eCraft2Learn

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

Deliverable D3.4

Manual of project- and craft-based learning STEAM training for teachers

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

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EXECUTIVE SUMMARY

This deliverable will design and develop teacher education and training courses material taking into account the following features: personalised and adaptive learning context including the concepts and the elements of craft- and project-based learning pedagogical approach; offering positive experience through hands-on activities; and support for orchestrating the whole process including the management of the technological resources. This deliverable consists of the basics of the project- and craft-based pedagogy, STEAM education and opens the basic concepts of the technology that is being used during the training – including the plan for the training.

1 INTRODUCTION

This deliverable will design and develop teacher education and training courses material taking into account the following features: personalised and adaptive learning context including the concepts and the elements of project- and craft-based learning pedagogical approach; offering positive experience through hands-on activities; and support for orchestrating the whole process including the management of the resources (3D printers, DIY electronics, etc.). This deliverable can serve as pre- and in-service teacher education in order to prepare teachers to implement eCraft2Learn in schools. In the workshops, teachers are prepared to their new roles as coach, facilitators, and enablers. Given the teachers hand-on experiences on how to work with the eCraft2Learn ecosystem (Figure 2) in the same ways that they are expected to work on and act in it with their students.

2 FOUNDATIONAL KNOWLEDGE OF PROJECT- AND CRAFT- BASED LEARNING - STEAM TEACHER TRAINING

"Imagination is more important than knowledge" - Albert Einstein

STEAM is used here as an educational approach to learning. In this approach, **science**, **technology**, **engineering**, **arts** and **mathematics** are seen as access points for guiding student activities, such as inquiry, dialogue and critical thinking, which enhance learning. This approach is assumed to produce students who take thoughtful risks, engage in experiential learning, persist in problem-solving, embrace collaboration and work through the creative process. With regarding the arts and the skills students are expected to possess can be developed through product design, where introducing new digital technologies can encourage the incorporation of new materials and disciplines.

The eCraft2Learn framework is built on the ideas of inquiry- and design thinking-based approaches. We shall utilise an inquiry-based approach, more specifically called project-based learning (PjBL), which is based on the idea of inquiry and problem-solving processes. In PjBL, the learning process is constructed around projects in which the students are working (see Blumenfield et al., 1991). Students have the freedom to choose the subject matter and to define the central content of the project they want to work with. Products like computer animations and websites can trigger communication and collaboration (see Blumenfield et al., 1991; David, 2008; Helle, Tynjälä, & Olkinuora, 2006; Tal, Krajcik, & Blumenfeld, 2006). Students develop their own questions, which are open-ended and which may lead to diverse solutions (Savery, 2006).

The cross-cutting idea of the eCraft2Learn pedagogical design is personalised learning, which is a progressively student-driven model. Zmuda, Curtis and Ullman (2015, p. 7) note that in "personalised learning, a student is deeply engaged in meaningful, authentic, and rigorous challenges to demonstrate desired outcomes". Personalised learning also serves as a base for a project-based approach because of meaningful and authentic challenges. Moreover, the project-based approach includes different stages whereby the student is proceeding progressively. It is a student-driven model with more or less degrees of freedom, depending on the student's prior knowledge and experience and the task and goals of the curriculum.

21st-century skills include i.a. of skills of collaboration - negotiation and communication - and creativity, critical thinking, problem-solving and learning to learn skills as well as ability to use technology and engage in real-world tasks (see Bell, 2010; Binkley et al., 2012; OECD, 2010). These skills are reported to be the core skills in the knowledge society as well as in the work life. Students should embed these skills when finishing their basic education for being ready for further continuing their studies and taking steps to the work life. The nature of working life is changing rapidly, just like the society as a whole, therefore we cannot prepare our children for something that is not yet known, but equipping them with the skills that they manage is the best thing to do. Because the information and technology are available, but the skills on how to get the information what is needed, how to utilise it and how to make the best out of technology, we create the ecosystem around this project where we can practice these skills in the safe environment.

We do know that inquiry-based learning processes and working in teams can be challenging for students (Kollar, Fischer, & Slotta, 2007; Linn, 2006). In particular, when students are mostly working in teams, they face several challenges, which might occur due to lack of engagement on knowledge-construction processes regarding formulating questions, challenges, collecting evidence, interpreting results, explaining and evaluating these explanations and the process or different processes of project work (Mäkitalo-Siegl, Kohnle, & Fischer, 2011). Therefore, support should be offered in order to help students with the inquiry-based and design-thinking processes as well as with working in teams. This kind of support might require expert guidance or scaffolding as well as small group scripting. However, an open question is whether those students who are facing challenges are using the help that is available from multiple sources (e.g. teachers, peer learners, experts, the online environment; see Mäkitalo-Siegl & Fischer, 2011; Huet et al., 2013).

We endeavour to connect the project to a realistic context – students' everyday life – so that they can see the relevance of this project and the connection between school (school subjects) and the world outside of school (see also digital fabrication and making in education; Blikstein, 2013; Gershenfeld, 2007). Students explore the world in order to identify questions or puzzling situations, which might then turn out to be a problem for which they have to find a solution. The student is active, taking responsibility for his or her own learning. It gives him/her an opportunity to engage in an in-depth investigation of worthy topics. This approach gives the learner greater autonomy when constructing personally-meaningful artefacts, which are seen as the representations of their learning (Grant, 2002, p. 1).

