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eCraft2Learn

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

Deliverable D3.3

Open educational resources description

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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SYNYO GmbH, Austria, (SYNYO)
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EXECUTIVE SUMMARY

This deliverable (D3.3) describes the open educational resources (OERs) types that will be generated, produced or collected for the eCraft2Learn action. The OERs will form part of the eCraft2Learn digital platform to provide adaptive assistance to the learner (based on the learners' novice/intermediate/advanced profile) while interacting with and developing their projects through the unified user interface (UUI).

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1 INTRODUCTION

Open Educational Resources (OERs) have been defined as "technology-enabled, open provision of educational resources for consultation, use and adaptation by a community of users for non-commercial purposes" (UNESCO 2002). Pirkkalainen & Pawlowski (2010) define OERs as *freely accessible resources for educational purposes.* These open resources may consist of learning objects, articles and textbooks, software tools, instructional/didactical designs and assets like pictures, links and short texts.

The eCraft2Learn project aims at producing OERs linked to the personalised and contextualised use of the eCraft2Learn ecosystem. The produced OERs will be released under a Creative Common license the facilitates the free usage, modification and (re)sharing of the resources (e.g., CC BY, CC BY SA). In particular, this task (T3.3) will develop OERs for learners and teachers and lay the grounds for the development and implementation of structured access login to the resources so that both users are offered personalised and adaptive assistance. In personalised and adaptive learning context, there is a need to consider what the requirements for open educational resources are. We envision producing or collecting a pool of resources from where users can select suitable materials based on their needs, in order to proceed with the development of their work. Resources are to be accessed and shared easily, taking into account user's needs and skills. Furthermore, as teachers have a clearer view about their student's skills, needs and knowledge, open educational resources in the teacher's interface of the eCraft2Learn digital platform, will be presented such that teachers can easily build suitable "support kits" for a given project. Those customised kits can then be offered to the learners for certain educational level.

In the implementation of digital platform of the eCraft2Learn ecosystem, collecting digital traces of the learners' interaction with the digital resources as well as their reporting of their project's physical progress development will support the collection of learning analytics data for the creation of learners' profiles. These data will then provide support to the teacher/coach in their work. That is, based on the learner analysis, suitable help materials and steps on how to proceed with their craft- and project-based project learning will be offered. Furthermore, taking advantage of the open learning spaces linking classrooms to the outside world, the OER will provide access to educational online videos, reaching experts, consulting communities of likeminded spirits (e.g., Arduino kid forum) and so on. (Technical annex, eC2L). Moreover, the eCraft2Learn learning ecosystem aims at creating a collaborative, open, playful and non-judgmental environment that supports learners' creativity. Learners are encouraged to walk around and collaborate freely with peers and to share ideas and solutions with peers and teachers.

In this report, we describe the OERs put forward by the eCraft2Learn project for adaptive and personalised learning. The current OERs fall in the following categories: documents, descriptions and instructions, tools and materials, videos and other online resources.

2 Resource Types

Open educational resources will be described in terms of their access from the UUI. The open educational resources will be accommodated according to the users (teacher/coach or student) that is, once a project is loaded by the student or initiated by the teacher in their respective interfaces, resources available to assist with the development of the project will automatically made accessible to the user for easy access. This will also take into account the level of expertise of the student user, in order to facilitate personalised resources ranging from beginners how-to instructions to experts demo videos. Resources will be made available in the form of documents, videos, online links, short descriptions and instructions, and so forth, as described below.

2.1. Documents

Documents are text file resources created, for example, using the following extensions .docx, .odt, .txt, .pdf (this does not exclude using other text file extensions as needed). They provide explanation on the description of the project digital platform and on the frequently used theoretical concepts when developing a craft- and project-based learning experience within the eCraft2Learn environment.

2.1.1. Theoretical concepts

This document provides a description of the pedagogical aspects of the eCraft2Learn craft- and project-based methodology and its interrelation with technological deployments (see Appendix I). The theoretical concepts document describes the eCraft2Learn ecosystem taking into account the perspectives given by Dillenbourg & Fischer (2007) regarding the elements that an educational ecosystem should include, summarised as follows:

- Redefining learning objectives in light of new competencies gaining importance (creativity, communication, (autonomous) problem solving, entrepreneurial spirit, etc.);
- Training for teachers (explanations on the general eCraft2Learn ideology);
- Remodelling the role of teachers (explanations on the teacher's role as a coach within the eCraft2Learn ecosystem);
- Redesigning (physical) learning spaces (explanations on the technical core and its interrelation with pedagogical stages proposed in eCraft2Learn);
- Integrating physical learning materials and tools (e.g., electronics components, 3D-printed parts) with their software counterparts (e.g., simulations and programming environments through the UUI);
- Orchestrating the flow of learning (e.g., the interaction between explanation, practice, exploration, etc., as well as the five stages pedagogical model of the eCraft2Learn ecosystem) (see D3.1).

2.1.2. eCraft2Learn digital platform - the Unified User Interface (UUI)

This document provides information on the working of the project digital platform at a general level (see Appendix II). The description of the UUI is given at a general level using non-technical jargon.

2.1.3. Roles in the eCraft2Learn Ecosystem

This document provides information about the specific roles envisioned for the eCraft2Learn ecosystem. Within the ecosystem each user (i.e., learners and teachers/coaches/ facilitators) and experts (reachable through the digital platform), as well as the digital platform itself has a role to play. Those roles are defined and explained in the corresponding help document (Appendix III).

