!
Barriers/ Facilitators	
Extensions	At this point, Nikos tells them to plug the USB connector on their Arduinos into their classroom workstations, which have the Arduino coding environment on them. They load the software from the device onto their screens, and he explains to them what each line of code does, and what makes the LEDs light up. He then shows them how to add new lines of code that trigger a drum sound when the light is triggered. For the remaining time, the students play collaborative rhythms using drum sounds made by their paper and Arduino drum machines. Some of the students even get the idea that they can go back to the software and replace the drum sounds with sounds of their own voices. Now they are enjoying making music together, while having learned about music technology through an exploratory, hands-on approach.

Table 3 Use case Greek school

6.3. Non-formal Education: Robot Building Workshop (Greek School)

Name of use case	***'We-build-Robots'in Athens***
	USER – P1
Age and Level	Technopolis, a non-formal educational institution that fosters educational activities of new Technologies and STEAM. They would like to engage kids into some Robotics activities. Sofoklis, a facilitator from Technopolis likes the idea a lot and sets up a call for a workshop called 'We-build-Robots'. Sofoklis himself is very interested in technology and has built already robots for several years from many different materials. He and his colleagues are trained by an educational institution dedicated to enable people to hold STEAM workshops with kids. For this workshop, 20 students, aged 9-15, subscribed. Robotics is very popular amongst youngsters for the moment in Greece, thus it is not surprising for him that so many students subscribed. He expects that those that subscribed are very familiar with their mobiles including the different apps.
Primary Actor and main goal	From his previous experiences with students he knows that primarily the students are keen to play with "such a cool thing as robots" while their parents are happy to have some creative educational activities during the weekend for their kids.
	CONTENT – P3

Topic and Content	Sofoklis plans, to ask the students to assemble a robot, using lego pieces, blocks, rubbers etc. After that they shall use an Arduino kit, exploring different programs to make it work. The “classroom” is divided in pairs of 2 or 4 kids each, depending on the use of tablets or laptops. Sofoklis has decided that each group is working on the same project rather than each group taking over only a part of the project since he feels that the kids are more motivated if they are doing their own project from start till the very end. Also, all three objectives of familiarizing with crafts, the making and new technologies are tackled by all the students in that way.
	ENVIRONMENT – P2

Description of Environment and possible pre-conditions	The last times Sofoklis has performed the activity, each workshop usually took 6-8 hours divided in 2-hour sessions in subsequent Sundays. However, from the last evaluation Sofoklis received feedback from several parents, that they would prefer to have the kids there for 1, or 2 days so he decides to go for a 2 days workshop, 4 hours per day. The course takes place in a vibrant, colourful open space venue, inside a lab consisting of one large table and some supplementary smaller ones to accommodate the whole group. Usually, the students find the venue exciting due to its particular shape and layout. Sofoklis is not bound to any adaptation to a curriculum but there is a need for each workshop to be aligned with the strategic goals and educational program of Technopolis. Due to the fact that the workshops of Sofoklis is closely connected to STEAM, he is very much in line with the overall set goals. Sofoklis has full support also in terms of raising awareness and participation in his workshop. For once there is a media plan, set up each semester, for the upcoming workshops. Press releases and invitations are sent to schools and to a subset of a large contact database. Also, printed booklets are made available as well as announcements through different (social) media channels.
Preparatory work	For the workshop, Sofoklis needs an Arduino set and uses also Scratch and WeDo 2 for the programming. In case he needs other software, it is easy for him to install since there are no limitations of installation. He checks if the software is pre-installed and if the program runs also on the tablets. Also, Sofoklis buys the materials needed for the workshop.

Description of Activity	Sofoklis starts off at the very first Sunday explaining the 20 students some basic understanding of terms such as “voltage”, “current”, “motor”, and “sensors”. He asked the students to determine what their robot should do. With the given materials, one group decides to build a wheeled robot, that will act as a ‘wheeled butler’ carrying things in a small box. The students should determine the route of the robot towards a specific location by writing commands for moving forward, backward, left or right respectively. Sofoklis is summarizing with the students what materials they would need for their, driving’ dustbin. The students are following a step-by-step printed direction. Although Sofoklis sees that they are sometimes struggling, he lets the students solve their issues themselves. Encouraging them to think creatively requires sometimes quite some patients from him, but he makes them also stop at various points and check together their robot from time to help ensure they have configured things properly before moving on to next steps. Thus, while constructing the students repeatedly try it out in the room. During that process, they realize that their initial programming in Arduino is leading the robot in the wrong directions. They re-program their device again and again until they are satisfied and personalize by adding eyes on it. At the end of the workshop they present their ‘butler’ in front the other students, using it to carry some candy bar paper to the bin.
Other Stakeholders and their possible Interests	
	EVALUATION – P4

Success and condition	At the end of the 2 days' workshop, all the groups were able to finalize their robots. Sofoklis had the impression that students had fun and joy by creating their own robots. Some even asked if they could to do more and come again for creating an even more advanced robot.
Failure and conditions	Only one student was not able to take part in the finalization of his robot since he had to leave earlier at the last day. Unfortunately, his robot never worked and the student left fairly unhappy.
Barriers/ Facilitators	At the end Sofoklis ask the students if they have other ideas for workshops and what they would find interesting. He experienced, that the interest and curiosity of students as well as parents is limited because they are just not used to/ not familiarised with makers and the option they would have. Thus, they don't really know what to wish for. However, after this workshop, he was able to collect many different creative ideas from the students in all kind of areas not only technology, but also including art and other sciences.
Extensions	Sofoklis discusses with the students how the butler robot could reach the target more easily. They suggest to modify the algorithm of the robot in order to intercept remote commands via a Bluetooth interface.

Variations	Students are asked to propose different applications for their robot. So, they suggest to cover it with a shell made of colour paper in order to look like a ladybug. So, its route to the target becomes more amusing. The girls that are following the lessons find this alteration from butler to ladybug very artistic and pleasant.

Table 4: Use case non-formal Greek school

6.4. Basic Building Blocks for Use Cases

At this stage the use cases presented in the three previous sections should not be seen as complete implementation guides (to be covered by D3.4 - Teacher Trainings - and D4.5 - User Manuals -). However, WP4 discusses multiple options for programming environments and hardware components which are then grouped into families of solutions linked with specific steps of the pedagogical model presented in D3.1. These solutions will include:

- on the hardware side: sensors, actuators, computers on a chip, micro controllers and 3d-printers and
- on the software side: 3d-modeling software, access to AI cloud services, web-based or local programming languages.

The above selection is not meant to be exhaustive but helps to illustrate how existing use cases can be specified with the help of these building blocks selected, evaluated and, where necessary, adapted in WP4.

7. Conclusion and Outlook

The present document has been outlined the methodology of the use cases and presented the first three cases. In the next weeks and months after submission of this deliverables, the user cases will be further advanced by interviews, further input from partners and the analysis of the questionnaire. However, it is expected that also additional use cases will follow, depending on the concrete ideas and needs of the users identified and the technologies that will be selected by the technical partners (M10). Further, personas will be deviated from the interviews performed. They will allow increased insights into concrete needs of users and consequently influence also the advancement and adaptation of the eCraft2Learn environment.

The present document has been drafted in parallel with the development of the eCraft2Learn technical platform (D4.1) but has vivid exchange of the initial use cases. This established working procedure will be followed further in the next week. The advanced use cases will be integrated in a highly iterative process of agile development: especially during the third period (M10-M15), where we increasingly seek for interaction with the users and their inputs for further adaptation.

8. References

Anderson, C. (2012). Makers: The New Industrial Revolution, *Random House*, New York.

Bader, R.& Sloane, P. F. E. (Hrsg.) (2000). Lernen in Lernfeldern. Theoretische Analysen und Gestaltungsansätze zum Lernfeldkonzept. *Markt Schwaben*: *Eusl-Verlagsgesellschaft,* 33-50.

Balanskat, A., Blamire, R., & Kefala, S. (2006). A review of studies of ICT impact on schools in Europe: *European Schoolnet*.

Baylor, A. L., & Ritchie, D. (2002). What factors facilitate teacher skill, teacher morale, and perceived student learning in technology-using classrooms? *Computers & Education* 39, 395–414.

Benkler, Y., & Nissenbaum, H. (2006). Commons- based peer production and virtue. *Journal of Political Philosophy*, *14*(4), 394–419.

Rasch, B., Friese, M., Hofmann, W. & Naumann E. (2006). Quantitative Methoden 2. 2. Auflage. *Springer,* Heidelberg, Berlin ISBN 978-3-540-33309-8.

Boud, D. (2006). 'Aren't we all learner-centred now?': the bittersweet flavour of success. In P. Ashwin (Ed.) Changing higher education : the development of learning and teaching. pp. 19–33. London: Routledge.

Bryderup, I. M., & Kowalski, K. (2002). The role of local authorities in the integration of ICT in learning. *Journal of Computer Assisted Learning*, 18, 470–479.

Carroll, J. M. (1994). Making use a design representation. Communications of the ACM, 37(12), 28–36.

Carroll, J. M. (1996). Becoming social: expanding scenario-based approaches in HCI. *Behaviour & Information Technology*, 15(4), 266–275.

Carroll, J. M. (2000). Making use : scenario-based design of human-computer interactions. Cambridge, *Mass.: MIT Press*.

Cooper, A., Reimann, R. &Cronin, D. (2007). About Face – The Essentials of Interaction Design, p. 77.

Cohen, D., & Hill, H. (2001). Learning policy: When state education reform works. New Haven, CT: *Yale University Press*.

Dillenbourg, P. (2008). Integrating technologies into educational ecosystems. Distance Education, 29, 127–140.

Fraser BJ (2012). Classroom learning environments: retrospect, context and prospect. In: Fraser BJ, Tobin KG, McRobbie CJ (eds) Second international handbook of science education. *Springer,* New York, 1191–1239.

Galanouli, D., Murphy, C., & Gardner, J. (2004). Teachers' perceptions of the effectiveness of ICT-competence training. *Computers & Education*, 43, 63–79.

Galvagno, M. and Dalli, D (2004). Theory of value co-creation: a systematic literature review.

Gašević, D., Dawson, S., & Siemens, G. (2015). Let's not forget: Learning analytics are about learning. *TechTrends,* 59(1), 64–71.

Given, L. M. (2008). The Sage encyclopedia of qualitative research methods. Los Angeles, Calif.: *Sage Publications*. ISBN 1-4129-4163-6.

Goodyear, P. (1999). Pedagogical frameworks and action research in open and distance learning. *European Journal of Open and Distance Learning*. Retrieved from http://www.eurodl.org/materials/contrib/1999/goodyear/

Gomes, C. (2005). Integration of ICT in science teaching: A study performed in Azores, Portugal. Recent Research Developments in Learning Technologies.

Flick, U. (2006). Qualitative Sozialforschung. Eine Einführung, Reinbek bei Hamburg.
Flick, U., Kardoff, E. & Steinke, I. (Hg.) (2005). Qualitative Forschung. Ein Handbuch. Reinbek bei Hamburg.

Helfferich C. (2005). Die Qualität qualitativer Daten. Manuel für die Durchführung qualitativer Interviews. Lehrbuch, Wiesbaden.

