Intellectual Output 4

MAKE IN CLASS

Developing Maker-based Learning paths in class to prevent early school leaving

Handbook

MAKE IN CLASS

Co-funded by the Erasmus+ Programme of the European Union

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MAKE IN CLASS HANDBOOK

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DRAFT VERSION

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INTRODUCTION

Chris Anderson (2012), former editor-in-chief of *Wired* maga-zine, defined the maker movement as “a new industrial revolution.” This new era is characterised by three main elements: the use of digital desktop tools, the sharing and online collaboration culture, the use of common design standards to facilitate sharing and fast iteration.

Similarly Mark Hatch (2014), CEO and cofounder of TechShop published a manifesto “Maker Movement Manifesto” which describes making as the result of nine factors: make, share, give, learn, tool up (access to necessary tools), play, participate, support, and change. Anderson and Hatch highlight the importance of the construction of physical objects as a feature of the maker movement that makes it distinct from the earlier computational and Internet revolutions.

One of the main obstacles to the introduction of project work at school is represented by the extreme difficulty in integrating this kind of activities into the standard school curricula. Often the implementation of project works at school requires an extra effort in terms of time, human resources and logistics. Usually the teachers cannot spend their school time in this practices and the students can do that as extracurricular activity

This Teacher’s Handbook is a product of **Make In Class**, an Erasmus+ KA2 development of innovation project, co-financed by the European Commission. Its aim is give the guidelines on skills and competences achievable through maker-based activities in secondary schools. It was designed as an easy to use tool to support teachers in integrating maker-based activities in their lessons. The methodology described can be used by educators interested in implementing these activities at schools, with special focus on the early school leavers. To this end this booklet endeavours to give the following practical advice:

- ❑ What technologies may be used to create makerspace activities
- ❑ Setting up a Maker Space
- ❑ The Learning outcomes to be derived from the maker activities
- ❑ Financial Aspect
- ❑ Examples of Practical Hands on Activities with relevant Health and safety concerns
- ❑ Evaluation of said activities

Chapter 1

MAKERSPACE TECHNOLOGY

In a MakerSpace there are many ways to create things and ideas using new manufacturing techniques with computer aided machinery. These techniques were originally found only in industry, but in recent years, they have increasingly reached private individuals through Fablabs and MakerSpaces. These technologies are also very important for schools, so in the end important for our Make in Class project.

The "Maker Movement Manifesto" describes makers' activities and mind-sets organized around nine key ideas: make, share, give, learn, tool up (i.e., secure access to necessary tools), play, participate, support, and change. Embedded in the Making Culture, there is the possibility to evolve and make changes to this definition giving the possibility to include the creation of tangible and intangible outputs, all oriented to produce effects in a real off line context.

It is clear how this definition, potentially include any kind of technology from the traditional to the most advanced ones.

Researchers identify the following four categories of technology commonly used, which enable many of the maker-based activities:

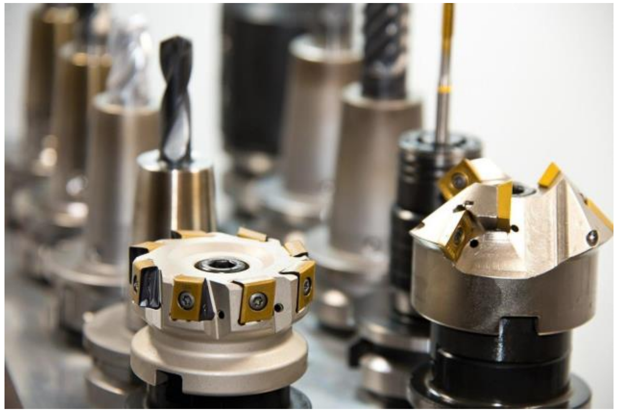
1. Digital fabrication tools

The first is digital fabrication tools, which includes 3D printers, as well as CNC machines, laser cutters and the computer-aided design (CAD) software to draw the objects.