2.2. Descriptions and Instructions

2.2.1. Raspberry Pi

The technical core of the eCraft2Learn ecosystem will be deployed using Raspberry Pi 3 (RPi3) due to its characteristics, low cost, easy deployment and wide and active support community (see D4.2). Within the adaptive help that the digital platform will offer, demonstration videos on how to setup up the RPi3 will be linked from the Raspberry Pi foundation and presented to the teacher/coach's user interface for assistance[1]. These videos will also be accessible from the *How-to* section of the learners unified user interface.

2.2.2. Arduino board

In the eCraft2Learn platform, external devices such as Arduino boards will be used to control sensors and actuators. The user can program, monitor and communicate with the Arduino boards using the eCraft2Learn platform. Arduino boards have digital and analogue pins that allow users to control actuators such as LEDs, Piezo components, servo motors, DC motors, and the PWM technique provides some pins with the possibility to fade LED's, custom control DC motors, vibrators, etc. Input components used can be everything from simple digital buttons, to temperature sensors, light sensors, proximity sensors, motion sensors, variable resistors (such as potentiometers, flex sensors, pressure sensors, etc.), to more sensors that are tied to other communication protocols. The Arduino board provides the learners with ways to turn their projects into standalone, portable digital artefacts suitable for a wide variety of use scenarios.

2.2.3. 3D Printing

3D printing is now being used across a wide range of industries including engineering, automotive, aerospace, construction, architecture, medicine, product design, food and fashion and is influencing

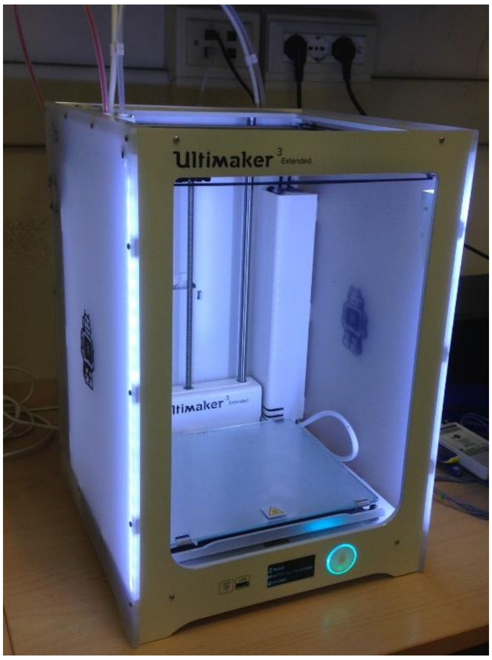
[1] https://www.raspberrypi.org/help/videos

many production techniques and systems. 3D printing technology was initially used in industry for rapid prototyping and this is still the most commonly use. However 3D printing is increasingly being utilised as a production technique for producing tools, jigs and manufacturing custom parts, and it is rapidly evolving to be used a manufacturing tool for production of final parts and products.

3D printing technology enables students to fully engage with the iterative design of product prototypes. Even if the final product is manufactured using other materials and techniques, during the design development stage small-scale models can be quickly produced in order to test out ideas. Rapid prototyping allows students to produce multiple design iterations in developing their prototypes.

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 e.g., Arduino, in order to make their artefacts. This provides a real link between craft based activities in school with actual product development practices in industry.

In its simplest form, 3D printing can be used for manufacturing high quality custom casings with complex and/or creative geometries for electronic components and parts in order to produce a product prototype. To take this one step further, 3D printing can be utilised to manufacture the product itself, this can have spaces for housing elements of the product such as custom electronics but also programmable components can be used and embedded into the design of the 3D printed product. Examples projects include robotic devices, programmable vehicles and custom mechanical devices/machines that solve a particular problem.



3D printing design skills development - students should develop their knowledge of the following key concepts and skills in order to produce good 3D models and prints.

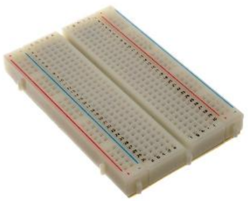
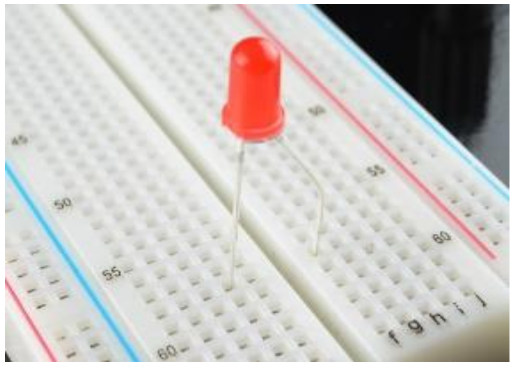
- The 3D printing process
- 3D modelling - extrusion to 3D from a 2D design
- 3D modelling - using 3D CAD software
- Designing models for 3D printing
- Slicing 3D models and preparation for 3D printing
- 3D printer controls - inserting and changing filament; starting, pausing and aborting prints
- 3D print troubleshooting

In the project, Ultimaker2+ and Ultimaker3 3D printers will be used due to their characteristics and suitability to the project (see D4.2).