Jonassen, D. H., Carr, C., & Yueh, H.-P. (1998). Computers as mindtools for engaging learners in critical thinking. *TechTrends,* 43, 24–32.

Kaplan, D. (Hrsg.) (2004). The Sage handbook of quantitative methodology for the social sciences. Thousand Oaks: *Sage*, ISBN 0-7619-2359-4

Katterfeldt, Dittert & Schelhowe. (2015). Designing digital fabrication learning environments for Bildung: Implications from ten years of physical computing workshops.

Kobbe, L., Weinberger, A., Dillenbourg, P., Harrer, A., Hämäläinen, R., Häkkinen, P., & Fischer, F. (2007). Specifying computer-supported collaboration scripts. *International Journal of Computer-Supported Collaborative Learning*, 2, 211–224.

Kennewell, S., Parkinson, J. & Tanner, H. (2000). Developing the ICT capable school. London: *RouteledgeFalmer*.

Kremer, H.-H. & Sloane, P. F. E. (2001). Lernfelder implementieren. Zur Entwicklung und Gestaltung fächer- und lernortübergreifender Lehr-Lernarrangements im Lernfeldkonzept. Paderborn.

Lai, K. W., & Pratt, K. (2004). Information and communication technology (ICT) in secondary schools: The role of the computer coordinator. *British Journal of Educational Technology,* 35, 461–475.

Motschnig-Pitrik, R., Kabicher, S., Figl, K., & Santos, A. M. (2007). Person centered, technology enhanced learning in action: Action research in a course on organizational development. In Kabicher, S. (Ed.) (p. S2A–6–S2A–11). Presented at the Frontiers in education conference - global engineering: knowledge without borders, opportunities without passports, 2007. FIE '07.

Nielsen, L. (2013). Personas. In: Soegaard, M. & Dam, Rikke Friis (eds.). "The Encyclopedia of Human-Computer Interaction, 2nd Ed.". Aarhus, Denmark: The Interaction Design Foundation. Available online at http://www.interaction-design.org/encyclopedia/personas.html

O'Donnell, A. M. (1999). Structuring dyadic interaction through scripted cooperation. In A. M. O'Donnell & A. King (Eds.). Cognitive perspectives on peer learning (pp. 179–196). Mahwah, NJ: Erlbaum.

Osborne, J. & Hennessy, S. (2003). Literature review in science education and the role of ICT: Promise, problems and future directions. London: Futurelab.

Ramsden, P. (1998). Managing the effective university. *Higher Education Research & Development,* 17, 347–370.

Russell, T. (1999). The No Significant Difference Phenomenon. Montgomery, AL: International Distance Education Certification Center.

Simons, H. (1980). Towards a science of the singular: Essays about case study in educational research and evaluation. Norwich, UK: University of East Anglia, *Centre for Applied Research in Education*.

Stake, R. E. (1995). The art of case study research. Thousand Oaks, CA: *Sage*.

Triggs, P. & John, P. (2004). From transaction to transformation: Information and communication technology, professional development and the formation of communities of practice. *Journal of Computer Assisted Learning*, 20, 416–439.

Wake, B. (2003). INVEST in Good Stories, and SMART Tasks, available at: http://xp123.com/articles/invest-in-good-stories-and-smart-tasks/

William, D., Coles, L., Wilson, K., Richardson, A., & Tuson, J. (2000). Teachers and ICT: Current use and future needs. *British Journal of Educational Technology*, 31, 307–320.

Yin, R. K. (1984). Case study research: Design and methods. Newbury Park, CA: *Sage*.

9. Annex

9.1. Annex 1 - Use case Template

Date	Author	Description of change
17 March 17	Hofer, m.	Initial draft – aligned with revised Pillars
25 March 17	Voigt, c	Feedback to initial version
30 March 17	Hofer, m.	revision

Template:

Name of use case	*<give your use case a name>*	comments
	USER – P1	
Age and Level	*<indicate the age level of you user and the level of knowledge>*	P1/Q1: Who are the stakeholders? P1/Q3: What (pre-)knowledge do the learners and the facilitators (teachers) have?

Primary Actor and main goal	*Pl. Describe the user (ie. student age xy, teacher)*	**P1/Q4: What are their interests and hobbies they have?** **P1/Q2: What are the preferences of these stakeholders in technology, pedagogy and general interest?** **P1/Q6: What is their youth culture they are embedded (norms, values, practices)?** **P1/Q5: What is their aim/goal?** **P1/Q7: How do they define their role(s)?**
	CONTENT – P3	
Topic and Content	*<indicate the content of the use case>*	**P3/Q1: What is the topics/projects that users would like to perform?** **P3/Q2: Are these topics embedded in projects? If yes, how?** **P3/Q3: What are the learning objectives by students/teachers?** **P3/Q4: Are there any other topics or subjects evolving out of the original activity?**
	ENVIRONMENT – P2	

Description of Environment and possible pre-conditions	*< describe Environment which must be true before this Use Case can be executed, i.e. school, non-formal environment, teamwork, afternoon work, project of school ... >*	**P2/Q1: How long shall/can the activity take?** **P2/Q3: How can 'traditional' pedagogy embed Maker movement and Open innovation?** **P2/Q7: How can we stimulate the production and sharing of knowledge?** **P2/Q9: What are the organizational and technical limitations in schools (i.e. is it allowed to install software on school PC's, is it necessary to be compatible with already used software)?** **P2/Q10: Are there compatibility issues at school? If yes, which ones?** **P2/Q11: Is project based learning possible or does it require integration in the curriculum?** **P2/Q12: Are mobile applications appreciated and useful for the user group?** **P2/Q4: How does the environment in and outside school look like?** **P2/Q6: What are organizational requirements (ie. curriculum adaptation, whom to inform, …)**

Preparatory work	*<is there any preparatory work to be done; if so, which ones>*	**P2/Q8: What materials and technology is available/ or need to be organized?** **P2/Q5: What are the technical requirements? And which technology and tools are used?**
Description of Activity	*< describe the activity the user is doing, including the used technologies and tools used>*	
Other Stakeholders and their possible Interests	*<List the various stakeholder who may not directly interact in the use case but which might have an interest in the outcome of the use case. Identifying stakeholders and interests often helps in discovering hidden requirements which are not readily apparent or mentioned directly >*	**P2/Q2: Who can give support to the learners/teachers?** ***P3/Q6: Is the activity itself and/or its outcome shared with anybody?***
	EVALUATION – P4	
Success and condition	*<Is the use case successfully implemented? If so, what were the success criteria?>*	
Failure and conditions	*<Describe any possible failure and the explanation for it>*	*Has the use case failed? If so, describe why?*

Barriers/ Facilitators	*<Describe any possible other barriers or facilitators for your use case>*	
Extensions	*<Enter possible Extensions of the described use case and their steps*	*e.g. a student has an idea on how to proceed further or improving further>* P3/Q4: Are there any other topics or subjects evolving out of the original activity?
Variations	*<Describe possible other variations of the use case>*	P3/Q5: Has the user developed variation(s) of his/her original plan?

9.2. ANNEX 2 - QUESTIONNAIRE TECHNOPOLIS

Educational Workshops for Children by the Industrial Gas Museum and INNOVATHENS!

Please let us know what you think of our Educational Workshops and help us to improve our services!

*Please if you accompany more than one child, fill in the form once for each.

It will only take a minute!

*Required

1. **How old is you child?** *
   Mark only one oval.
   - 4-5 years old
   - 6-8 years old
   - 9-12 years old
   - 12-15 years old

2. **Which of the following topics do you find more interesting?**
   Mark only one oval.
   - Experiments/ Physics/ Chemistry
   - Technology
   - The Arts
   - Constructions
   - Other: ____________________

3. **Which is the preferable duration of a workshop for you and/or your children?**
   Mark only one oval.
   - 2- 3 hours
   - Two days for 2-3 hours per day
   - More than two days
   - Other: ____________________

4. **How are you being informed of our educational programs?**
   Mark only one oval.
   - Facebook
   - INNOVATHENS Newsletter
   - Technopolis Newsletter
   - INNOVATHENS Webpage
   - Technopolis Webpage
   - Publications- Editorials (digital or printed)
   - From Friends/ Word of mouth
   - Other: ____________________

5. **Have you ever visited Technopolis in the past?**
Mark only one oval.

- Yes
- No
- Other: ______

6. **Have you ever visited the Industrial Gus Museum and/or INNOVATHENS in the past?**
Mark only one oval.

- Only the Industrial Gus Museum
- Only INNOVATHENS
- Both
- Neither
- Other: ______

7. **How familiar are you with the New Technologies?**
Mark only one oval.

	1	2	3	4	5	6	7	
Not much	◯	◯	◯	◯	◯	◯	◯	A lot

8. **How familiar is your child with the New Technologies?**
Mark only one oval.

	1	2	3	4	5	6	7	
Not much	◯	◯	◯	◯	◯	◯	◯	A lot

eCraft2Learn

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

Deliverable D3.2 – M10

Description of Use Cases

This project has received funding from the European Union’s Horizon 2020 Research and Innovation Programme under Grant Agreement No 731345.

PROJECT DESCRIPTION

Acronym:	**eCraft2Learn**
Title:	Digital Fabrication and Maker Movement in Education: Making Computer-supported Artefacts from Scratch
Coordinator:	University of Eastern Finland
Reference:	731345
Type:	RIA
Program:	HORIZON 2020
Theme:	Technologies for Learning and Skills
Start:	01. January, 2017
Duration:	24 months
Website:	https://project.ecraft2learn.eu/
E-Mail:	office@ecraft2learn.eu

Consortium:

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

Edumotiva, Greece (EDUMOTIVA)

Mälardalen University of Sweden, Sweden (MDH)

Zentrum für Soziale Innovation, Austria, (ZSI)

The University of Oxford, United Kingdom, (UOXF)

SYNYO GmbH, Austria, (SYNYO)

University of Padua, Italy, (UNIPD)

Technopolis City of Athens, Greece (TECHNOPOLIS)

Evothings, Sweden (EVOTHINGS)

Arduino, Sweden (ARD)

Ultimaker, United Kingdom (ULTIMAKER)

Linnaeus University, Sweden, (LNU)

DELIVERABLE DESCRIPTION

Number:	**D3.2, M10**
Title:	**Description of Use Cases**
Lead beneficiary:	**ZSI**
Work package:	WP3
Dissemination level:	Public (PU)
Type	Report (R)
Due date:	30.10.2017
Submission date:	31.10.2017
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Acknowledgement: This project has received funding from the European Union's Horizon 2020 Research and Innovation Action under Grant Agreement No 731345.	

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EXECUTIVE SUMMARY

This deliverable continues the work of D3.2 by establishing further scenarios and enhancing one use case that has been presented in M5.

Since this deliverable is a continuation of the previous one, it neglects to repetitively outline the eCraft2learn's aims, definitions of terms or the methodologies used (pl. See D3.2- Month 5) but focuses exclusively on the materials gained within this period and the resulting use cases and personas.