STEAM provides a way to engage boys and girls of all ages to explore the idea of electronics and technology (Magloire & Aly, 2013). The inclusion of arts and craft in science projects enable a space for creativity and innovation during the process. Electronics and technology as learning subjects usually attract more boys than girls, and girls have traditionally been more attached to artefacts when the product was meaningful to them (Magloire & Aly, 2013). According to Fristoe, Denner, MacLaurin, Mateas and Wardrip-Fruin (2011), girls' interest in creating games is mainly in the context of *relationships, social interactions and storytelling*. Therefore, working in teams could fascinate girls because of the social interaction aspect (Mäkitalo-Siegl & Fischer, 2013) as well as arts and craft (Magloire & Aly, 2013) to work with projects involving electronics and technology. Weber and Guster (2005) have studied gender-based preferences towards technology. The population of their study consisted of middle school students and high school technology education classes. They found no differences in activity between genders; however, significant differences were found in relation to design and use. "Females found design activities more interesting whereas males preferred utilising types of activities" (Weber & Guster, 2005, p. 59). "Since making is based on what is personally relevant to an individual, it allows people of all backgrounds to pursue their interests and to use technological tools to develop their own projects. It can create more channels for girls to positively identify with computer science and engineering fields" (Intel Report, 2014 p. 7).

3 PERSONALISED LEARNING AND ADAPTIVE SYSTEM

Every student has an individual background of knowledge, experience and skills. Personalised learning aims to tailor teaching to individual needs, interests, and aptitude to ensure that every learner achieves and reaches the highest standards possible (Heller, Steiner, Hockemeyer & Albert 2006, 75). Therefore, we need a system that can adapt the personal needs and interest of learners in order to provide both learning content and pedagogic environment/methods for the student (Nguyen & Do 2008, 395). The eCraft2Learn-ecosystem will adapt to the need of the students and teacher.

The cross-cutting idea of the eCraft2Learn pedagogical design is personalised learning, which is a progressively student-driven model. Zmuda, Curtis and Ullman (2015, p. 7) note that in "personalised learning, a student is deeply engaged in meaningful, authentic, and rigorous challenges to demonstrate desired outcomes. Personalised learning also serves as a base for a project-based approach because of meaningful and authentic challenges."

Miliband (2006) defines the personalised learning through five components. 1) It emphasizes knowing the strengths and weaknesses of each student and the assessment of learning. 2) Developing the competence and confidence of each learner through teaching and learning strategies that build on individual needs. 3) Every student has the possibility to enjoy the curriculum choice – they are engaged and excited by the curricula. 4) The starting point for the class organisation is always student progress. 5) The community, local institutions and social services support schools to drive forward the progress (Miliband 2006, 25-26).

By using the project-based method, where different stages are included the student proceeding progressively and by their own pace as well as selecting the theme based on their interest. Therefore, we could state that project-based method used is supporting personalised learning. Moreover, it is a student-driven model with more or less degrees of freedom, depending on the student's prior knowledge and experience and the task and goals of the curriculum.

The assumption is that the students don´t have much previous experience of making robots - they choose the path for their learning approach which can be more advanced or for beginners. Students are able to choose their learning/working path through the platform which includes short videoclips that instruct students to plug the wires, to programme and execute the 3D printing. These videoclips are also presenting innovative artefacts and what previously has been done.

4 THE ECRAFT2LEARN PEDAGOGICAL FRAMEWORK

The eCraft2Learn pedagogical framework is developed within five stages and is based on the idea of the project- and craft-based learning within open learning scenarios. The five pedagogical stages are as shown in Figure 2. The students´ learning process is supported in every stage with proper technologies which are a part of the eCraft2Learn ecosystem as well as teachers and experts are.

The eCratf2Learn project- and craft-based learning methodology consist of five stages; ideation, planning, creation, programming and sharing (Figure 2), that aim at learning through projects and producing a computer-supported artefact. Usually, inquiry-based learning is initiated when students pose questions, problems or scenarios and the process is supervised by a "coach" (teacher acting as a coach). Students identify study issues and formulate questions in order to develop their knowledge or solutions. The process is intrinsically argumentative, where the students create questions, obtain supporting evidence to answer the questions, explain the evidence collected, connect the explanation to knowledge obtained from the investigative process and finally create an argument and justification for the explanation. Inquiry-based methods are usually related to scientific activities and scientific thinking in STEM. However, we refer to STEAM when there is need to take into account arts and craft and therefore, we integrate inquiry-based method with Design Thinking method where hands-on activities are highlighted.