2.2.4. Tools and Materials – Electronic Components for Learning

The tools and materials used within the eCraft2Learn ecosystem are described below, as they would be presented for each skill level of the learner. The list of tools and materials will increase as the eCraft2Learn ecosystem deployment advances.

Category	Novice	Intermediate	Advanced	Example
General definitions	**Input device** A device used to capture and pass data to the circuit that is built. Examples: microphone (capturing sound), webcam (capturing image/video), button (capturing a push), etc. **Output device** A device that, when current is applied, can affect the physical world somehow, through for instance showing light, making a sound, or making something else to move. Examples: LEDs, speakers and motors. **Sensors (inputs)** there are digital or analogue sensors. Analogue sensors have a continuous reading (from 0 to 1023, for example) over time (like photocells or temperature sensors). They must be connected in the Arduino analogue ports. **Digital signal** Digital signals have a set span of values. When you use an Arduino, digital signals are either On or Off - 'HIGH' or 'LOW' - 0V or 5V/3.3V. On an Arduino board, there are 14 digital pins that can be used to write or read to and from electronic components. On a Raspberry Pi, there is a considerable number of digital inputs/outputs on its 40-pin connector that comply with 3.3V logic. More specifically, 3.3V logic levels means that the Raspberry Pi will interpret anything very close to zero volts as a logic '0' and anything higher than around 2V as a logic '1'. Applying higher voltage levels on these pins could damage the board. These pins can be programmed to intercept signals from digital input devices (sensors) or to control output devices (actuators). A very interesting alternative is to use an Arduino board (plugged in a USB port of the Raspberry Pi unit) as an extension board for the Raspberry Pi that provides extra digital pins. Snap4Arduino tool offers the necessary visual programming command options.			

Category	Novice	Intermediate	Advanced	Example
General definitions	**Analogue Signal** Our world is analogue, with infinite values of for example sounds, or colour values. When you create interactive projects, you need to take both the analogue and the digital world into account. With an Arduino board, you use the analogue pins to read spans of values from sensors, or the Pulse Width Modulation (PWM) pins marked with a ~(tilde) symbol to control the current flow to a connected component. On a Raspberry Pi, there are no pure analogue input pins, and so two alternative options are made the scene. The 1st option is to use a specially designed A/D circuit chip (a Raspberry Pi "hat"). The 2nd option is to use an Arduino as an analogue sensor board, in conjunction with the Snap4Arduino software package. When need for analogue output (indeed, pseudo-analogue output), the PWM option is a feasible solution using the Raspberry Pi unit as well, in a similar way as in case of Arduino. More specifically special libraries add PWM functionality to Raspberry Pi GPIO pins. Last but not least, is the option to use an Arduino as a pseudo-analogue pin board, assisted by the Snap4Arduino software package.			
Circuit building		**Breadboard** Solderless circuit building base for electronic prototyping. The components´ legs make electrical contacts with the metallic horizontal rows strips. The double positive and negative lateral rails are used to "power" the board and facilitate the electrical connections. The electricity will flow from the positive to the negative polarity.		
		**Toggle switch** An electrical component that can open or close a circuit by interrupting or allowing the flow of current		

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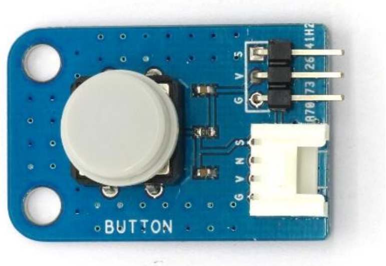
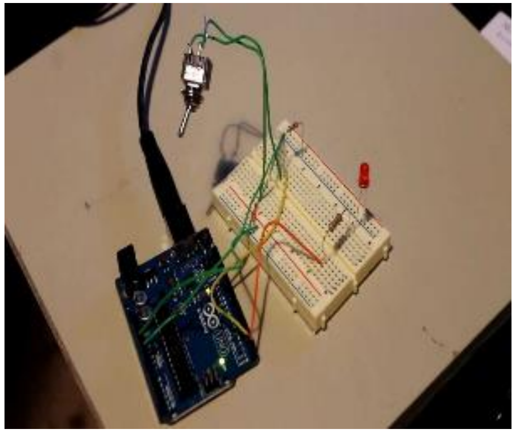
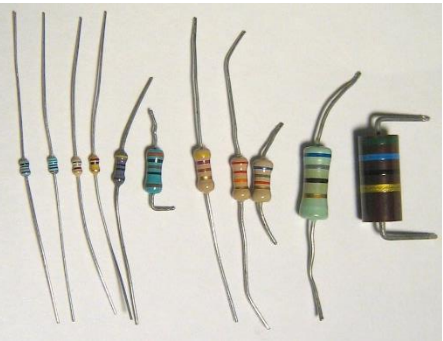
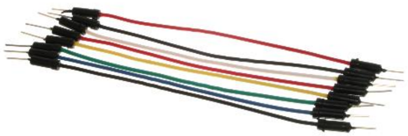
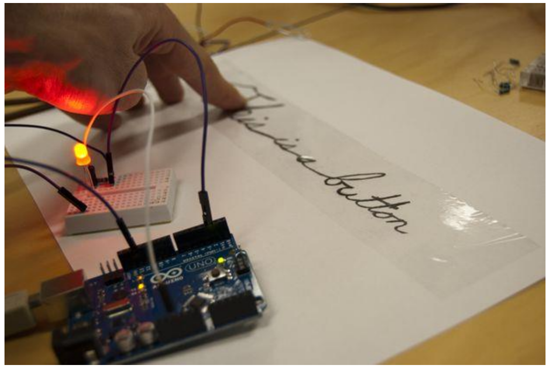
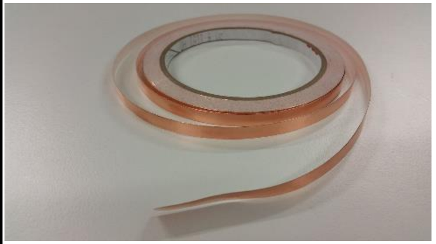
Category	Novice	Intermediate	Advanced	Example
Circuit building	 **Pushbutton or button (input)** A switch mechanism used for controlling the behaviour of your circuit. For instance, you can make a LED turn on/off by pressing a button			 *online video sample* https://www.youtube.com/watch?v=zaWD6CxN2tc
	 **LEDs (output)** Light-emitting diode (LED) is a semiconductor light source. This means that if connected *correctly* to an energy source (battery) it will turn on. They come in colour and consume very low energy.			
	 **Resistors** Common electronic components to limit the current in a circuit. The coloured stripes indicate the resistor value: the bigger the value, the more resistance resulting in decreased current flow.			