1 INTRODUCTION

"Crafting combined with programming is fundamental!"[1]

Deliverable 3.2 - month 10 is an extension of the work performed in D3.2 - month 5. Thus, the second deliverable builds on the established methodology, explains necessary adaptations, outlines further use cases for eCraft2Learn technologies and processes and launches the first personas.

- The developed methodology for elaborating the use cases was followed to a great extent: the second set of co-created use cases exploits the inputs of the questionnaire for students (partner Technopolis), the interviews performed in WP 2 as well as the facilitators specific interviews.

Still, each of the cases has their own development 'history' and relies on different qualitative and quantitative inputs from actual users (students, teachers or facilitators) and experiences made by the project partners. Due to the holiday season, we directly integrated single teachers in concrete use cases and one-use case was tested in real (the Making robot use case was tested during the SciFestival in Finland) which allowed adaptation according to the experiences made within a different setting.

The possibilities to design, create and produce in programming and printing are extremely high, even with the 'pre-selection' of WP 2 of tools, the guiding pedagogical principles and the data analysis. Thus, very different ideas and use cases were developed. During this working period, we challenged several discussions on different topics. I.e. one major issue was the choice between pre-fixed tools vs. very basic elements for the students to work with. However, one has to note that there can't be a 'one-fits-all' recommendation found in the use cases, since such a choice depends on many different factors. In this deliverable we tried to reflect these factors in the use cases and also within the personas. It reflects the variety of persons and conditions in different environments, rather than proposing solutions.

The structure of this document focuses on these two vital points - the use cases and personas - by shortly outlining the aims and objectives (section 2), a data analysis (section 3) for elaborating the personas (section 4) and the use cases (section 5). Chapter 6 gives also an outlook for the next possible use cases to be delivered in month 15.

1 Andrea Alessandrini, interview on 13 Juni 2017.

2 AIMS AND OBJECTIVES

The eCraft2Learn environment combines the new maker movement, open innovation, pedagogy and technology. In this manifold ecosystem the use cases shall help to focus on the intended user of the eCraft2Learn services, rather than on the technical challenges of how to develop those tools and services.
The major aim of this set of deliverables (two further versions in month 5 and 15) is to reflect on the diversity of the end-users, captured in a combination of use cases, user stories and design claims, including the description of personas (month 10 and month 15). It puts its focus on possible application scenarios and on integrating feedback from stakeholders.
As outlined in the DoA of eCraft2Learn, the use cases will be developed particularly for providing also insights into:

(1) Preparation, planning and logistics of - formal and informal - learning units,
(2) Orchestration of subsequent learning events and
(3) Impact (like empowerment of learners), especially in formal settings.

Thus, this deliverable outlines on a more practical level the implications, needs and organizational necessities for the target group (i.e. What learning model will be chosen? or How do we operationalize the open learning or the making?) as well as technical perspective (i.e. Which tools shall we include in the portal? How do we need to design the technical solutions in order to be user friendly?).

3 SOURCES USED FOR PERSONAS AND USE CASES

3.1. INTERVIEWS

As one source of qualitative information the interviews performed in WP2 (Deliverable 2.1) were used. Although the main focus of these interviews lays are the ecosystem of education, teaching and learning, some partial information revealed highly relevant information to be used for the personas as well as the use cases.

For this deliverable, we selected in total 15 interviews with teachers in Europe that were done by the partners. The interviews displayed information on the teachers' day to day work, the environment they are embedded in, their needs and difficulties, their ambition and obviously their respective ecosystem. These interviews were used to develop different types of personas that reflect potential users for eCraft2Learn as well as to frame the fictive use cases.

For the adaptation of the 'Robot building' use case, a semi-structured interview/reflection guideline (Annex 1) was created with the aim to reflect on different factors of success and failures. Further, it allowed to adapt the initial 'Robot building' use case. For this, two persons were involved: for once the facilitator of the workshop, Andrea Alessandrini, LNU (online interview on the 13th of June), and Hanna Nygren, UEF (also online interview on 6 June 2017) observing the workshop from a pedagogical and organizational perspective. The fact that the students were asked afterwards for their impression, critics and assets they have gained from this workshop also led to a different view on the workshops and revealed improvements. Thus, the use case got adapted for this version of the deliverable accordingly.

3.2. Analysis students questionnaire

3.2.1. Restrictions

It has to be mentioned that a detailed and scientifically analysis is limited, due to the way they have been collected, to the number of answers and to the discontinuity of questions. Besides, answers are limited to Greek students, and thus there is a significant geographical restriction. However, for our major purpose – the collecting of indications for preferred topics, durations of workshops, pre-knowledge, etc. - the data are valuable input for constructing persona and use cases. Consequently, the data sets were each analyzed separately.

3.2.2. Data Sets

In order to understand how the setting in a informal environment should be ideally designed, we targeted students who were visitors of science centres. Two datasets were made available from partner Technopolis, collected from Spring till Summer 2017 (questionnaire in Annex of D3.2 - Month 5). The questionnaire was filled out either by the guiding parents or (depending on the age) by the students themselves.

One set consisting of 130 observed entities and the second data set of further 44. Four of the individuals of the second dataset were under 6 years old. Since that category is irrelevant for the purposes of this study, these observations were removed, leaving 40 in this dataset.

Due to the different wording of questions and significantly different underlying information and categories of the two datasets, fusing them was deemed rather unfavorable, and a separate analysis was necessary. Wherever possible and reasonable, comparisons were made.

Some incompatibility and incomparability arose mainly due to the following reasons:

i. The first dataset does not include information assessing the preferable duration of a workshop (as referred to by question 3 of the underlying questionnaire).

ii. The child's familiarity with the new technologies (question 8 of the underlying questionnaire) was assessed on a scale between 1-5 in the first dataset and 1-7 in the second one.

iii. The age categories of the subjects assessed in both datasets were significantly deviant from each other – while in the first one the categories were “12-13”, “14-15” and “15-17”, in the second dataset these were “6-8”, “9-12” and “12-15”.

While the interest in certain topics (as assessed by questions 2 of the underlying questionnaire) was by the questionnaire itself and first dataset addressing the interest of the child itself, in the second dataset this was worded as “Which of the following subjects do you find more attractive for your child to participate?”, thus asking for the parent’s interest instead of the child’s. It was assumed that each entry of "0" means a missing entry which was thus omitted from further analysis, except where it was considered informative including the information. Graphs sometimes represent absolute numbers while others percentages. In most cases the choice fell on absolute numbers because of the small size of both samples, however sometimes the percentage dimension is also presented – whenever this is the case it can be recognized by the %-sign on the x-axis.

The variables “Familiarity with new technologies”, “Subject of interest” and “Preferred duration [of workshop]” were deemed of interest, as were the interactions of each of them with the variable “Age” and the one between “Familiarity [of child] with new technologies” and “Subject of interest”.

3.2.3. RESULTS OF FIRST DATASET

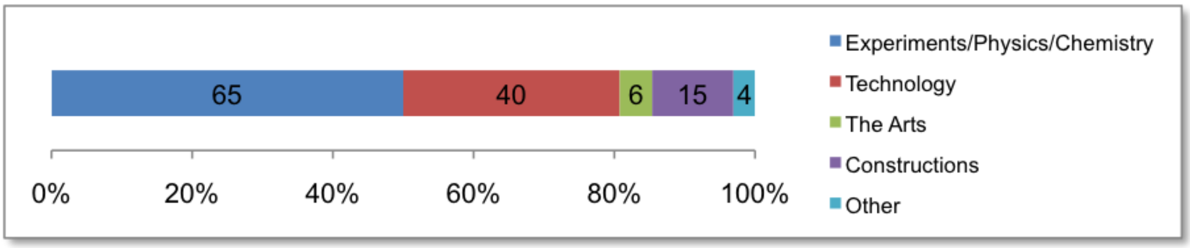


FIGURE 1: Students answers on their major topics of interest

Of the 130 answers of the first dataset, 65 students (50%) were interested in topics of natural sciences and performing experiments, followed by 40 students who favored technology. As it can be seen in Graph 1, further 15, 6 and 4 students were interested in constructions, art and other topics respectively.

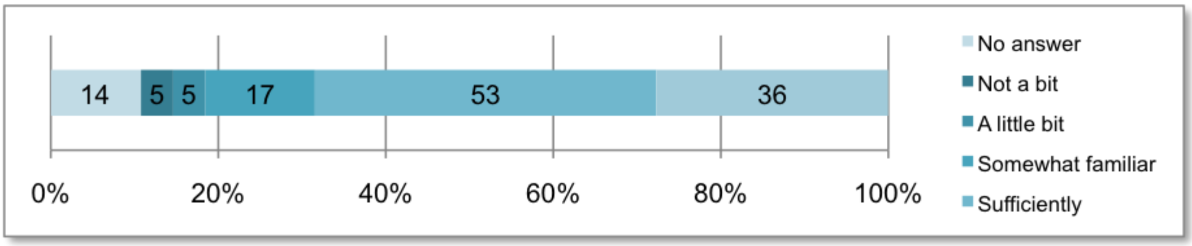


FIGURE 2: Students estimate on their familiarity with new technologies

99 students (more than 60%) consider themselves sufficiently or to a great degree familiar with new technologies

3.2.4. Interactions

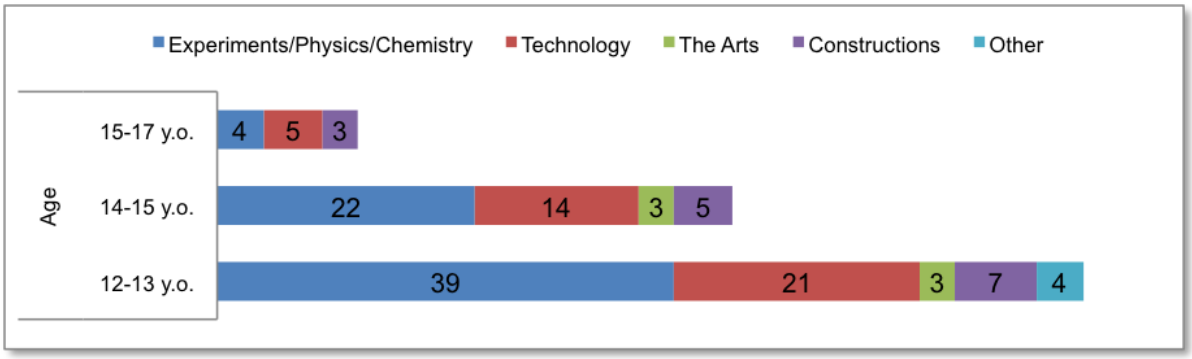


FIGURE 3: Age and topic of interest

The students interest in experiments, Physics and Chemistry are a large majority, and there is no correlation with age and those interests. Only few are interested in construction and art. This result is not surprising, considering that the questionnaire were collected from visitors of a science communication centre, but it emphasizes the need for further efforts to raise the interest in arts, constructions and other sciences connected with crafting and technology.