3D printing

3D printing technology is one of the most important manufacturing techniques in digital production, both in the industrial and since some years even in the private sector. This technology has been used since the 1980s, when it was developed for the simple and inexpensive creation of prototypes.

3D printing makes it possible to produce three-dimensional objects. Before printing, the objects have to be designed using any 3D modelling software. The printing is done by layering the object and is therefore an additive manufacturing technique. The layered structure is realized by physical or chemical



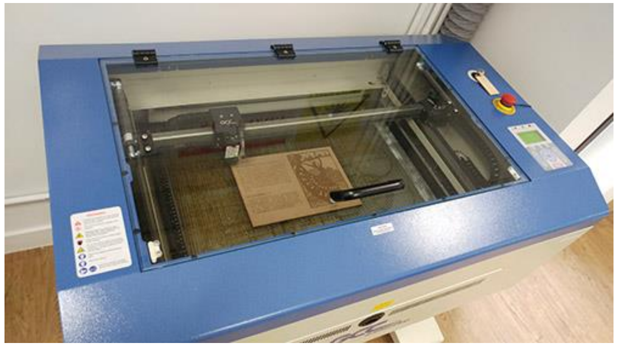
hardening or melting processes. Either a liquid (e.g. synthetic resin) is hardened in layers, a powdered material is melted in layers or a material is melted and then quickly applied in layers again and hardened. Standard materials for 3D printing are plastics, synthetic resins, ceramics [3] and metals. There are now also carbon and graphite materials that allow the printing of carbon parts. FDM or resin printers are usually found in makerspaces. The high-performance laser sintering systems are very expensive due to their technical complexity and can only be found in large MakerSpaces or in industry. For schools a FDM printer is recommended. These printers work according to a very simple principle called Fused Deposition Modelling (FDM). In this case, a plastic, usually in the form of a plastic cable (filament), is transported through a feed-producing transport module (extruder) to a print head with a two-axis bearing, which is used to heat the filament to the melting point and then push it through a nozzle (Nozzle), which causes the filament to taper from a diameter of approx. 3 or 1.75 mm to 0.4 mm (standard nozzle diameter). The principle is applicable to all meltable or liquid materials that harden quickly, so there are now 3D printers for various materials such as concrete, ceramics, metals, chocolate and sugar, the possible uses are becoming more and more diverse. Nowadays the 3D printer is no longer used for prototyping only, but is also used in construction, in the food industry, in medicine, aerospace and other industries.

CNC milling machine

Like 3D printing, the CNC milling machine is another sort of the digital manufacturing technique in production and prototyping. It offers the possibility of creating individual pieces and prototypes as well as series in a short time. Unlike 3D printing, this is a subtractive manufacturing technique. A milling machine is a cutting machine tool that removes the material from a work piece by means of rotating cutting tools in order to bring it into the desired shape. CNC is the abbreviation for Computerized Numerical Control (CNC) and refers to an electronic process for the control of machine tools. Machine tools are machines for the production of work

pieces with tools, the movement of which is determined by the machine. In the case of a CNC milling machine, this control is carried out by a computer. As with 3D printing, the template for the workpiece is created using construction software, also known as CAD (computer-aided design). When using a CAM system (computer aided manufacturing), the data from the CAD program with which the components are constructed can be converted into a CNC program with the help of a postprocessor, taking into account other factors such as the geometry of the tools, speeds, feed rates. The work piece can then be produced automatically with the CNC program, therefore only a few people are needed on the machines.

Lasercutter



In the laser cut, a solid is cut with the aid of a continuous or pulsed laser beam by material ablation or the surface is engraved. It is possible to cut almost any material with a laser. However, it must be noted that different parameters such as wavelength, power, pulse energy and pulse duration are required for each material. In practice, it is not feasible to build a single laser cutter for all materials and applications, because the requirements differ too much. There are laser cutters that are particularly suitable for cutting organic materials, while others can process metals better. By adding oxygen, you can possibly expand the field of application of a laser so that it is still possible to cut other materials. The higher the performance of the laser cutter, the more expensive the acquisition costs.