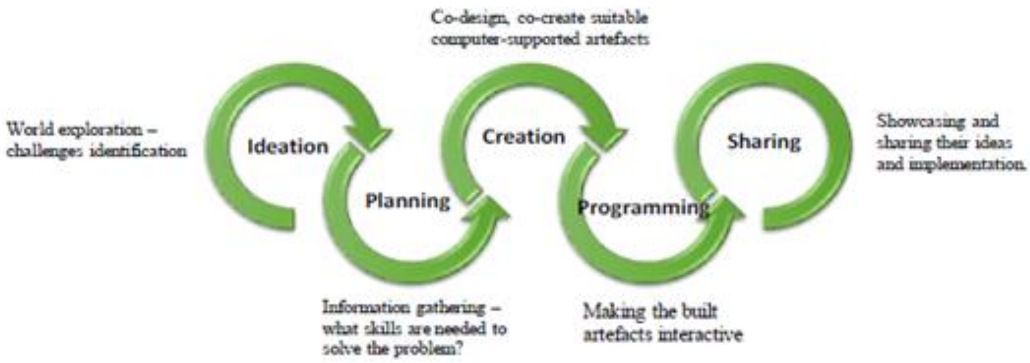

Figure 1: Five stages of craft- and project-based learning methodology

5 eCraft2Learn-ecosystem

Elements of educational ecosystems include e.g. redesigning (physical) learning spaces, Integrating physical learning materials (e.g. electronics or 3D-printed ones) with their software counterparts (e.g. simulations) and remodelling and training for teachers (see Dillenbourg, 2008). The eCraft2Learn ecosystem is designed and developed to work as the pedagogical framework which is based on open education resources. The learner plays an active role in the practical making of connected artefacts. The eCraft2Learn pedagogical model enhances learner's awareness of learning process and self-regulation (which includes self evaluation). It promotes the learner's pathway by enhancing the design of technology implementation and designing the necessary support available (WP4). Pedagogical model also meets users' needs and increase users' engagement through a participatory design approach. Model supports teacher's role as a coach. The eCraft2Learn framework is designed to support learners, teachers, peers and sometimes facility managers in making the crafts-based learning ecosystem happening. (see Technical annex, eC2L)

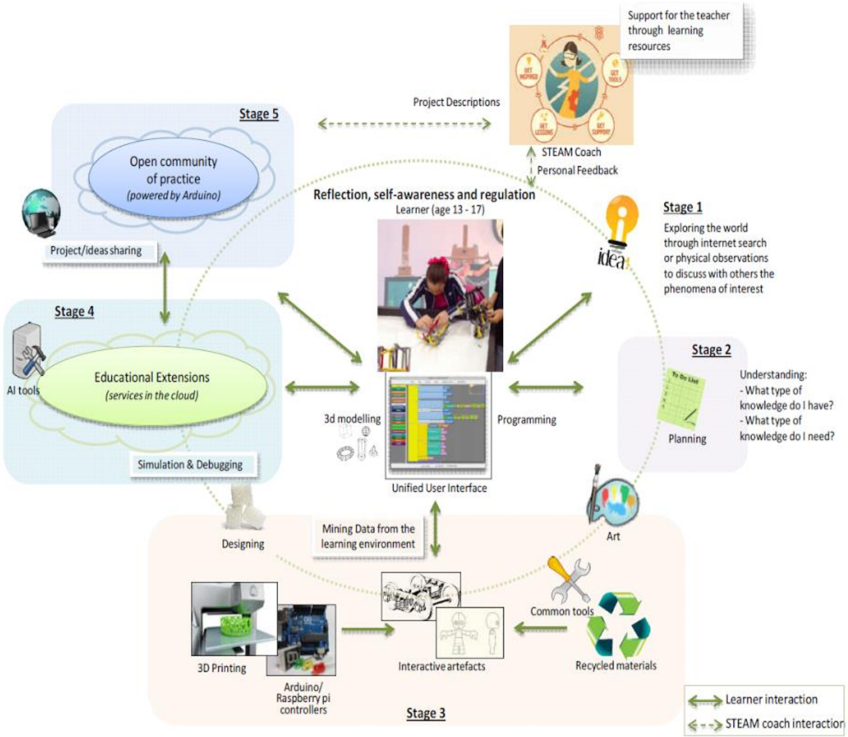

Figure 2: eCraft2Learn ecosystem indicative scenario

5.1. ROLES IN ECRAFT2LEARN ECOSYSTEM

The eCraft2Learn ecosystem deploys a craft- and project-based methodology. The ecosystem consists of a web-based eCraft2Learn working platform, aimed to cater for all relevant stakeholders; learners, teachers (coach, facilitator) and experts. The eCraft2Learn learning ecosystem creates a collaborative, 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.

Students are learning peers, each with their own set of strengths and weaknesses. They all are somewhere on the learning curve, and by helping each other and working together they progress together, often faster than when working alone. As the project advances, they learn with and from each other. Students can take on roles during the process of building their personal skills. Everyone has a chance to participate with his/her own know-how. According to Robertson et al. (2013), design team members may work in different roles during the process, e.g. project manager, technology specialist, design partner, researcher, learning scientist, collaboration facilitator, etc. In this way, students learn that more heads are better than one and that different people have different expertise, which contributes to richness. They learn how to collaborate, communicate and reason (critical thinking skills) and how to be creative in a group.

The role of the **teacher** or ‘coach’ is to facilitate and steer the learner and the project ‘back on track’ when needed. The teacher, who most likely already knows his/her students, encourages them to explore and seek information from different sources instead of giving complete answers. The teacher also encourages peer learning, discussion and exploration. According to Boling and Smith (2014), the one who works as an instructor spends the working time discussing with students and confronting their challenges.