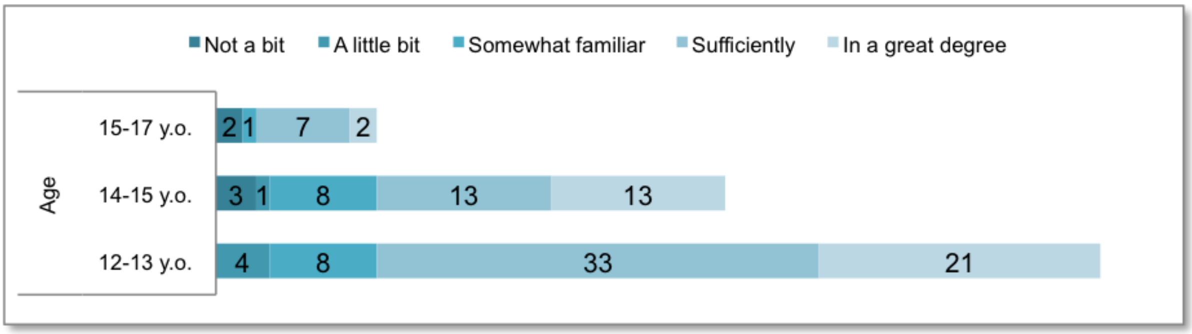


FIGURE 4: Age and familiarity with new technologies

The majority of the students feel comfortable with new technologies (age group 14-15 and 12-13). Given the low number of answers from the age group of 15-17, no significant conclusion can be drawn. Thus, the eCraft2Learn has to consider also the fact that not all students feel sufficiently familiar with new technologies and might need to construct the environment accordingly.

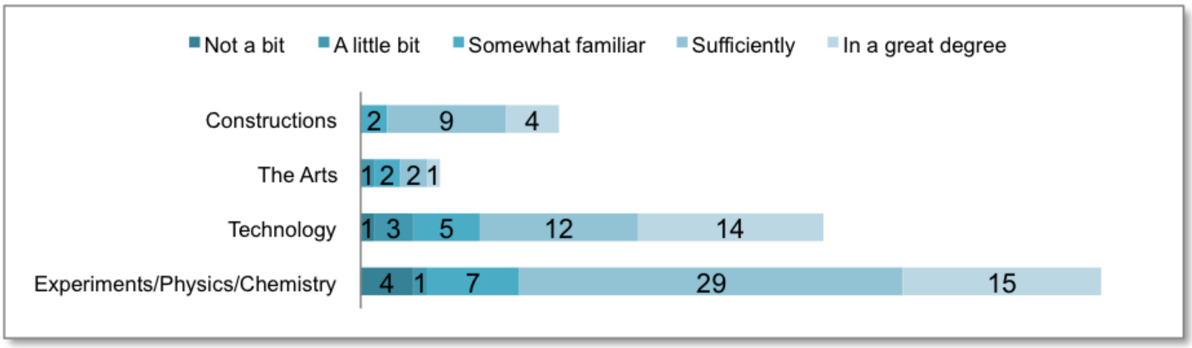


FIGURE 5: Topic of interest and familiarity with new technologies

3.2.5. Results of 2nd dataset

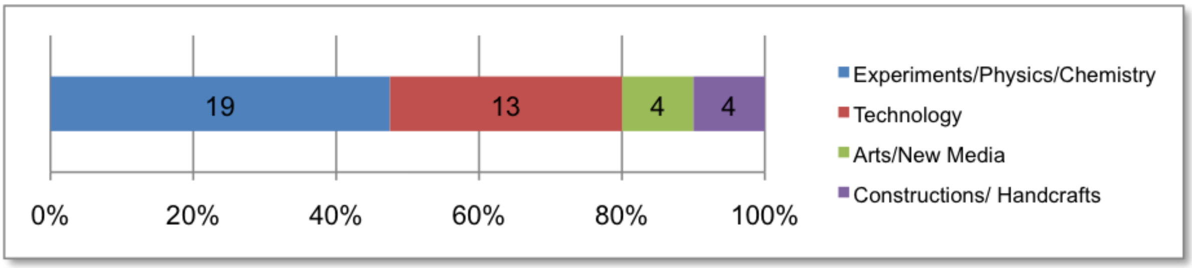


FIGURE 6: Parent's preferred topic for child

Comparing the data with the first dataset, the results are similar: most students are interested in Experiments/Physics/Chemistry and Technology.

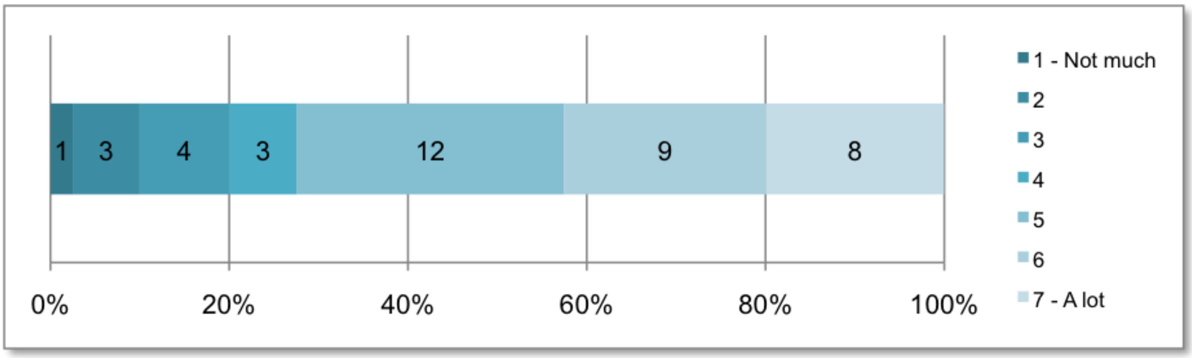


FIGURE 7: Familiarity with new technologies

Again, many students feel fairly comfortable with new technologies. 20% of this sample even state that they are highly familiar.

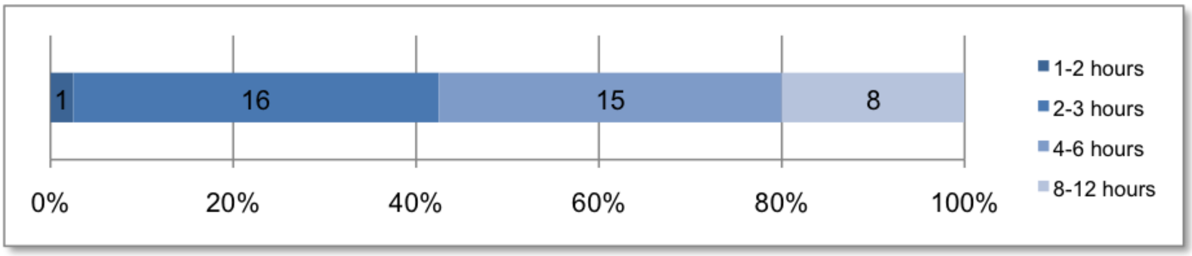


FIGURE 8: Preferred duration of workshop

The majority of the students preferred duration of a workshop between 2-3 hours and 4-6 hours. Several students would dedicate 8-12 hours. Only one student would limit the workshop to 2 hours.

3.2.6. INTERACTIONS

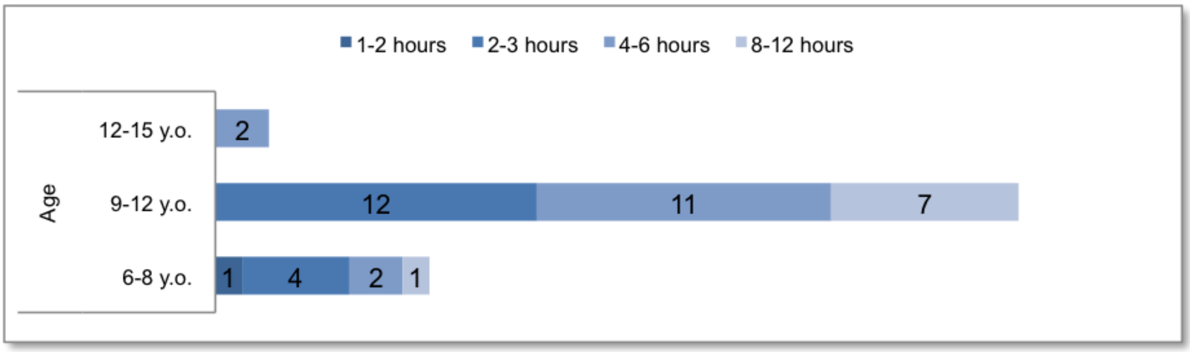


FIGURE 9: Age and preferred duration of workshop

Comparing the age group with the preferred hours, no significant indication can be given.

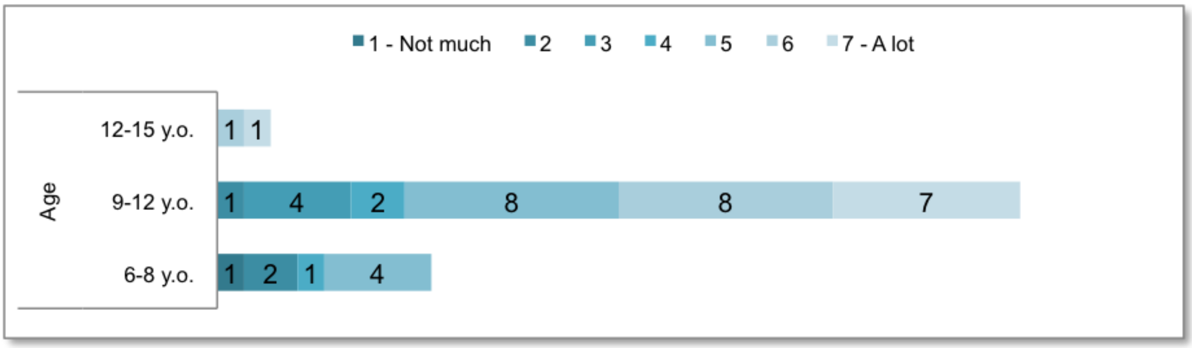


FIGURE 10: Age and familiarity with new technologies

Given the low response of answers to the question, no reliable conclusion can be given, but the majority of the students feel more or less familiar with new technologies. This corresponds with the results of the first data set.

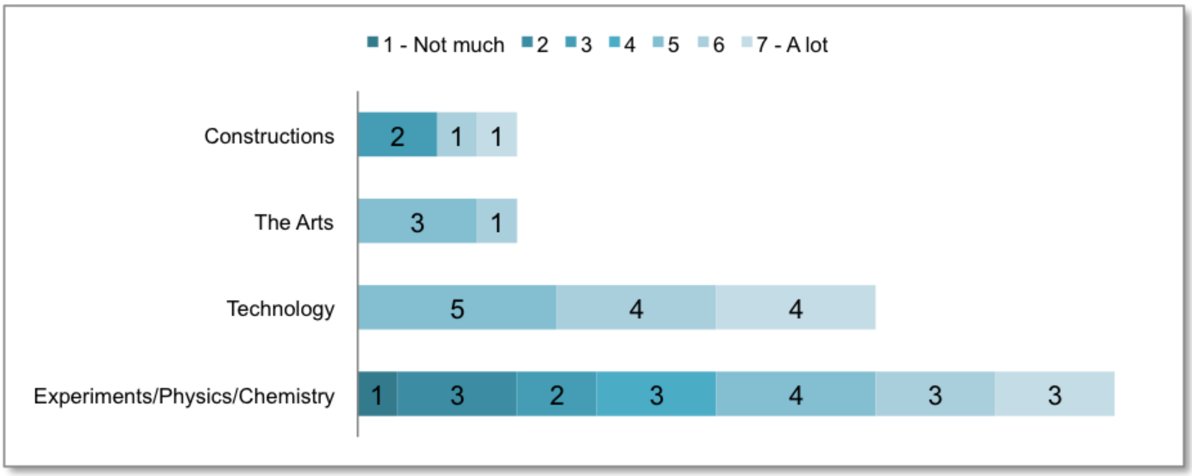


FIGURE 11: Preferred topic and its familiarity with new technologies

4 PERSONAS

Scenarios are a good tool for design, since they depict the work practices designers aim to support. However, their weakness is that they might not sufficiently be engaging. Personas are a method for enhancing engagement and reality. Thus, the aim of the different personas in this document is to increase the understanding of the end users that will teach and learn with the eCraft2Learn environment.