Category	Novice	Intermediate	Advanced	Example
Circuit building		**Jumper wires** Used for electronic prototyping on a breadboard, to connect components, resistors and microcontrollers.		 **Capacity sensor with pencil drawing** http://www.instructables.com/id/Turn-a-pencil-drawing-into-a-capacitive-sensor-for/ *Further examples* *Copper tape electronics* http://chibitronics.com/copper-tape-tutorial/
		**Copper tape** Copper tape provide ways to make surfaces conductive, and are useful when working with children, most of the time applied to paper, cardboards, etc. Tip: you could use aluminium foil paper and glue to get the same effect!		
		**Conductive thread** Thread used for hand sewing, for instance with e-textiles		

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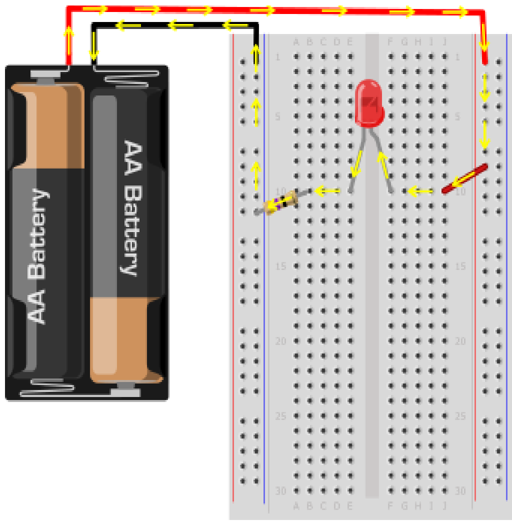
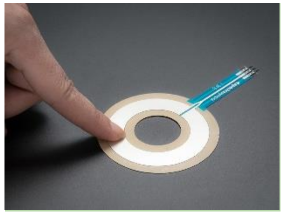
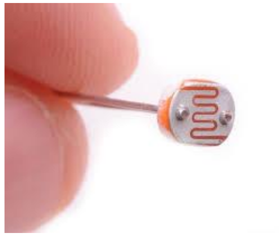
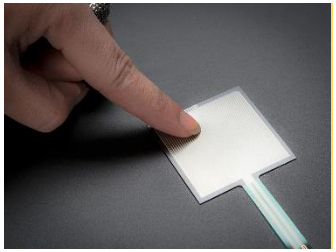
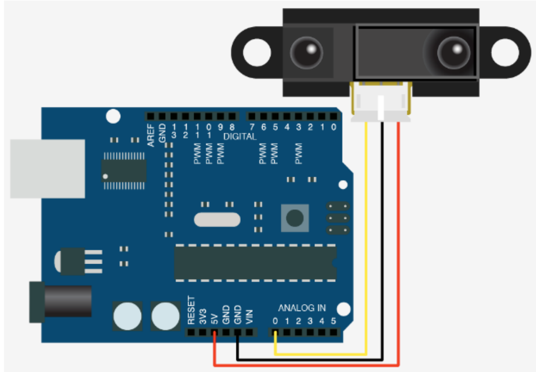
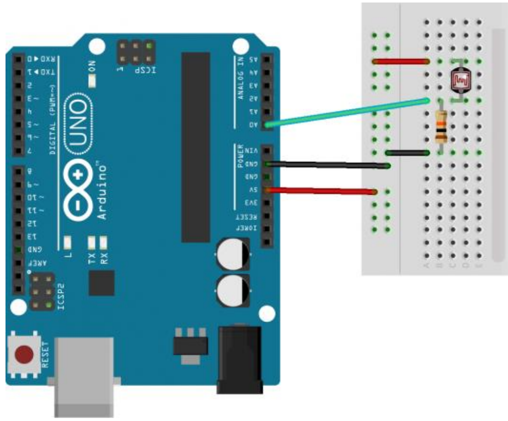
Category	Novice	Intermediate	Advanced	Example
Circuit building	 **Conductive paint** Paint that allows electricity to flow. Circuits can be painted on different materials including paper, cardboard, wood, metal, etc. Need to wait for paint to dry. Tip: this material can be expensive! Sometime the use of a graphite pencil do the same job.  9V battery  3V coin battery  3.7V li-ion battery **Battery** One type of power supply for your project. Batteries are useful if your project cannot be powered by the Arduino. All kind of batteries might be used (from a standard AAA, coin, lithium, etc.). Electronic projects usually require 5V, so a voltage range between 4.5 to 9V would work. Some projects might require 3.3 V, in this case two AA or a couple of Coin batteries might be useful. More amperage the battery provide, the more they will last. Other power options: Batteries + battery holders, power bank (mobile phone charger), wired wall socket connection.			