The machine itself is a complex arrangement of partly movable, partly fixed lenses and mirrors, through which a laser beam generated in a laser tube is sent. With the help of these mirrors and lenses, the laser is redirected and treated so that it can be directed to the intended interface with little loss and high precision. The laser beam is generated by complex physical processes. As a standard, focused high-power lasers are used, including the CO2 laser (a gas laser) or increasingly Nd: YAG laser (solid-state laser) as well as the more efficient, easily focusable fiber lasers.

The laser cutter is used wherever complex outlines (two or three-dimensional), precise, fast processing (10 m / min to over 100 m / min [2]) for the production of three-dimensional breakthroughs and / or a contactless, almost force-free [3] machining are required.

Plotter and Cutter

A plotter, also called curve recorder, is an output device that displays function graphs, technical drawings and other vector graphics on different materials. Therefore it is one of the few devices that is able to reproduce a vector graphic immediately without having to convert it into a raster graphic before. The cutter is a plotter using a knife instead of a pen. The knife can be used to cut contours of a vector graphic in thin materials such as self-adhesive foils, cardboard, paper, leather, felt and much more. Before cutting, very thin material is applied to a transport film coated with assembly adhesive and to maintain more stability during the cutting process. There are two main types of device concepts: drag knife and tangential knife. With the drag knife, the knife tip is not attached in the centre of the cutting head. During cutting, the knife is dragged along the contour (dragged), the resulting offset must be factored into the cutting path by the plotter software. However, this technology is less complex than the tangential knife and is

implemented in cheaper devices. With the tangential knife devices, the knife sits exactly in the centre of the cutting head and must therefore also be turned in the cutting direction on all curves. This requires a complex cutting head, but brings a more precise cutting result and is primarily used in the commercial sector.

2D/3D Modelling Software

Building or finding a 3D object is the first step for any digital fabrication process. Online there are a lot of suitable free applications you can use with your students such as Tinkercad (https://www.tinkercad.com/) which is web-based and perfect for beginners, Fusion 360 (https://www.autodesk.com/products/fusion-360/students-teachers-educators) which is slightly more advanced, SketchUp (https://www.sketchup.com/) or SketchBook (https://sketchbook.com/)

2. Things to bring the digital world into the real world and vice versa

The second category includes "things to bring the digital world into the real world and things to bring the real world into the digital world, and just iterate back and forth". That includes 3D scanners to complement the 3D printers, as well as Xbox Kinects and stereoscopic infrared cameras that can do gesture- or touch-input tracking.

3. Electronics

A third category includes electrical equipment, including microcontrollers such as Arduino, system-on-a-chip (SoC) computers such as Raspberry Pi, soldering kits to connect components and workstations that are static- and heat-safe.

Microcontrollers

Microcontrollers are essentially simple miniature personal computers (PCs) designed to control small features of a larger component, without a complex front-end operating system (OS). They can be found in a wide range of devices and objects such as vehicles, robots, office machines, mobile radio transceivers and home appliances, among other devices. They can be used for using actuators and sensors.

One of the most used microcontroller is Arduino (https://www.arduino.cc/), an open-source electronics platform based on easy-to-use hardware and software. It is intended for anyone making interactive projects.

There are other microcontrollers such as Raspberry Pi (https://www.raspberrypi.org), a tiny but powerful open source computer or LittleBits (https://littlebits.com) are colour-coded electronic building blocks that each have a specific function and snap together with magnets to make larger circuits.

Electronic tools

Electronic components such as (led boards, battery boards, conductive thread, spools, etc.) for building simple circuits, machines, computer motherboards and robotics are usually used for creating different kind of objects, robots, games and any other object requiring motors, actuators or sensors.

Coding

Coding, also called computer programming, is a series of instructions to a computer in a specific computer based language such as Scratch, Python, HTML, Java, C++ and more. Thanks to a variety of coding tools, students and teachers can learn to code in a safe and easy environment.