The eCraft2Learn working platform is designed to be easy to approach and use. The platform encourages the learner to share thoughts and ideas. It contains videos on creating DIY artefacts and references hyperlinked to reliable, original information. At the same time, the platform works as a portal where previous projects are documented. On the eCraft2Learn working platform, there is an opportunity to get online help from an expert who has the requisite knowledge. Experts encourage students to ask questions and present their ideas. Experts give concrete examples, share their own knowledge, give constructive and positive feedback. In the online platform, students can utilise carefully planned prompts in order to help them to proceed to each stage.

Experts can assume different work roles to support the learner through challenges encountered during the project in online or face-2-face situations. The expert’s role thereby varies during the five steps of eCraft2Learn’s project-based learning. The student can be seen as an active worker who works in the group, explores, finds solutions to authentic challenges, searches for information and solves problems. Experts can work with coding, robotics and design. In the following segments, there is a more detailed description of the stages of craft- and project-based learning with the role descriptions included in each stage.

5.2. Description of the workshops in May 2017

In order to preliminary test the suitable integration of the 5 stage pedagogy with the core technology hardware and software tools we selected for the eCraft2Learn ecosystem, a preliminary eCraft2Learn Workshop was organized in May 2017 in Joensuu SciFest 2017 international event. Five groups of around ten participants (aged 10 to 16) from five different schools were divided into smaller groups to create 'robot heads'. Creating the robot heads proceeded based on the idea of five stages of craft- and project-based learning methodology; (1) Ideation, (2) Planning, (3) Creation, (4) Programming, and (5) Sharing. Notably, the first three stages seemed to mix during the development of the tasks, and *during this trial, these stages were not supported by all the technologies described here (3D printer was not available)*. Students had all the crafting material on their tables (e.g. paper, carton boxes, toilet paper rolls, scissors, pencils, tape, glue, LEDs, wires, sensors, etc.), as well as a Raspberry Pi computer running Scratch4Arduino (S4A) connected to an Arduino Uno running the S4A firmware, for programming. Students had a chance to explore programming first before starting to define their challenge. Pedagogically, creating and programming were integrated but only one group started with programming. The goal of programming was to make the eyes of the robot blink. After the eagerness of creating the robot head using all the material on the table, the enthusiasm diminished, as there was a time gap between the creation of the actual head and the programming session.

The technologies used in the workshops (RPis, Arduino boards, S4A software, and other electronic components) were suitable considering the development and the previous experience of the students. Still, clear and short instructional videos may be needed to help students to perceive what measures have to be done and in which order. This could ease to use the technologies and make it more approachable.

5 MATERIAL KIT

This section includes the basic information for the teachers about the technology which is used during the eCraft2Learn -teacher training. The material kit includes tools and materials for working. Creating an artefact in this context boils down to making something that makes daily life better, easier or more fun. The artefact is planned and prepared by using recycled materials combining them to new materials (3D-printing, led-lights, programming).

The level of complexity can be changed depending on what electronic components are included. This also supports the idea of personalized learning where the student can pick an appropriate and purposeful learning path. Drawing circuits with conductive ink or shaping conductive clay creates the same end result as soldering wires onto a PCB. And while visual and textual coding can produce the same result, the level of complexity is very different, as is the learning outcome.

In order to practice innovation, it is important that learners feel comfortable to go beyond the intended use of electronics and feel encouraged to explore alternative methods and uses for the tools at hand.

5.1 DIY ELECTRONICS

The maker culture is a hacker-related, technology-oriented culture deriving from Do It Yourself (DIY) culture. While DIY methods include building, modifying, and repairing objects without the direct involvement of experts or professionals, maker culture is similar; focused on the creation of new technological objects, or tinkering with existing ones. The interest of maker and DIY electronics have been growing ever since these tools and technologies became available outside the industry. Today, they are more affordable, accessible, easy to use, and in a democratising context based on information sharing philosophies derived from the open source movement. Programmable microcontrollers and computers such as the Arduino and Raspberry Pi, are often user-friendly and widely used by 'DIYers' and makers around the world. Contemporary, commercially available DIY electronics can be said to have a varying degree of difficulty of use. With everything from the plug and play magnetic components like Little Bits, to Arduino board kits with regular electronic components and documented experiments, and Raspberry Pi microcomputers - all with a wide range of learning materials accessible online. The choice of platform and electronics largely depends on target group and goal of use.

The availability of easy to use and cheap electronics, coupled with rich documentation and information sharing culture, has inspired pedagogues to integrate elements of maker culture into their classrooms. This kinesthetic hands-on learning approach has been seen as a complement existing pedagogical methods and materials.

We are referring to simple components, like connector cables, breadboards, photo resistors, potentiometers, servo motors and LEDs, which all can be used in conjunction with the RPI and the Arduino units, to implement the designed artefacts. These DIY electronics components, in conjunction with the RPI and the Arduino units and 3D printed parts, can cause a significant change for the better in how we learn.

Indeed, whereas software has already become increasingly more accessible to a broader audience, this is not always the case for hardware, where complexity and high costs for materials have been considerable barriers to learning. The eCraft2Learn project recognises the potential in digital fabrication and making DIY technologies; when coupled with proper learning methodologies such as learning by making these technologies can provide learning experiences that promote young people's creativity, critical thinking, teamwork, and problem solving – skills that are essential in the workplace of the 21st century. Hence, the 21st-century learning ecosystem should be designed in a way where students are actively engaged with the learning task, hands-on activities and with each other.