Category	Novice	Intermediate	Advanced	Example
Sensors (input) *(See Appendix IV for a description of the help document on sensors selection)*	**Potentiometer** A sliding or rotating contact that create a resistance change.  **Light sensor/Light dependent Resistor (LDR)/photoresistor** A light sensor transforms the light intensity into a resistance analogue value (0-1023). 	**Pressure sensor** Measure the physical force pressure applied to the sensor returning a value  **Infrared (IR) proximity sensor** The sensor measure the distance of an object and return a value (e.g. cm). 	**Gas sensor (carbon dioxide, methane, etc.)** Sensitive for a range of gasses and are used for indoors.  **Ultrasonic sensor** It detects the distance of the closest object in front of the sensor *(it use sound instead of light as in the IR sensor)* 	 **IR proxmity sensor – Arduino connection**  **Photoresitor – Arduino connection**

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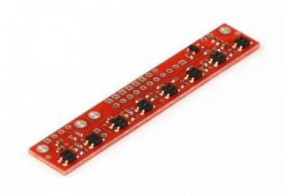
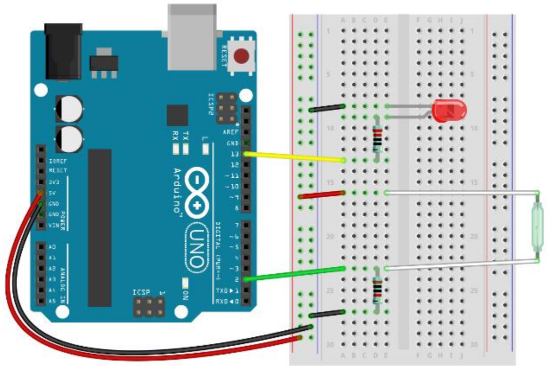
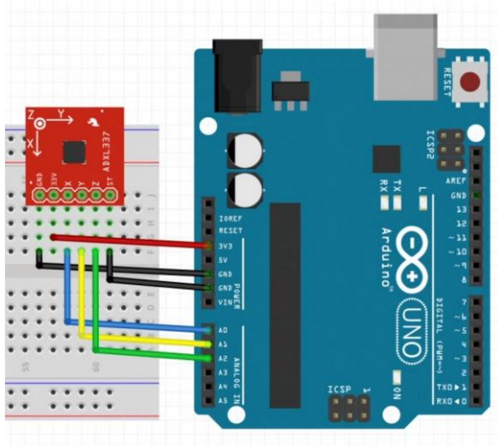
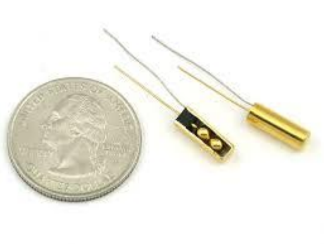
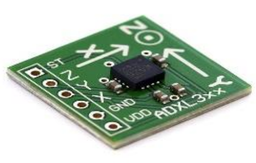
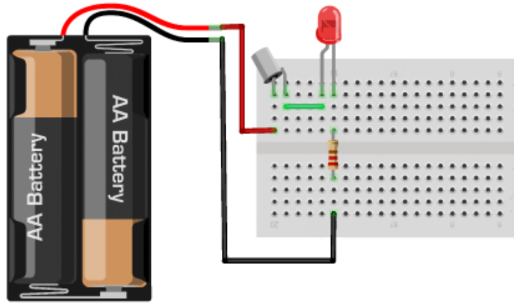
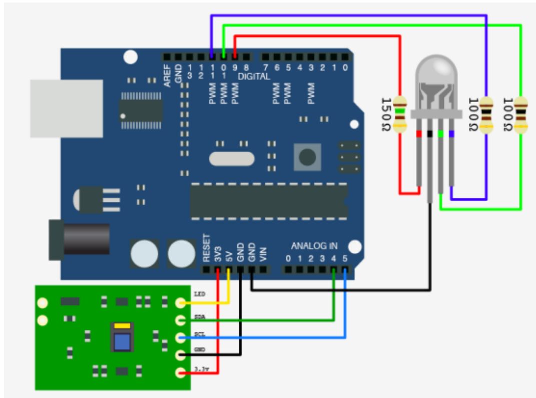
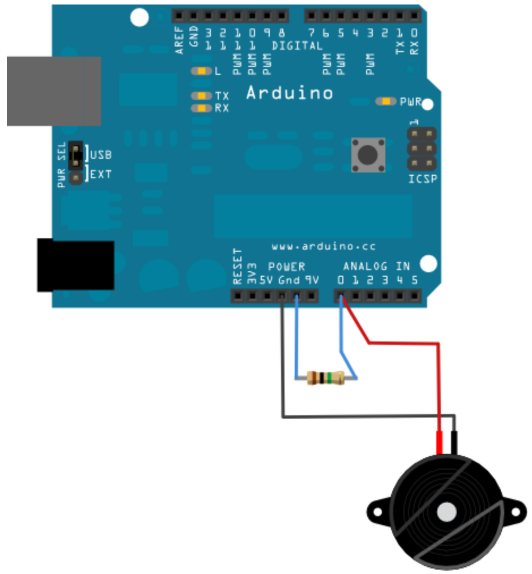
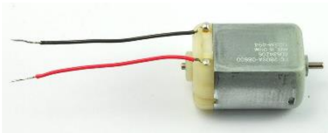
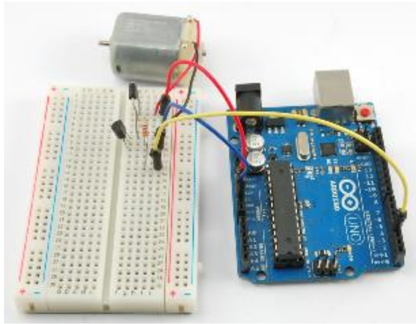
Category	Novice	Intermediate	Advanced	Example
Sensors (input)	**PIR (Passive Infrared) sensor** The PIR sensor can sense movements of people, animals and other objects. 	**Flex sensor** The sensor flex is a variable resistor which return a resistance value depending the amount of bending.  **Magnetic switch** An electrical switch that reacts when a magnetic field affects it.	**Infrared (IR) array** It is a miniaturized version of several coupled IR sending and receiving LEDs. The infrared light receive back the light from the transmitter LED when hit a reflective surface. It senses the presence or the absence of a line, for example.  **Accelerometer** It senses acceleration over (x,y,z) axes. It returns a value that it is usually used to describe the orientation of an artefact. The sensing axes can go from two to several (12 and more).	 **Magnetic switch – Arduino connection**  **Accelerometer – Arduino connection**