Persona build on the different scenarios and data collection and support the engagement. The following created personas build on the data collected (interviews and questionnaires) in the last period (M5-M10). Although based on facts, the personas are fictional people but they have names, age, gender, values, educational achievement, socioeconomic status life stories, goals and tasks etc. By describing personas, the potential users shall gain more emphasis in the development of the tools.

The following section describes several personas that might become potential users of the eCraft2Learn environment.

Susan

35 – Science Teacher – Finland

Susan is a Finnish secondary school science teacher and has a class of 20 fifteen-year-olds. Half of her class are female students. She is 35 years old, has two kids age 10 and 7 and she goes twice a week in a gym. Susan is very much interested in technology and was the driving force that her school bought a 3D printer for different projects. For her, it is important to build a collaborative learning environment in and outside of the classroom. The projects that she is launching with her students are mostly global themes and topics, sometimes even found in the local community. She believes that her role as teacher includes also to empower her students and encourage them for creative and critical thinking.

Nikos

42 – Teacher of Science and Music – Greece

Nikos lives in Athens and teaches Math, Physics and Music. He is 42 years old, is member of a band where he plays the drums. His other passions are robots and building different kinds of vehicles. With his older son, aged 9, he has built already several of them with different systems (Lego Robot, Clix, etc.). Thus, he is very fond of projects where students have to find ideas and craft their own creations. He is a teacher that pays high attention to the individual needs of students, and proposes tools that can be customized to these needs. He is very flexible allowing students to work with other tools, since he is of the opinion that each student needs to make his/her own experiences for learning. He supports the students and checks the progress from time to time but leaves it up to them to create, design, craft and program their creations. If a student has issues, he discusses with them the problem and guides them to possible solutions. Still, he is quite restricted within his curriculum but he is very creative in finding ways to combine both, project and curriculum requirements. This is also due to a very flexible headmaster that has high trust in Nikos and his way of teaching.

Petros

28 – Non-formal Education Trainer – Greece

Petros age 28, has studied IT, Physics and Math in Greece. He decided not to continue with an academic career since he wanted to be closer to teaching. Thus, he took part in a training of an educational institution dedicated to enabling people to hold STEAM workshops with kids. Now he is working as a facilitator in a non-formal educational institution that fosters educational activities of new Technologies and STEAM. He believes that learning can be fun and that it should be combined with hands-on activities. He lets go of clutter and focuses on the essentials, thus on the principles that kids should understand. Petros has built already robots for several years from many different materials and is increasingly interested in the maker movements. He is member of an online maker platform where he supports quite often the makers that seek for creative solutions in programming or IT in general. Last year he was traveling to Rome to take part in a big maker faire.

Barbara

37 – Science Teacher – Austria

Barbara is an Austrian teacher for Math, Biology and Crafting for secondary students. She is 37 years old, married, has three kids and loves to go hiking with her family. Her husband, Andreas, is teaching Math, Physics, Sports and IT. She is a very motivated teacher, knows how to spice up the classroom to engage the students and uses simulations and computer programs for her teaching in Math and Biology. She made good experiences with gamification of learning, although some of her teacher colleagues are rather critical with this kind of teaching. But she is acknowledged in her school as innovative and open person. She is convinced that also education has to be innovative and understands her teaching as the preparation of the students for the ‘real’ working life. She sees an issue with the fact that she has to fulfill the curriculum and at the same time the possibility to take part in so many interesting projects. Thus, she needs to be very selective in projects she launches. Due to the fact that she has only limited IT knowledge, she needs very clear and detailed instructions when she launches projects with IT inclusion. Luckily her colleague who teaches IT is a great team player and is often willing in launching projects together with her. She herself learned already a lot from these common projects, but she feels not confident enough to do her next crafting project herself (sewing bags with flashing lights).

Dimitris

55 – School Principal – Greece

Dimitris is a principal for a second-grade school with 400 students in Greece and before becoming the principal, he was teaching IT, Maths, Physics and Sport for more than 20 years. He comes out of a three generation of teachers, is married for 31 years and turns 55 next year. In his duties he has a lot of administrative tasks, but he is very interested in what innovations happen in education and tries to support his teachers in implementing these innovations. Often, they have to handle financial restrictions as well as restrictions due to the curriculum, but Dimitris tries to provide the teachers a good framework in which they can act flexibly. Thus, he is very open to collaborations also outside the school and tries to keep up with the technological development. He has high trust in his IT administrators and he knows that his team of teachers work very well by supporting each other in different projects and initiatives. When supplementing an IT lesson, he would like to give the students the possibility to explore with different systems and understand the basic principles behind it but also foster their soft skills like creativity, their ability of planning, collaboration and creation. At the same time, he looks out for systems that are easily accessible, moderate in costs and highly effective for the students.

Veikko

12 – Student – Finland

Veikko is a 12-year-old student in Helsinki. Twice a week he attends the swimming training. He likes techno music, plays piano and is fond of online games and computers. Veikko also has a younger sister, Neela, that just started school. Since they live a bit outside of Helsinki, both have to leave early in the morning to go to school. His favorite subjects at school are English and Sports. He is very fond of projects in school since he is a very creative youngster. Also at home he is persevering in crafting things. While reading Harry Potter in English, he decided to craft a magic wand for himself with sparkling lights when waved properly. With the help of his parents, a technical engineer and a lawyer, he managed to create his own wand.

Elena

17 – Student – Greece

Elena is a Greek student living in Athens. She is 17 years old and attends a higher private school. Her favorite subjects are Arts and French. She is very gifted in sewing and knitting and has designed for herself already several clothes and accessories like bags, scarves etc. She regularly visits websites and blogs that deal with fashion and design. She has a lot of friends that she meets in the community center, but of course she has much more 'virtual' friends in Facebook. Elena usually posts her creations there to present what she has done. She considers herself as an average student but she has difficulties in Maths and Biology since her interest in these subjects is really low. As a very creative person she likes collaborative projects with her classmates where she immediately takes care of really cool designs but leaves the conceptualization usually up to the others.

Noah

12 – Student – Austria

Noah can’t remember a time where there wasn’t some form of digital media in his home. He received a Nintendo DS at Christmas when he was 6 years old, and since then has moved up to a PlayStation3 videogame console. He is very active and involved in sports and loves going outside playing with his friends, with the Nerfs, or ride his bike. When his friends come over they often decide to stay indoor to play a computer game, even when it’s nice weather outside. He attends a public secondary school in Austria and during his summer holidays he visited a camp on robotics and programming. He is very proud of his first self-created robot and continued to expand a little online game he created himself in Snap! Noah is now 12 years old, but he is sure when he has finished the NMS (secondary school) he wants to go to a higher school that focuses on IT.

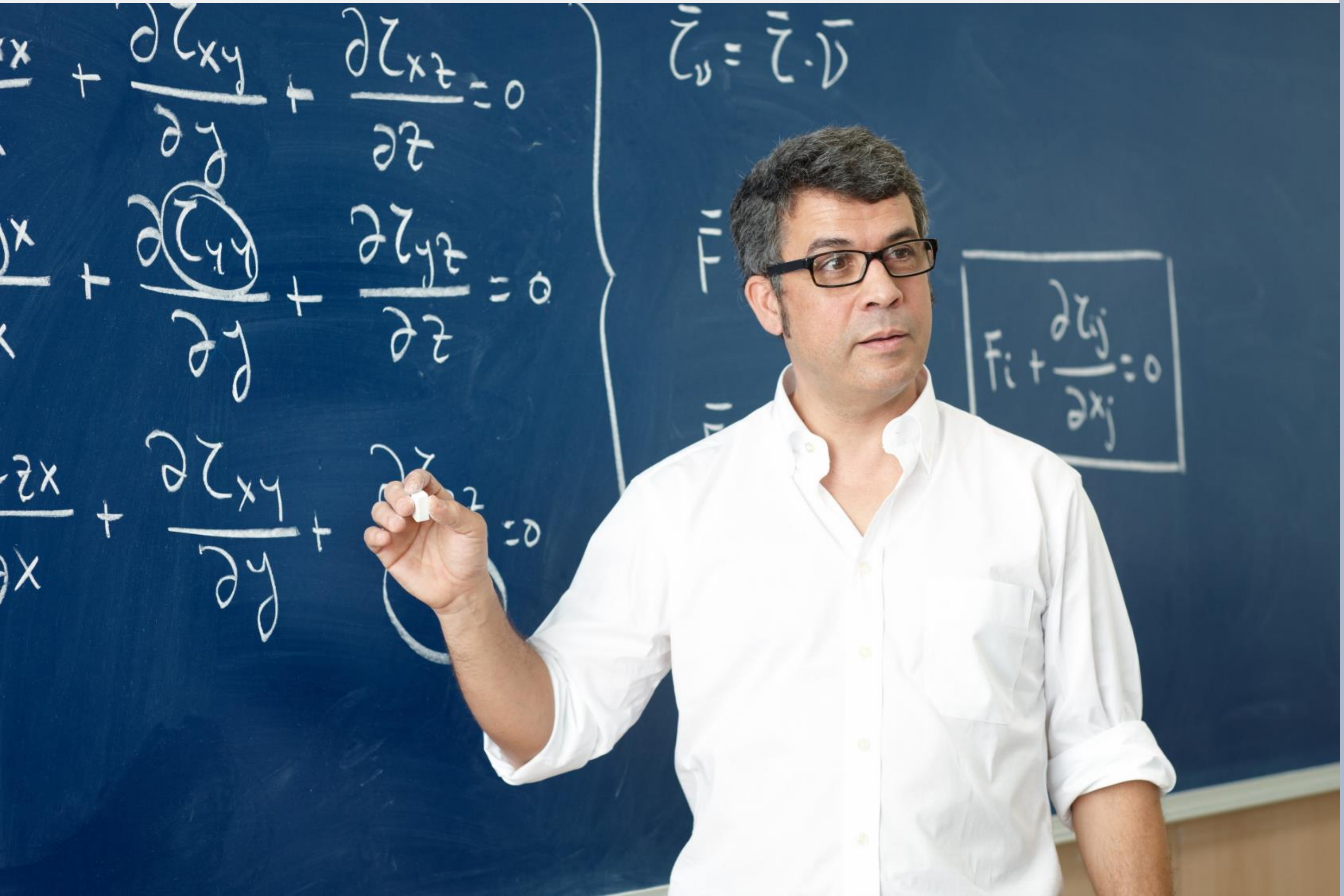
Bora

12 – Student – Albania

Bora is twelve and studies in a private international school in Albania. All her classmates have personal tablets and emails where they receive homework from their teacher. She is currently working on a historical drama project about the Austrian royal family of Habsburgs where she will represent the character of the Empress Maria Theresia. She loves history, languages and cultures and is mostly interested in female leaders because they show that girls can be powerful. Complementing the drama, Bora prepared a PowerPoint presentation with facts and figures about the Habsburgs and uploaded it in a shared folder of her Google drive. She is now searching Google for costumes fit for her drama character. In her free time, she likes playing with her little sister, teaching her English through YouTube videos, or talking to her friends through pictures on her Snapchat or Instagram.