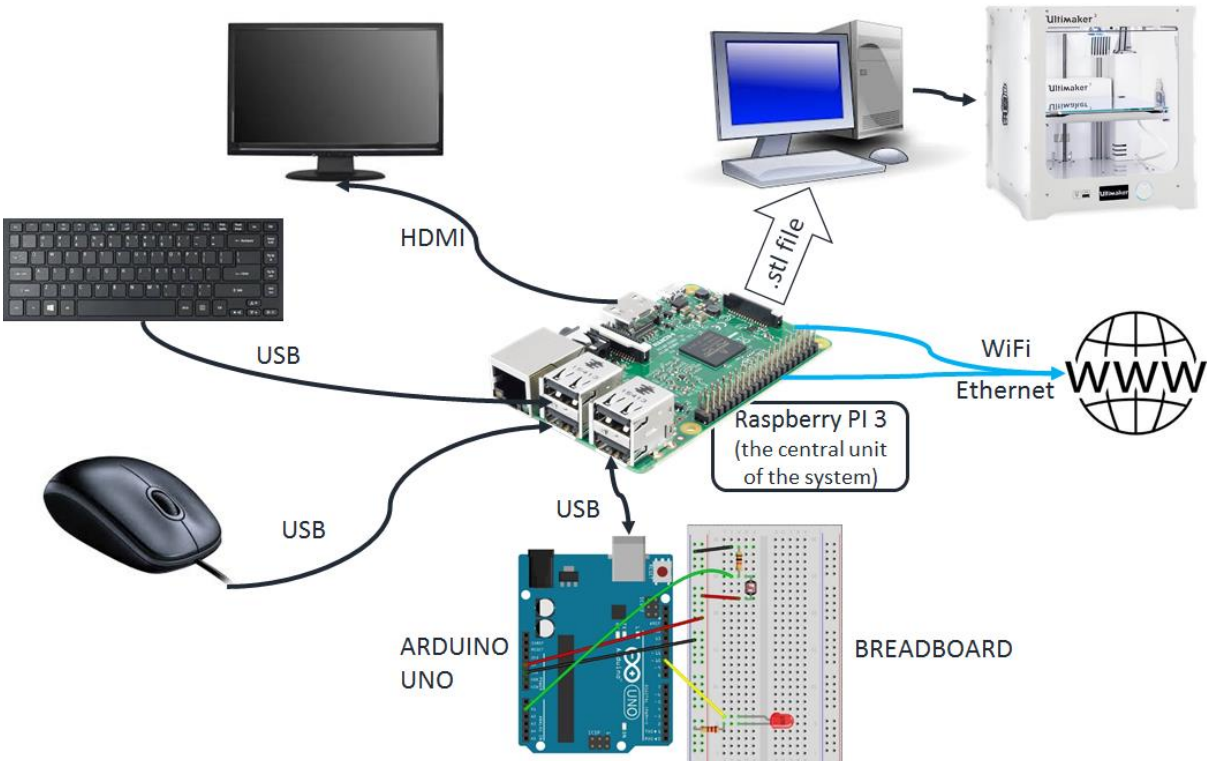

Figure 3: Representative hardware architecture of the technical platform in the eCraft2Learn ecosystem with a PC controlling the 3D Printer for generality. In the next months an implementation with a RPI3 controlling the 3D Printer will be investigated.

5.2 WIRING THE VARIOUS COMPONENTS

Two kinds of wired connection actions are necessary in order for the laboratory to operate and the artefacts to work. The first tackles with power supply and interconnection issues of the fundamental components of the lab, like the 3D printer, the Raspberry Pi based workstations or their screens. The second tackles with powering up and interconnecting the artefact themselves.

5.3 ARDUINO

Arduino boards are made to enable non-engineers to create interactive objects using electronics and programming. The board design, its extensive online documentation and online community makes

Arduino an ideal platform for learners. As Arduino was born out of the need to teach through hands-on prototyping, a beginner can easily make interesting things happen with little previous knowledge of electronics and coding. This enables learners to understand the general concepts early. The eCraft2Learn Raspberry Pi device, that as opposed to the Arduino is used as a desktop computer, will be used to communicate with external devices. In most cases, these external devices will be Arduino UNO boards, which in turn are exploited to implement computer supported artefacts. The user can the program, monitor and communicate with these artefacts - via the Arduino UNO boards - from the RP3 device interfaces.

5.4 Raspberry Pi

Raspberry Pi [https://www.raspberrypi.org/] is a credit-card sized computer that plugs into a computer monitor or TV, and uses a standard keyboard and mouse. It is a capable little device that enables people of all ages to explore computing, and to learn how to program in languages like Scratch and Python. It's capable of browsing the internet and playing high-definition video, to making spreadsheets, word-processing, and playing games. Furthermore, the Raspberry Pi has the ability to interact with the outside world, and has been used in a wide array of digital maker projects, from music machines and parent detectors to weather stations and tweeting birdhouses with infra-red cameras. (Deliverable 4.2)