Category	Novice	Intermediate	Advanced	Example
Sensors (input)		 **Tilt sensor** A switch that measures the tilting in two axes. The metal ball inside the sensor closes the contact of the circuit when tilted.  **Piezoelectric sensor** A device that measures changes for example in pressure, force or sound and transform it to electricity (voltage)	 **Gyroscope** The *Gyro*, similar to the accelerometer, senses rotation in degrees over the 3 axes (XYZ).  **Colour sensor** It perceives and distinguishes among colours and it might returns RGB values.	 **Basic tilt sensor connection** Further reading: https://learn.adafruit.com/tilt-sensor/using-a-tilt-sensor  **Colour sensor – Arduino connection** See further details: http://bildr.org/2011/01/adjd-s371-tutorial/

Category	Novice	Intermediate	Advanced	Example
Sensors (input)			 **Microphone** This sensor perceives sound signals and distinguishes, for example between a loud sound and a weak sound. Tip: Not useful for human voice recording projects! 	 **Piezoelectric sensor – Arduino connection** see sample application here https://www.arduino.cc/en/Tutorial/KnockSensor

Category	Novice	Intermediate	Advanced	Example
Actuators (Outputs)		**DC motor** A motor that converts direct current (e.g., from a battery) into motion. With this, you can make wheels turn, for instance. 	**Servo motor** They are DC motors with a position sensor and a control circuit used for tasks that require precise motion (e.g., a robot arm) 	 Further reading: http://encyclopedia.kids.net.au/page/el/Electric_motor

To practice innovation, it is important that learners feel comfortable to go beyond the intended use of electronics and they should be encouraged to explore alternative uses. For instance, piezo output components, that are commonly used to generate sound, can also be used for input as knock sensors. Instead of using LEDs as output to emit light, they can be used as input to analyse colour. IR arrays can be used to read complex patterns, Bluetooth as proximity trackers, NFC (near-field communication) tags to create musical instruments, and so on. Furthermore, it is fairly simple to construct DIY sensors, being introduced to the basic idea of variable resistors. Linear potentiometer can then be crafted from paper with conductive ink or stretch sensors made using knitted conductive yarn.

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2.3. VIDEOS

There are some descriptions based on the literature which we should take into account when having videos as part of the educational material for different levels of learners. According to Lowe (2004), for novices, the most relevant information in videos should be brought up clearly. Videos should not load with too much information, especially if subject is complex. Sections of the presentation must follow logical order, and contents, which are related to each other, should be presented in clear sequence. For novices, it is necessarily pay attention to substantial content because they focus on more perceptually conspicuous information, though information is irrelevant. In addition, Hegarty (2004) mentions, that video should contain clues so that viewer knows what he/she should acknowledge. According to Clark and Mayer (2011, 23), novices need more structure and guidance in video than advanced learner.

Learning can be fostered through videos by reducing cognitive load, so that the learner can use more capacity for processing during learning. Cognitive load can be reduced by eliminating irrelevant and unnecessary voices, pictures and words. Narrative should be presented simultaneously with corresponding pictures or animation, so that presentation is coherent, and words should be presented as narration rather than as text on the screen. Furthermore, corresponding subject, for example words and pictures, should be placed near each other. (Mayer, Fennell, Farmer & Campbell, 2004.). Video's clear, step-by-step explanations will help learner's understanding about what is going on (Kay & Kletskin, 2012). For using the professional concepts and complicated descriptions on the phenomenon, it is better from the novice learner's point to use simple concepts and describing the phenomenon as simple as it is possible. For advanced learners professional concepts can be used more and more without explaining the concepts all over again, which makes also the more complex phenomenon representations possible. Clark and Mayer (2011, 83) present, that using words and graphics together is more important to novices than learners with high knowledge. These learners can create mental images while reading text for example how the pump works. Learners with no prior knowledge usually need pictures to support text.