Christoph

41 – Science Teacher – Austria



Christoph is 41 and teaches physics in an Austrian public school. He is married and has two little children with whom he spends most of his free time besides playing and watching football with friends. The state given curriculum in physics in pretty strict and does not foresee much time for project-based learning during the school hours. The school financial resources have also been restricted and he can hardly find small means for buying equipment he needs for projects. Yet, the school lies in a rich area, so he engages students' parents in funding projects and decides to cut-off some lessons which he deems less important from the curriculum and dedicate the hours to projects. He certainly wishes he could have more time and resources to conduct great projects but he chooses to do what he can with what he has. He believes that letting students do things together can teach better physics and better social skills. Teamwork and social aspects are essential to him and include one of the focuses of his projects.

Ivana

56 – Teacher of Biology and Chemistry – Slovenia

Ivana is 56 and has been teaching Biology and Chemistry in a Slovenian high school for her entire career. She is very fond of technology in general and especially technological innovations in the field of education. She believes that good IT skills should be a prerequisite for recruiting teachers, and enhancing their skills continuously keeping updated with technological advancements in the digital era, is essential for 21st century education. Around ten years ago, when her children moved out from home to pursue higher education she was left with more free time than earlier. Together with some teachers of her age, Ivana created a teacher's team for projects integrating at least two STEM subjects. Since then, their school has been participating in national and international competitions winning important prizes and building itself a reputation. Some of the projects have brought up such successful innovations that have ended in collaborations with prestigious companies and patents. Almost all the project work is carried out in Ivana's free time and financed with alternative means. Ivana considers this a hobby but regrets the lack of time of her colleagues who are interested in project work and educational technology but don't have any time or resources available.

USE CASES

4.1. VARIATIONS/ADAPTATION - BUILDING ROBOT

Revision History

Date	Author/contributors	Description of change
April 2017	Andrea Alessandrini	First Scenario: Robot Building Workshop (Greek School)
May 2017		SciFestival - actual application of use case
June 2017	Hanna Nygren, Andrea Alessandrini, Margit Hofer	Reflection interviews with Hanna Nygren (observer) and Andrea Alessandrini (workshop facilitator)
October 2017	Calkin Montero, Hanna Nygren	Revision of original scenario based on the feedback of participants and interviews
October 2017	Margit Hofer	Slight corrections and final version

Recycled ToyRobot (from the SciFest experience)

Age and Level:

SciFest is a scientific faire, that attracts thousands of visitors every year. There are companies, schools and departments from university who are running the workshops, experiments or presenting showcases and their products/services which is related to science, engineering, technology, arts and crafts, mathematics, and other subjects taught at schools. One of the workshops of SciFest was dedicated to creating recycled robot heads (and bodies!) out of cardboard boxes, plastic bottles, and other available, easy to find everyday materials. Idea of the workshop was to engage not only kids who are enthusiastic about technology, but also kids who are interested in arts and crafts. Sonja also observes that 10-16-year-old kids can take part of this workshop. For more advanced students, there is the opportunity to choose tasks that are more challenging. Robots are very familiar, especially for boys, but hardly in any place, have kids built up a robot head from the recycled materials. Some kids are also familiar with programming, but Sonja notices that especially it is hard to engage girls and some boys for this activity; they think that it is boring. Therefore, Sonja thinks of modifying her idea to let the kids in her club to use their imagination to create/bring to life their own version/conceptualization of what a 'robot' is by making their own Recycled ToyRobot. This could attract the interest of a wider group of boys and girls. The workshop was about making and hands-on activities, with the aim of attracting a wide variety of girls and boy (e.g., those who are not so interested in technical activities such as programming). This was to emphasise that robot building is more than programming. Sonja, an after-school crafts and arts club instructor, is very interested in handcrafts and she likes to make things by herself, because then what she makes is personalised and has her signature. She is not interested in ready made products and has not had interest in programming. She wants to teach her club kids to be creative and that they can recycle things for creating something new. She and other colleagues from the club are observing and participating in the RoboHead workshop in SciFest, involving themselves in a short hands-on activity to understand how this workshop could be run with the kids at the club.Sonja also observes that 10-16-year-old kids can take part of this workshop. For more advanced students, there is the opportunity to choose tasks that are more challenging. Robots are very familiar, especially for boys, but hardly in any place, have kids built up a robot head from the recycled materials. Some kids are also familiar with programming, but Sonja notices that especially it is hard to engage girls and some boys for this activity; they think that it is boring. Therefore, Sonja thinks of modifying her idea to let the kids in her club to use their imagination to create/bring to life their own version/conceptualization of what a 'robot' is by making their own Recycled ToyRobot. This could attract the interest of a wider group of boys and girls.

Primary Actors and main goal:

The primary actors will be the instructor (Sonja), the students (boys and girls). Instructors are concerned about the feedback they receive from the parents (secondary actors). Parents are little bit concerned about programming, because kids are playing with the computer for long periods of time. However, parents appreciate that the SciFest activities that they have the opportunity to see (and test if they wish) are more than just programming with the computer, more creative activities are performed. Main goals of the Recycled ToyRobot scenario are to boost kids' creativity, problem solving and team skills as well as to demystify the use of technology while keeping in mind ecological perspectives (using recycle materials for building new toys/things/robots). Furthermore, girls enjoy being creative using crafts and arts, as well as some boys, too. Technology could be attractive for boys more than for girls, but it might be that when integrating crafts and technology, all kids can find that there is something they are keen to make/create and enjoy.

Topic and Content:

In the Recycled ToyRobot activity, kids are asked to plan and design their own version of what a robot/toy is, using recycled materials, such as paper rolls, boxes, plastic yoghurt mugs. An interactive part of the toy, such as the eyes, will be made using LEDs (light-emitting diodes), which will be programmed to blink at a certain rate. At the beginning of the activity, the kids are given the instructions, they form groups and are introduced to the five stages of craft- and project-based learning (ideate, plan, create, program, share). They are also asked to follow the instructions about how to make the LEDs blink. There are 3-4 students in each group and each group has their own PCs and Arduino kits at the table as well as different recycled materials, pencils, glue, scissors, colour paper, foil paper, etc. Each group is designing their own version of a ToyRobot and how the eyes of the robots will blink or how lights in the eyes are on or off.

Description of environment and possible pre-conditions:

Kids can perform the activities within 1.5 hours (however 3D printing is not included to this activity). The feedback received from the students that participated in the SciFest version of the activity indicates that some students wouldlike to involve 3D design and made the robots more professional looking. This implies that the activity could be set to be developed in longer time (2 days or more), so that kids really have a chance to carefully design and take longer time to make/create their ToyRobot. The robot building activity originally took place at SciFest, an inspiring environment, where the students can get comments and feedback as well as ideas from the audience and professionals visiting the event. There could be open place for everyone to join in, use the materials and get instructions and help when necessary. The activity is based on STEAM subjects, which serve well the curriculum of schools. However, more students might be interested when receiving the information about the workshop. Using social media and school network more efficiently could help to reach the wider audience.

Preparatory work:

For the activity, an instruction manual of the steps to follow when using the virtual programming environment (Snap4Arduino) needs to be prepared.
Also, during the workshop, an Arduino Uno board connected to a Raspberry Pi3 computer was set up, as individual work stations for each group. When other software is needed, if there are no restrictions of installation, it is easy to install. The instructors should check that the necessary software are pre-installed and the programs run. In addition, recycled materials as well as crafts materials should be collected and made available during the activity development.

Description of Activity:

The instructor starts with a short introduction about what kids are supposed to do, what the process is and what the materials and tools to use are. The students are asked to form groups of 3-4 students and take a work station (Arduino board connected to a Raspberry Pi PC) and start working. In the SciFest version of the workshop, one group designed a square robot head, where the robot eyes are blinking one after another. Another group designed an elephant robot head - big eyes were supposed to be 3D printed, where the LEDs are set in the middle. Since there was not 3D printing available, the students set for using cardboard to create the eyes of the elephant. Students planned themselves, which recycled materials they need. They also decide what part they need to 3D print for the head. Students are dividing the tasks among themselves, and when the group member struggles with a task, the other members are ready to help: they seem to solve the problems by themselves. Instructions are following the processes and especially in 3D designing and printing students need more guidance, because it is new for them all. Some problems with properly printing the 3D design meant that they needed to try printing again after adjusting their design. The instructor is helping by not giving direct answers but leading the group to check their design in order to print it correctly. At the end of the activity, the groups present and explain their creations for everyone else to see.

Other Stakeholders and their possible Interests:

Parents who provide positive feedback to their kids. Creative designers and makers with a positive attitude. Results also might interest companies and investors who might appreciate to have inspirations from young people.

Success and condition:

At the end of the workshop/activity, all groups are asked to present their creations to all and asked feedback about the implementation. Teachers experience that they have not seen the students working so well together and being so engaged on that kind of learning process. Even the girls were excited about the hands-on activities and arts and crafts and their ToyRobots look well designed and carefully made. As the groups got more experience they started to talk about how they could design and make more advanced ToyRobots, which would be more complicated and high-design product that reacts to voice, movement or light changes in the environment.

Failure and conditions:

Time considerations for taking the project to completion. For instance, during the SciFest experience, there was one group, where one of the group members had to leave earlier and the other two were not able to decide how to continue with the activity. Their robot head was a simple one and it seemed that the two members were not happy about the result: it was not the product they designed in the first place.

Barriers/Facilitators:

Barriers
Are the groups working well?
Grouping makes difference, to get students to work well with each other and make sure that they have time to work on their ToyRobot.
Is the given time sufficient for the workload?
Tracking the time is important. The students need to understand that the amount of time they have and the workload will be in good balance.
Do the students have the information they need to succeed? Role of the instructor/teacher/coach
A limitation arises if the students do not have any idea about how to build a ToyRobot and creativity is missing. The instructor is to intervene: how to guide them to be free of the limits set by their own mind set.

Facilitators
Motivation
Some students were keen on the idea that they can create and make a real product by themselves.
Peer networks and Internet Information finding, a powerful tool to fuel creativity.

Extensions:

From the robot head workshop to the ToyRobot activity the robots can advance towards becoming more interactive and reactive to changes in the environment. For instance, creating a robot alarm to wake the person up when it is day time; a robot guard to sound an alarm whenever someone trespasses a forbidden room; a talking robot that reacts to the close presence of people; etc.