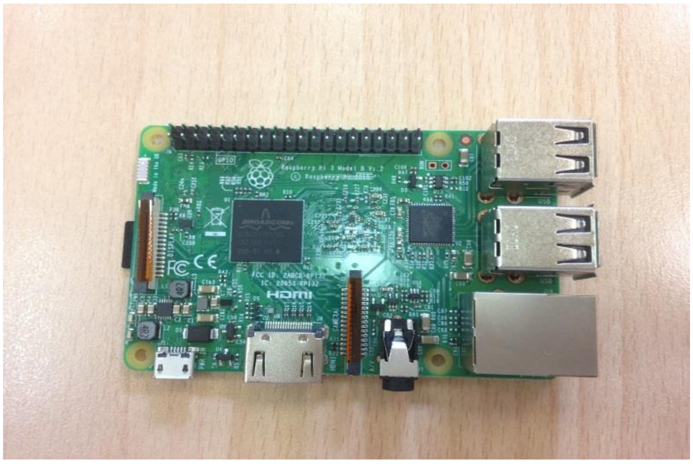

Figure 4: Raspberry PI 3

5.5 Printing

3D printing is widely used in different fields like in the medical field, healthcare and in surgery as well as in architecture and industry. The inclusion of 3D printing technology into the eCraft2Learn ecosystem, provides students with a means to design and manufacture physical components and/or parts that will integrate with the DIY electronics eg Arduino, in order to make their artifacts. This provides a real link between craft based activities in school with actual product development practices in industry. The eC2L-working platform includes examples of 3D printed artifacts/project integrated with DIY electronics.

The materials being fed into the machine (feedstock) can have inherent hazards and may release vapors and gases that may be more hazardous, for example, after they are heated during the 3D printing process. Within the laboratory we have to review the Review safety data sheets for feedstock materials before using. The 3D printing equipment is designed to use certain types of materials. The most common type of desktop 3D printer technology joins thin strands, or filaments, made of ABS (Acrylonitrile Butadiene Styrene) or compostable materials, such as PLA, a biodegradable thermoplastic aliphatic polyester derived from corn starch tapioca. Using a computer-generated image, a 3D printer heats and melts the feed material, placing layers of filament on top of one another to form a precise 3D replica of the image.

A NIOSH Research Rounds publication recently published a study that discusses health and safety considerations when working around 3D printers. Particle emissions are the focus, especially when multiple printers are running simultaneously. Another consideration is toxic vapors that can be generated by heating plastics. Safety recommendations include the following:

Use 3D printers ONLY in properly ventilated areas.

- Task ventilation may be useful for some styles of 3D printers.
- Choose low-emitting printers and feed materials/filament when possible.
- Wear proper personal protective equipment. Have a risk assessment to determine what is required.
- Purchase and use the manufacturer's supplied controls, such as an interlocked enclosure. (Enclosures appear to be more effective at controlling emissions than just a machine cover.)
- Maintain a safe distance from the printer to minimize the inhalation of emitted particles.
- Turn off the printer if the printer nozzle jams, and allow the printer to ventilate before removing the cover.

3D printers are best located in a room that has additional ventilation. Heating of certain thermoplastic filament can generate toxic vapors and vapors with high volatile organic compounds (VOCs). Most 3D printers do not come with an enclosure, exhaust ventilation or any filters. The following should be assessed before purchasing and installing a 3D printer:

- Building/Room where 3D printer will be located
- Placement of the 3D printer in the space itself
- Selection of printing feedstock

According to MIT the basic 3D printing rules and safety instructions are the following:

Hazards

1. Extruder and motors are HOT during operation
2. Extruder and motors may be HOT at any time
3. PINCH POINTS while machine is moving
4. Removal tools are SHARP

Dos

1. Do clean up after yourself
2. Do inform a mentor of machine errors or damage
3. Do inform a mentor of missing tools or supplies
4. Do ask a mentor if you have any questions or concerns
5. Do exercise caution when using cleaning tools

Don'ts

1. Don't use the printers unless you have been trained
2. Don't attempt to modify or fix a printer without mentor approval
3. Don't let 3D printing become lazy engineering!

Ultimaker 2+

This is the most common choice of Ultimaker 3D printer currently for schools as it is a great value all-around professional desktop 3D printer that delivers consistent results. Engineered to perform, the Ultimaker 2+ is user-friendly. With a simple display and control dial, even young students can operate this printer independently with a little prior instruction. The Ultimaker 2 Extended+ offers the additional benefit of an additional 10 cm of build height, perfect for larger prints that students may require.

Ultimaker 3

The Ultimaker 3 (fig. 4) is the most reliable dual extrusion 3D printer available, allowing students to print models in 2 colours or materials without pausing the print. This professional desktop printer allows for prints with more complex geometries to be created by using dissolvable PVA for printing the support structures. This provides greater opportunities for the student to realise more complex designs.