Videos and other multimedia presentations can foster learning by increasing interest for current topic. Interest can increase for example when both verbal and pictorial representations are combined in video. When video is consistency, integrated with prior knowledge and human voice, interest is increasing. Listening and understanding is easier, especially for novices, when words are used in a conversational style instead a formal style. (Mayer etc. 2004.) When speech is comprehensible, learner can concentrate on listening and processing information.
Videos are helpful for learners, especially when complicated activities are performed, 3D modelling and connecting the certain cables in order to turn lights on, depending of course the learner's prior experience and knowledge. However, when the videos are made from the view of maker's, it is easier for learner to observe the right movements from the perspective of the maker, especially for novice learners.

According to Mayer (2004) personalization makes the learner to feel that the content of the video is personally relevant. Personalization assist a cognitive processing of information and increases learner's willingness to integrate new information to prior knowledge. Learner's interest increases when the self is used as a reference point. That encourages the learner to an active cognitive processing.

Learners can find the useful videos by themselves and add the video links to the platform for sharing those useful videos with other users, too. It would be also good to discuss with the learners why they experience the videos good from their perspective. Then we can find good indicators which trigger the learner's mind and interest. Learners are also free to create their own videos, which enhance several different 21st century skills, such as creativity, critical thinking and presentation and communication skills.

Learners might experience it worthwhile, when they can decide where and when they watch videos and learn. A video with plenty of material should be divided into smaller, meaningful parts in order to avoid spending time rewind the entire video to the right section. Instead, the learner should be able to the right clip. If the video is long and contains many steps or sections, each section should be signified clearly, so it is easy to find the one learner needs to watch. When learner can control what he/she needs to learn and what is the pace of their learning, learning feels more motivating. (Kay & Kletskin, 2012.) Clark and Mayer (2011, 212) mention, that for novices, video's should be determined optimal segments or there should be pauses at those points, because novice cannot necessarily make good "instructional decisions".

Lessons, which require problem solving (and learning from it), are suitable for more experienced learners to develop their transfer skills (Clark & Mayer, 2011, 23). Too slow and simple examples and explanations can make more experienced learners lose their effectiveness or even depress the learner (Clark & Mayer, 2011, 323). Advanced learners benefit from using the right terminology.

2.4. Other Online Resources

Several online resources will be made accessible from the unified user interface (UUI) via links. These resources will be provided as they are in the websites where they are hosted. Whenever possible, given that the resources are shared with open access licences, appropriate videos of processes (e.g., making simple circuits with LEDs, etc.) will be reworked according to the criteria described in Sect 2.3, in order to make appropriate shorter versions to be used within the eCraft2Learn digital platform, as well as sharing them with the open community.

External links to be used include:

a) Arduino resources

- Built-in examples
  https://www.arduino.cc/en/Tutorial/BuiltInExamples
- Code reference
  https://www.arduino.cc/en/Reference/HomePage
- Tutorials on Arduino project hub:
  https://create.arduino.cc/projecthub

b) Raspberry Pi learning resources

- There is a very large collection of sample projects, online lessons, and teacher plans at https://www.raspberrypi.org/resources/.
- Several free Raspberry Pi MOOCs are available including
  https://www.futurelearn.com/partners/raspberry-pi,
  https://www.coursera.org/learn/raspberry-pi-platform, and
  https://www.coursera.org/learn/raspberry-pi-interface.

c) Maker/DIY resources

- Sparkfun learning resources
  https://learn.sparkfun.com/
- Make Project tutorials
  https://makezine.com/projects/
- Hackster.io project tutorials
  https://www.hackster.io/
- Instructables
  https://www.instructables.com

3 Digital Traces for User Customisation

The personalized profile of the student can be build through several educational data mining methods. These methods include classification, cluster analysis and anomaly detection for instance. The models of the students are built from the data that is collected from UUI and its tools.

The classification is based on the labels that the teacher places to the data that are connected to the certain student. The classifier will build the rules that have an influence in labelling the students after the classifier has been trained. The cluster analysis is unsupervised machine learning process where no labels have to be given to the model beforehand but instead the model will group all similarly behaving students together. This helps teachers to understand the similarities between the students. For detecting outliers and thus adapting to the surprising situations during the making sessions, the analytics software will mark the data that UUI collects which are not in the middle of normal distribution. In this way, the teacher can build models from the students that may not be performing in the normal way.

The previously introduced data mining methods help teachers to build accurate model from the students. The models can be used to personalize the experiences that the students are having in the unified user interface (UUI). Also, the teacher is able to create interventions depending on the models built in the educational data mining system.

4 Conclusion

This deliverable presented an initial description of the OERs that will be produced, used and accessed through the eCraft2Leard digital platform. These OERs will be made available to the open community through appropriate creative common licenses. The database of the OERs will grow as the project progresses.