Variations:

Some students would like to design projects with the LEDs lights embedded to the accessories of clothing.
Students started to think also how they could for example help the elderly people for having them the robot with blinking eyes, when their phone is ringing in the other room.

4.2. My cool Flashlight school bag

Revision History

Date	Author/contributors	Description of change
20 July 17	Hofer, M. B. Fischbacher	Initial draft of Scenario
27 July 17	B. Fischbacher	Adaptations
3 August 17	Hofer, M, Voigt C., Unterfrauner E.	Discussion of scenario; testing with Arduino board
4 August 17	Fischbacher B.	Integration of feedback and change.
20 September 17	Ehrndal, M.	Some additional tech content

The flash light school bag

Age and Level:

Veikko is a 12 years old student in Helsinki. He goes twice a week to swimming training, likes techno music but he is also fond of online games and computers. With the age of 10 he got for Christmas a Lego robot and with the help of his father – an engineer – he managed to get the robot going.

Primary Actor and main goal:

At school he acquired some basic programming skills already. Veikko also has a younger sister that just started school. Since they live a bit outside of Helsinki, both have to leave early in the morning to go to school. Especially in winter it is still dark when they leave home.

Topic and Content:

Veikko has an innovative teacher who launches different projects. This month the teacher got some Arduino boards to launch different projects. He understood that with Arduino you can programme many different things and combined with sensors he can create many things with different functions.

Description of environment and possible pre-conditions:

Veikko's teacher has asked them to build pairs and agree to a small project they would like to create. Veikko and his friend Pekka would like to do something of real usage that goes beyond playing or fun. Veikko and Pekka elaborate a plan to 'pimp' school bags: since they are leaving so early from home it is difficult for cars to see school kids in the dark, especially when there are no reflectors attached to the cool bags any longer (which leads often to discussions with his parents).
Thus, Veikko and Pekka decide to build a sensor for the school bag that would start flashing on his school bag once the light becomes low.

Preparatory work:

The teacher asked them to prepare a sort of 'concept' that outlines the idea behind, the usage, the materials and skills as well as knowledge they will need a.s.o. Thus, Veikko and Pekka start to investigate which components they would need and establish the list materials, the sensors, the LEDs they would need, a.s.o. The boys also consider the different circumstances for the design (ie. snow and rain on the sensors and the Arduino board, ...). They hand over their written plan to the teacher and discuss with him the outline.

Description of Activity:

Four days later, the teacher has ordered the needed Arduinos and each of the students have brought additional materials with them. Veikko has brought his old school bag for testing since he is not sure how to attach the LED lights, if he would need to make some holes in the bag, a.s.o.

The teacher helps him plan how to mount the LED lamps on the bag, and also reminds the students they need to insulate the component legs to avoid a short circuit. Before they start building, the teacher helps the students to test the photo sensor with one LED, as a 'proof of concept'. They search online for how to connect the components on the breadboard, and use an Arduino example sketch that reads analog values and maps them into the range suitable for LEDs. They learn about statements, and how to set a threshold for the lights to turn on. After the core concept has been prototyped, the teacher asks the woodwork teacher to help the students solder the parts together. The teacher has helped them draw a circuit on paper to aid them as they solder everything together.

Once everything is connected, it won't light up. The students are very disappointed, and are not sure what to do next. The teacher tries to cheer them up, and shows them a systematic approach to troubleshoot the error. They use the serial monitor to make sure they are getting values from the sensor, and that the threshold is properly set. After that, they upload a code to light up the LEDs only. They don't light up, and one of the students suddenly finds it's because they have not properly insulated the LED legs. Once the whole circuit has been properly insulated, all the technology is working as planned.

Other Stakeholders and their possible Interests:

As Veikko tells in the evening what he has done at school his sister also would like to have some flashing LED lights installed on her bag.
Veikkos realizes that the lights might need improvement in terms of design if used by smaller kids so that all the components are hold within one case. By creating this, the Arduino construction would be more stable than his initial installation and design. Thus, he designs a case in the 3D printing programme TinkerCAD.
His teacher allows Veikko to use the 3D printer at school to improve his project. During the creation of the case, there are a lot of errors to resolve at the beginning of the process to get the 3D model to print correctly. However, once in a while, the printing process fails, and Veikko has to discard the spoiled material and start the sequence again. Finally, Veikko managed to have the case printed and installs the Arduino in the case.

Success and condition:

One week later Veikko is allowed to take his LED lights home for his sister. Together with his mother, they only need to sew a Velcro stripe on the outside lunch box case of his sister schoolbag. Veikko connects the cable with the components in the case, turns off the lights and immediately the LED lights start blinking.

Variations:

This type of scenario, where learners try to find the solution to a problem relevant to their everyday life has the power to engage them in a completely different way.

4.3. GREENHOUSE

Revision History

Date	Author/contributors	Description of change
20 September 17	Ehrndal, M.	Initial draft of Scenario
24 September	Hofer, M.	additions
27 September	Hofer, M.	Final version

Greenhouse

Age and Level:

Jenna is a 13-year-old student in Helsinki. She cares deeply about the environment, and loves to take care of plants and animals. Her favourite school subjects are all related to natural sciences, and she is an independent learner who reads a lot about things she finds interesting in her spare time.

Primary Actor and main goal:

At school she has been introduced to programming and basic electronics, but since she didn't understand it instantly it affected her self-confidence. Jenna, having a perception of herself as a fast learner, is starting to think this is not her subject. She has also noticed that some commonly low performing students in her class seems to excel at these subjects. She wants to prove herself, but at the same time relate it to her interests to make it more motivating and meaningful for her.

Topic and Content:

Jenna's teachers, one technology teacher and one math teacher, want the students to work more cross curricular. This is the first year that they try to involve electronics and programming in their work together, and none of them have much experience.

Description of environment and possible pre-conditions:

The students are asked to work in pairs to realize their projects. Jenna wants to work with her best friend, Aina. They share similar interests, and as they have been introduced to Arduino and programming, they have also asked their parents to buy electronics to that they can learn at their own pace at home. Soon, Jenna and Aina agree that they want to build an automated greenhouse.

Preparatory work:

The teachers are not sure how to help them, they have only bought some kits with components and are not sure their idea can be realized. Most students have much simpler ideas, that the teachers can help to realize. Aina's father, who works in IT, knows about Arduino and Raspberry Pi, so he decides to help the girls order the material needed. He is later contacted by the teachers, so that he can share his knowledge on where to find components and educational resources with them.

Description of Activity:

Once the material has arrived, Jenna and Aina have a systematic approach towards testing them and putting everything together. As per Aina's father's advice, they split their problem into small parts, and test the solutions separately. Since they are both independent learners, they can find most information needed to build and code the core parts of their project by themselves. They test the light sensor first, to learn what values they receive in different light conditions. They then try the temperature sensor, and explore different way to build your own humidity sensor. Aina's father helps them to filter the captured data to make the values more stable.

Other Stakeholders and their possible Interests:

After spending some time realizing their spare time project, they decide to bring it to school to show it to their teachers. The teachers are impressed, and have Aina and Jenna present their project to the class. They also try to understand what resources and knowledge will be needed for themselves to support similar student projects to be created in school.

Success and condition:

The teachers learn that Aina and Jenna were able to build a more complex project not only because they had Aina's father as a support, but because they came into the project with no idea of how feasible it was. They were also able to realize the project independently as they did it at their own pace, driven by their own motivation and interest in the final result, and since they were both independent learners. In the end, Jenna and Aina had as much electronics knowledge and skills as the high performing students in the same subject.

Failure and conditions:

Without Aina's father helping out, the girls would not have had the support needed to finalize their project. The challenge for the school would be to make this visible, and provide the appropriate support. Jenna and Aina would perhaps not have had the opportunity to understand that they were as able as their other classmates in regards to hands-on technology. The eCraft2Learn systems ability to put the learners in direct contact with experts would make this scenario possible for more students.

4.4. PRANK MACHINE

Revision History

Date	Author/contributors	Description of change
20 September 17	Ehrndal, M.	Initial draft of Scenario
24 September	Hofer, M.	additions
3 October	Hofer, M.	Final version

The prank machine

Age and Level:

Elias is a 14-year-old student in Helsinki. He has a hard time concentrating in the classroom, and has started to skip some classes to hang out with friends around town. His main hobby is playing online video games with his friends. Since he has a lot of experience that he is also good at sharing, he is the leader of two MMORPG guilds. He has his own game oriented YouTube channel, and has gained around 200 followers since he started a year ago.

Primary Actor and main goal:

His technology teacher has started to introduce the class to Arduino. To her surprise, Elias who has stopped attending her Physics class, is excelling at Arduino and electronics. Although he is dyslexic, he seems to have little trouble programming in the Arduino IDE.

Topic and Content:

As Elias's teacher had the students create their own technology projects, she noticed Elias' ideas were standing out, but seemed very complex to carry out. She still wanted to find a way to support his enthusiasm. Since he learned so fast, she made him and another one of his classmates, mentors for the other students.

Description of environment and possible pre-conditions:

The teacher plans it so that her students can come up with concepts 6 months before the deadline in December. Although she does have a small lab with basic electronics components that she started to build up two years ago, she knows final projects often meant materials had to be ordered. Since some components had to be ordered from China, sometimes with weeks of shipping time, she made sure to collect material lists as early as possible. This year, as she had started to collaborate with the woodwork teacher, she had a bigger budget for materials, and planned on buying some soldering irons, wire strippers, as well as a laser cutter. After some lessons learned from the previous year, they had decided to collaborate later in the project, to make sure everything got finished in time for Christmas.

Preparatory work:

The teacher asks the students to prepare a sort of 'concept' that outlines the idea behind, the usage, the materials and skills as well as knowledge they will need. As Elias is planned to help out with a range of his classmates projects, he also agrees to simplify his own idea.

While other classmates are planning to create functional projects, Elias wants to create something fun. His teacher had something different in mind, but decides to avoid discouraging Elias, now that he is finally enthusiastic about a school topic. Elias wants to create a prank machine, so that he can film his prank victims for his Youtube channel.

His teacher helps him discard offensive pranks as well as pranks that are too technically complex for the time at hand. In the end, the idea is to create a machine that senses when someone comes close to the school Christmas tree, and that triggers the song 'Last Christmas' at the same time as the Christmas lights start to animate in disco-like patterns.

Description of Activity:

As students are doing research on components needed, some have to change their concepts based on technical limitations and material cost. One project planning to use five servo motors and three ultrasonic sensors is completely discarded. Although it is expensive, Elias wants to order an mp3 shield for his project. His teacher knows that the best way to easily control several LED lamps is through using an addressable LED strip, so she helps him order addressable LED christmas lights.

As the ordered materials arrive, the students prototype and test them to learn more about the components they are planning to use. Elias is quite disappointed as he notices the mp3 shield uses so many pins on his Arduino board that he can't fit the other components and functions he wants in his project. He decides to use two Arduino boards, and brings the one he has personally brought to school.