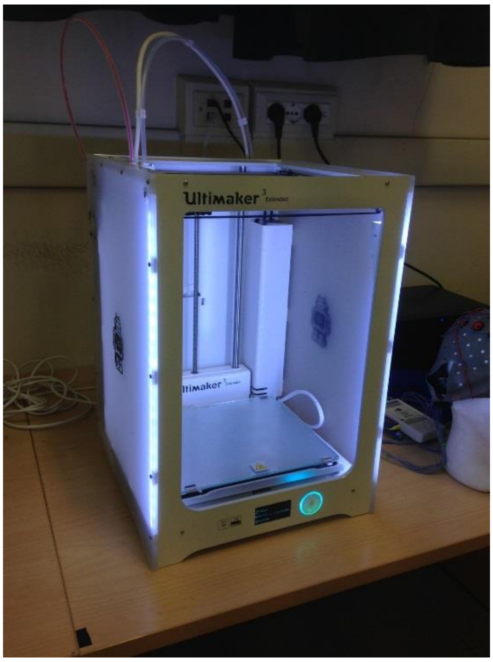

Figure 5: Ultimaker 3 printer

5.6 ECRAFT2LEARN-PLATFORM

The eC2L-platform is built to support the Five stages of craft- and project-based learning methodology (Figure 2). The platform provides support for ideation, planning, creation, programming and sharing. The platform includes relevant information produced and collected by professionals of technology and education. The idea is that the platform itself promotes the process of creating an artefact but also sharing ideas.

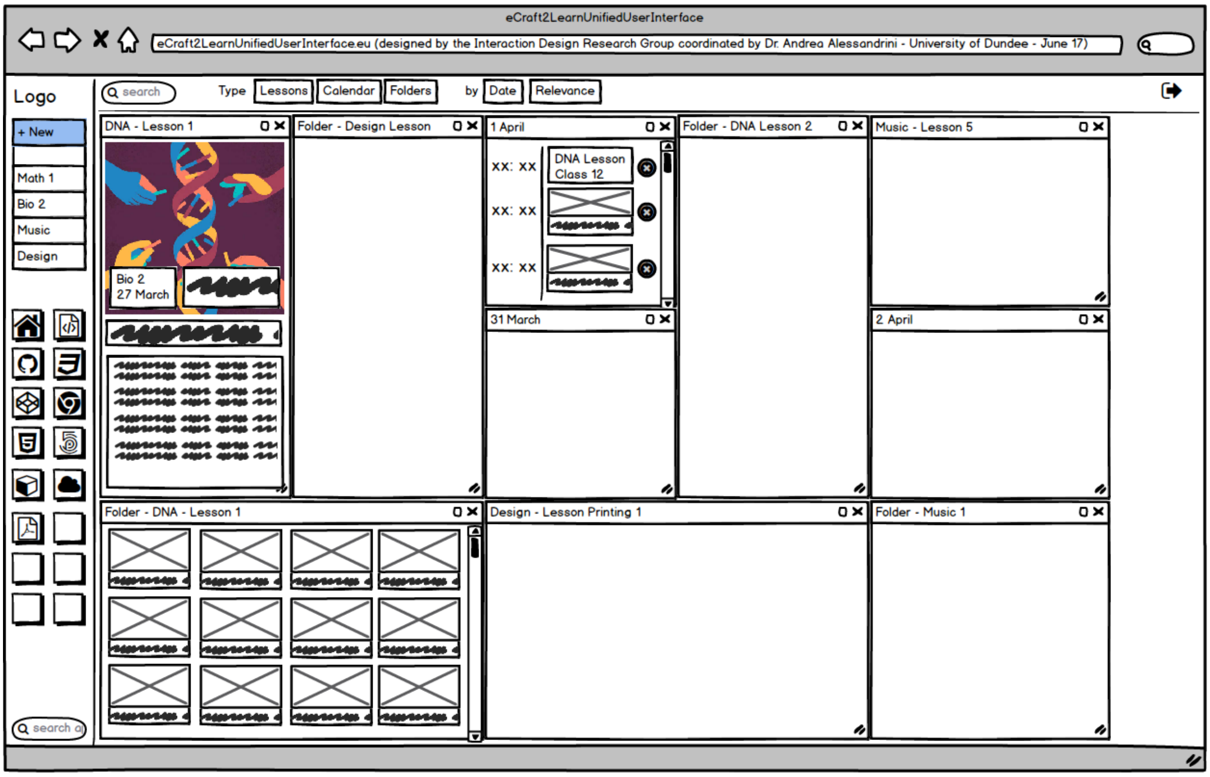

Figure 6: Sketch of the eCraft2Learn User Interface (UI)

5.7 AT THE END OF EACH LESSON

- Always unplug the raspberry Pi
- Always unplug all DIY electronics material
- Always unplug the 3D printer
- Put into a box the semi-developed projects
- Put into a box all materials and equipment that did not used
- Turn off all main power sources within the laboratory
- Open at least a window or door to properly flow fresh air within the laboratory especially after any 3D printing project
- Visual inspection of possible wire tears, short circuits that might cause injuries
- Visual inspection of moving mechanical parts and furniture of any damage

6 TRAINING PLAN FOR TEACHERS (20 H)

The intention of the workshop is to provide a model of teaching robotics, make it more approachable and easy. The aim is that the teachers will go through the same operations as their students. The workshop starts with “throwing teachers into the cold water”. After giving short and simple instructions the teachers are asked to build a robot head as in the pilot workshops during the SciFest 2017. Teachers are asked to give feedback of what they found familiar and what challenges they faced. They are also asked to ponder the integration into the curriculum.