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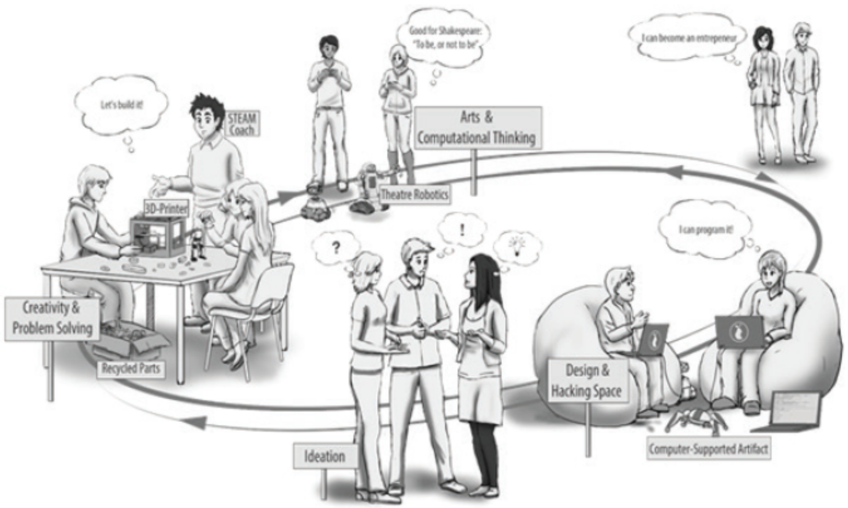
Appendix I – The eCraft2Lear Ecosystem

A snapshot of the document describing the eCraft2Learn ecosystem. The document is available via the UUI.

The eCraft2Learn Ecosystem

The eCraft2Learn ecosystem 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). PjBL is based on inquiry and problem-solving processes in the subjects areas of science, technology, engineering and math. The eCraft2Learn project will actively pursue and foster the inclusion of the arts in the development and implementation of PjBL. 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 eCraft2Learn pedagogical model enhances learner's awareness of learning process and self-regulation (which includes self evaluation). It promotes learner's personalised learning 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 participatory design approach. Model supports teacher's role as a coach. The eCraft2Learn ecosystem is designed to support learners, teachers, peers and other stakeholders (e.g., facility managers) in making the crafts- and project-based learning a reality.

APPENDIX II – THE ECRAFT2LEAR DIGITAL PLATFORM: THE UNIFIED USER INTERFACE

A snapshot of the document describing the eCraft2Learn digital platform. The document is available via the UUI.

The eCraft2Learn Digital Platform: The Unified User Interface

The Unified User Interface (UUI) is the main hub for using the eCraft2Learn digital platform. It provides access to the tools which are used in different stages of eCraft2Learn project development. Figure 1 shows a screenshot of the UUI. Each tile on the page represents a tool. The tiles are grouped in five sections, each representing one of the eCraft-Learn's pedagogical stages. The larger tiles represent the tools that are directly integrated/will integrate into eCraft2Learn ecosystem, while the smaller tiles are not directly supported by eCraft2Learn.

It is recommended that the tools are launched using this interface, as in this way, the eCraft2Learn's digital platform can:

1. provide additional help,
2. gather information for data analytics
3. ease the project management for the user

Each tile contains a small question mark icon on the top that provides simple help dialogs to the user. These are specially handy when a tool needs specific settings or extra maintenance.

APPENDIX III – ROLES IN THE ECRAFT2LEAR ECOSYSTEM

A snapshot of the help document that describes the envisioned roles within the eCraft2Learn ecosystem. It is available via the UUI.

Roles in the eCraft2Learn ecosystem

The eCraft2Learn digital platform is easy to approach and use. The platform encourages the learner to share thoughts and ideas. It contains videos on creating DIY artefacts and references for accurate information. At the same time, the platform works as a portal where earlier projects are documented. On the eC2L working platform, there is a chance 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 and expertise and 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. The design of the working platform is visually tempting and is made to respond to girls' interests.

Learners work together as peer learners with their strengths and weaknesses. 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.

APPENDIX IV – ROLES IN THE ECRAFT2LEAR ECOSYSTEM

Snapshot of the Sensor Jungle! document that provides guidance when selecting an appropriate sensor for a project. Available via the UUI.

How to choose sensors and actuators for your amazing project!

To orientate in the sensors jungle, you need first to describe in plain language what you would like to happen.

Describe this from the point of view of the subject or artefact experiencing your project.

What she/he/it (they) sees, hear, feel, and can do?

Describe it as it develops? What changes as the subject or artefact do something?

Don´t worry, You will review this!

Focus on WHAT happens, not how it happens. Don´t think to specific tools, technologies or sensor, just describe the what should happen. heard.

For example: you want present a robot entering the theatre stage like the Hollywood style! As the robot enter the stage, the theatre curtains open, the spotlight follows the robot, and an applause is heard.

Later, breaks your project into the input, output and processing (as process, not the software!) stages.

Next, identify your input and output as digital or analog will facilitate the search for the perfect transducers (sensors and/or actuators).

For example, if you want that the brightness of a light depends on how close a robot moves toward the center of the stage, you would need an analog input and output. If your light should be on or off, depending if the robot was there or not, then you need digital input and output.

Break your project description into units that fit into the table categories. Use this or a similar worksheet to fill in the input/output needs of your project.