Starting out, he tries out the mp3 shield with a special code library he has found online. Once he gets it working, since he found there to be few pins and power left for the sensor he had planned, he decides he will craft his own push button to trigger the song. The teacher helps him find tutorials online, and makes sure the textile teacher can allocate some time to help out ordering materials and sewing the button. Elias then finds resources online for how to connect and control the addressable LEDs he has ordered. He uses a PIR sensor to trigger a light animation when someone was close to the Christmas tree. The e-textile push button is made to be a carpet in front of the christmas tree.

Other Stakeholders and their possible Interests:

As Christmas break is approaching, Elias has his Christmas prank installed in the school's main hall. One day he decides to film the reactions, and edits a compilation of the best reactions. With the consent of the ones depicted, Elias then shares the compilation on his Youtube channel. It is spread locally in the school, giving him more followers, and it is suddenly shared on a famous blog authored by a "Maker".

Success and condition:

After some time, Elias starts to explore a new identity as a Maker. He contacts the blogger, and continues to expand his network as well as work on more advanced projects.

Failure and conditions:

It is being challenging for the teacher to evaluate the student projects according to the learning goals. Since the student projects are not framed by neither theme/topic nor technical solution, the variation of outcomes might make them challenging to realize and evaluate.

Variations:

The brief given was kept open, but could have been tied to specific technical solutions or related to certain theoretical topics

4.5. AIR POLLUTION BOX

Revision History

Date	Author/contributors	Description of change
18 July 17	Hofer, M.	Initial draft of Scenario
23 July 17	Hofer, M.	revision
24 July 17	Fischbacher, A.	Discussion, second revision
25 September 17	Ehrndal, M.	Revision of content
3 October	Hofer, M.	Final version integrated

Air pollution measure box

Age and Level:

Anna, 39 years old, is a second-grade student teacher for Biology, Maths and Physics in Austria. The new system of ‘Neue Mittelschule’ is meeting very much her personal way of teaching. A personal attitude of her being as teacher is to enable and empower students and connecting theoretical knowledge with practice. Thus, she is balancing her teaching a lot with different teaching methods and pedagogical approaches. She also tries to foster team work amongst the students since she is convinced that this is a core skill for the next generation. She tries hard to integrate the obligatory curriculum plan with the student projects, and is getting better at this every year.

Primary Actor and main goal:

Anna lives on the countryside in the mountains. Since ozone pollution is higher in the mountains, she plans to raise the awareness of her students towards air pollution. Last year she had everyone collaborate on the same project, but this year she wants the students to be freer to come up with their own ideas. She decides that all projects need to incorporate some specific technical components, and that they need to bring awareness of the invisible concept of air pollution.

From previous projects she knows that most of her 14-year-old students only have very basic skills in electronic or even programming, but all of them are very capable to handle different programmes. Some of them did amazing crafting the year before. As for herself, she has to confess that her abilities in programming or crafting is limited thus she is aware that she would need very clear and detailed instructions to get started on a project. Some time ago she talked to her colleague Mike who teaches IT in the class and he was willing to collaborate in case she finds an appropriate project that fits also to the IT curriculum. Together, they agreed all students would need to technically incorporate at least one sensor input, and any type of output. Apart from that, the students would be free to innovate.

Topic and Content:

Searching on the internet, she discovers the eCraft2Learn platform and decides it’s the perfect tool for her students since it supports team work. It provides her a frame for how to plan for her current as well as future student project assignments.

Reading on the instructions, she understands that she will need to provide prior to the project, some theoretical background knowledge to air pollution but since these fit well with the current school year curriculum she continues reading the other teachers experiences that have been shared on the eCraft2Learn platform.

Description of environment and possible pre-conditions:

Anna and Mike start by looking through the electronics and tools inventory from last year, to sort out all broken components. This takes longer than expected, and Anna decides that next year she will do this as soon as the term has ended.

After they have spent some time researching what materials and tools to purchase for the pollution theme, Anna calculates the related costs for materials needed. After making sure the cost falls within the yearly budget, Anna pays a visit to the local electronics store in the outskirts of the town. She spends the following days sorting components into compartments boxes, and makes sure to label all components and resistor values. She learned this from last year, as all components and resistors quickly became a mess.

Mike makes sure to update the computer rooms software with the latest version of the Arduino IDE. He also makes sure all students have access to the eCraft2Learn platform that has been installed in the classroom.

Preparatory work:

Two weeks later Anna starts with the educational content preparations. She decides to give some first initial input before starting the project in order to allow the students to gain a broad context of pollution, talking about atmospheric ozone, carbon dioxide emission, methane gas, and other substances that affects air quality.

Starting out, she wants all students to follow instructions to connect an Oxygen(O2) gas sensor, to read the values with an Arduino. This ensures individual assessment. For the project, she and Mike then give them the exercise to use incoming sensor values, from a gas sensor of their choice, to control an LED, a motor, a Piezo, or any other component. This, along with an explanation of what their code did, was the minimum technical solution and deliverable they needed to implement in order to pass Mike’s IT class learning goals.

Anna, on the other hand, was more interested in the biological pollution aspect, as well as the introduction of mathematical concepts such as < (smaller than), and >(bigger than) being used in the conditional statements. Other than that, she is also interested in how well they are able to collaborate and execute a project in groups, and plans to have the students keep a log of what they are doing. She later finds this type of activity tracking is partially integrated into the eCraft2Learn system.
She books the IT room and the crafting room in accordance with Mike, gets the o.k. from the headmaster and organizes the needed materials (Arduino boards, jumper wires, breadboards, gas sensors, and various other electronic components).

Description of Activity:

Anna gives her students the task to learn about air pollution. She splits her students into eight small groups, and ask them students to list causes, solutions, and to locate what gases are polluting the environment, and how. The students are told to work in groups to visualize the findings in one poster, and are then paired with another group to present their findings. The paired groups are then instructed that they now work together, and that they are supposed to create an interactive system that can detect one or more types of air pollution, and then carry out one or more actions(outputs). The teams brainstorm, present their ideas, and are given feedback on them based on relevance, usability, and feasibility. The concepts students have created are;

- A sensor box that opens a window when CO2 levels are too high
- A fart (methane gas) sensor that makes a Piezo beep as a threshold is reached
- An Ozone map (built to represent ozone levels in different areas around the school)
- “Bach’s air” - a portable instrument made out of sensors. The different inputs are transformed into tones for different instruments or music loops.

Anna and Mike meet the teams one by one, to help them iterate their ideas, and to understand what tools and materials they will need to complete the projects. After a few days, the 4 teams meet in the drafting room. Anna and Mike have brought the materials each group needs, meaning the practical part of the project has begun. Students take on different roles in the teams, and to ensure everyone are actively involved, they meet with the teams and have them describe their work. every week. The teams are encouraged to solve the problems they stumble upon on their own, and during the weekly support meetings they mainly get hints and links to relevant resources. They can also book Mike for an hour to help out with the soldering of the circuits.

Most groups have similar problem, such as dealing with gas sensor warm-up time, and setting appropriate threshold values. Some groups want to build their electronics into boxes, and get help from the wood crafting teacher. Anna and Mike decide to plan for her to be on board for the projects next year.

After five weeks it is time for final presentations. The students are asked to give a background description based on their initial research, demonstrate their prototype, and to talk about what they’ve learned throughout the process. One group of students are not finished, and their prototype is only half done.

They are asked to present their project later, and are told they cannot get the top grade for their project.

Other Stakeholders and their possible Interests:

As the wood craft teacher is contacted by the students to help them build cases for their electronics, she starts to imagine ways to incorporate these types of projects in her curricular activities. She starts to think about complex mechanical structures, as well as product design angles.

After discussing her thoughts with Mike and Anna, she decides that a laser cutter and an Ultimaker 3D printer should be purchased for next year. They also agree to collaborate more the following year, and have at least three cross curricular student projects that can be executed in a similar way.

To ensure their hours can be scheduled in synch to make this happen, they talk to the school principal. The principal is positive to this development, and encourages the teachers to present this at the next teacher meetup so that it can inspire other subject teachers to do the same.

Success and condition:

One week after the project is over, the last student group is able to demonstrate their prototype and get their grade. They are asked to write a post mortem to reflect on what they could have done different to deliver on time. In the end, all four teams were able to conduct research, create concepts, realize their ideas, and present their project and share what they learned to the class.

Failure and conditions:

Anna and Mike learned that their schedules needed to be more in synch, that they lacked the time, knowledge, materials and tools to build the electronics into physical objects. It was hard to keep track of the students' individual contributions to the teams, and this was something they wanted to improve for the following year.

Extensions:

Some students started tinkering after school, and would create interesting devices at home.

Variations:

The brief given to the students could be made more defined or open depending on the topic. The themes and topics could be varied as well.

5 CONCLUSION AND OUTLOOK

The present document has been further elaborated on different use cases and presented also some first personas. The grounding information to enable this elaboration was based on different sources like interviews (performed in WP2) and the feedback of teachers, two data sets of questionnaires as well as experiences made during workshops.

In the weeks and months following the submission of this deliverable, the user cases will be further developed. However, it is expected that also additional use cases will follow, depending on the concrete ideas that will be assessed by i.e the teacher training workshops, the technological development in the eCraft2Learn environment and the different discussions on pedagogical, technical and practical level. Further, additional personas will be elaborated in the last and final set of Deliverable 3.2. They will allow increased insights into concrete needs of users and consequently influence also the advancement and adaptation of the eCraft2Learn environment.

6 REFERENCES

Parini, J. *The Art of Teaching.* New York: Oxford University Press, 2005.

Major, C. H. *Teaching Online: A Guide to Theory, Research and Practice.* Baltimore: Johns Hopkins University Press, 2015.

ANNEX 1: INTERVIEW GUIDELINE SEMI – STRUCTURED

eCraft2Learn
WP 3 - semi structured Interview guideline for facilitators

to be used for creating

a. Personas and
b. Use cases (II)

considering also:

- Needs of WP2
- Needs of WP 4 - technical requirements
- Information needed for dissemination purpose - WP 6

Inform interviewee about purpose of the interview and the right to ask for anonymization and also the usage for dissemination purpose.

Questions for the eCraft2Learn Joensuu Workshop (SciFest) facilitators:

1. Tell us about yourself! What is your **background** and what experience do you have in which area(s)?

2. The workshop you did in Joensuu

    a. Can you describe a bit about the planning of the workshop, the preparations, and what has happened there?
    b. What was your specific role there?
    c. What was the **learning goal**?

3. How did you set up the learning activities?

    a. Was it easy for you (asking for **environment incl. barriers**, **conditions**, ...), or rather difficult?

4. Can you tell us a bit about your learners/participants?

    a. How well did they handle the technology and programming?
    b. Did they have many questions?
    c. Any specifics you observed like special interests, knowledge, abilities, ...

5. What **technologies** did you use with your learners and **why** exactly those?

6. Where there other people, supporting or other stakeholders? For this informal setting how many ‘advisors’ would be ideal?

7. Did you have the impression that the workshop was a **success or a failure**? If so, why?

8. What are the most important things to consider when planning a learning activity/ project?

9. Would you do something differently? If so, what exactly?

10. What items should the eCraft2Learn platform/system contain?

11. Anything else you observed or that you would like to add?