1. Training plan 4X45min. ***“Throwing to a cold water - Build a robot head”***

AIM/GOAL	CONTENTS	TECHNOLOGY/MATERIAL	WAY OF WORKING
Knowing each other and forming the teams To **build a robot head** with the given instructions	Short instructions are given to teachers (“Andrea´s concept”) following the basic pedagogical element: 1. Ideation 2. Planning 3. Creation 4. Programming 5. Sharing Teachers are shown some photos of robot heads created by children in workshops at SciFest	Recycled material (before these lessons teachers may be asked to bring some material)	Working in groups, self-guided, problem-based
Teachers get their first impression of building robotics	Teachers start creating a robot head i n groups	Material kit is provided for teachers as well as the instructions for making a robot head Arduino RasperryPi Material for wiring	
To get feedback from the teachers - teachers reflect in groups (and share it to others) *what was difficult, what went well, what was learned,* ***how the done things were connected to curricula***	Discussion in groups/ sharing the results (artefacts and thoughts)		Feedback/ shared discussion Time for questions, wondering and pondering

2. Training plan 4x45min. *"GIVING THE TOOLS TO PLAY"*

AIM/GOAL	CONTENTS	TECHNOLOGY/ MATERIAL	WAY OF WORKING
45 min. Opening the **basic concepts** (eC2L, STEAM) > finding the connections to curricula Present the idea of "Five stages of craft- and project-based learning methodology"	Brief overview of Lab's environment Teachers to become familiar with the laboratory equipment Students are divided into smaller groups *Teachers create a mind map of connections to curricula*	eC2L-platform (supporting the presentation) Arduino uno Arduino IDE Ardublock or similar Sensor and actuator components	Small groups (facilitated by the trainer, discussion, creating mind maps)
45min. **Wiring (leds)** going through the basic idea of wiring (instructed by trainer & platform) **Arduino** **RasperryPi**	Teachers are divided into groups to sort out the principles of - Arduino & wiring (leds) Activities focusing on tablet devices visual programming and interconnection with RPI3 or Arduinos.	eC2L-platform Arduino uno Arduino IDE Ardublock or similar Sensor and actuator components Raspberry Pi 3 units remotely connected Sensor and actuator components	Peer learning Small groups
45min. **Familiarizing with 3D-printing (snap, scratch)** (maker too) - "Playing with printer" - "It takes 30min. To learn the basic settings"	Teachers are instructed to print - an existing model - they are given certain forms that they have to code (Snap, Scratch) print/ create something special (playing)	Ultimaker 3D-printer Videos on platform Trainer demonstrating Giving the possibility to use Snap and Scratch (or the apps that are familiar)	Peer learning
45 min. **Feedback/presenting and discussing what has been made**	Reflecting what has been learned? What could be the pitfalls considering the students (children)?		Peer learning

3. Lesson plan 4X45min. "STARTING THE CREATION OF AN ARTEFACT"

AIM/GOAL	CONTENTS	TECHNOLOGY/ material	WAY OF WORKING
Starting to create an artefact that can ease the everyday life (Facilitator presents the challenge) **Exploring the eC2L-platform and using it for ideation and planning** To ideate and plan an artefact which can solve a real life problem	Defining the problem Opening the eC2L-plaform, exploring it with the trainer, getting inspiration	eC2L-platform Videoclips (on the platform) of innovations and artefacts, what has been done 3D-printers, RasperryPi, leds (facilitator remind that above-mentioned tool are in use) Recycled material (combined with new material)	Students define the problem through conversation, making notes, taking photos.
To start working with the five stages pedagogical model (Figure 2)	1. **Ideation**	laptops, smartphones, web browser, google drive, eC2L-platform, Pinterest Peer teaching can be used during the exploring a new working plate (crossing the group boarders)	notetaking, conversation in groups, together, mind mapping, making collage or with other technique eC2L-platform is supporting the ideation as well as YouTube-videos (of DIY, robotics)
To plan the artefact	2. **Planning**	During the planning students make list of the material they will need for their artefact and activities they need to perform.	Students set a target for their working and organise the division of labour Making a collage
To start to create the artefact	3. **Creating**	eC2L-platform Recycled material 3D-printers RasperryPi leds	Organised in the division of labour

4. Lesson plan 4X45min. “CONTINUING WITH WORKING”

AIM/GOAL	CONTENTS	TECHNOLOGY	WAY OF WORKING
To continue creating an artefact	3. **Creating**	eC2L-platform 3D-printers	Peer learning/support Lesson is used for working, creating the artefact,
To start programming the artefact	4. **Programming**	Also previous apps can be used	Peer learning/support

5. Lesson plan 4X45min. "FINISHING AND PRESENTING"

AIM/GOAL	CONTENTS	TECHNOLOGY	WAY OF WORKING
To make the programming for the artefact	4. **Programming**	Possibility to use Snap, Scratch, some already-known app The eC2L-working platform/ instructional videos	Creating, programming proceed hand in hand
Sharing the result of the process (artefact)	5. **Sharing**	eC2L-platform	Presenting the artefacts to each other and through the platform/social media
Making a lesson plan (connected to research)	Teachers are creating a short lesson plan this works as a document what has been learned	Lesson plan is being shared on platform	Individually

7 CONCLUSION

This deliverable offers the basic information about craft- and project-based learning and STEAM education for training the teachers. This deliverable consists of the basics of the project- and craft-based pedagogy, STEAM education and opens the basic concepts of the technology that is being used during the training. The deliverable also includes the procedure of training. In the heart of this deliverable are the 5-step pedagogy and the idea of giving a tool to teachers to teach robotics and ease their path into it.

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