These tools are divided into:

- Block- and Text-Based Code (i.e. Root Coding, Code.org, Microsoft MakeCode, etc.)
- Block-Based Code (Scratch, Tickle, etc.)
- Text-Based Code (Mozilla Thimble, CodeMonkey, Unity Learn, etc.)

https://www.digitaltrends.com/cool-tech/best-robot-kits-for-kids/

Robotic kits

You can find many robotic kits available with all the needed parts for assembling and operate many different robots. Robotics is becoming increasingly important at all levels of education as it includes design, electronics, programming and integration with different components.

(https://www.lucarobotics.com/blog/best-robot-kits https://www.makeblock.com/official-blog/254448.html)

4. Augmented Reality tools

The fourth category is virtual and augmented reality tools, such as Oculus Rift and Google Cardboard, as well as the software tools, such as Unity and Unreal Engine, to develop for those environments. Unity and Unreal Engine are video game development tools, but students can also use them to create interactive immersive virtual environments for devices such as Oculus Rift or Google Cardboard. (https://makezine.com/tag/augmented-reality/)

Chapter 2

SETTING UP THE SPACE

The standard equipment of a FabLab or MakerSpace worldwide includes cutting plotters, laser cutters, 3D printers, soldering stations, CNC milling machines. Since not every school has a corresponding room or sufficient budget for the standard equipment, we will show how to take a first step towards a Maker Space even without own space and little money. Considering that there is at least one PC room in school with at least 12 to 30 PCs and maybe even some laptops or IPads in class all connected to the Internet, we only do concern about the maker tools needed referring to our project proposal, instead of infrastructure of PCs. Of course instead of buying new things, you always can think of starting with refurbished machines, if you have barely any money to spend on making to get started.

Variant A Starter Package: No separate room - small budget (approx. 2.000 €)

If the school does not have its own room for a MakerSpace yet and only little budget, you can help yourself with a small **soldering equipment** (6 soldering stations, 6 side cutters, 6 pliers, 1 stripper, 6 third hands, electronic components and solder) (approx. 550,-), a **cutting plotter** including plotter foil (approx. 440,-) and 12 **BBC MicroBit** (visual programming with web-based interface) (approx. 420,-). You can also start with the new and very affordable 3D Printer **Prusa i3 MK3S mini plus toolkit** (450 €). For the transport to the classroom you take a ***mobile cart plus storage boxes*** (maybe already available at school) and pack it with FabLab relevant devices and tools.

The given links below are suggestions on the type of equipment needed, depending on the country you're from you can easily buy other machines or tools.

Soldering module: (Starter set 550 €)

https://www.instructables.com/lesson/Getting-Started-With-Electronics/

https://www.digikey.com/products/en - https://eu.mouser.com/

- **6 soldering stations** (240 - 300 €)
- **Additional material** (approx. 250 €)
- tweezers set
- 6 sidecutter
- spare tips for soldering iron depending on the soldering station chosen..

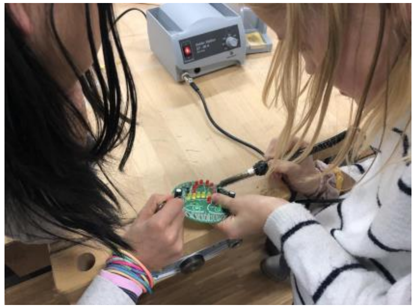
- 1 x soldering tip cleaner
- 6 x third hand (board holder),
- lead-free solder approx. 0,6mm diameter

Additionally to the starter set you can buy **material** for first projects **(around 200 €)**

Material for first projects: (about 100 €)

- LED set ,
- 30 button cells CR2032
- Brackets for button cells
- Copper Licenses

- **Soldering sets** and small projects for first soldering exercises (100 €)



Cutting plotter module: (starter 440 €)

- **1 Silhouette Cameo 4** cutting plotter (https://www.silhouetteamerica.com/shop/cameo) (330 €) How to use the vinylcutter see here: https://www.instructables.com/id/How-to-use-a-Vinyl-Cutter/
- **Accessories:** (about 100 €)
- 2 spare blades

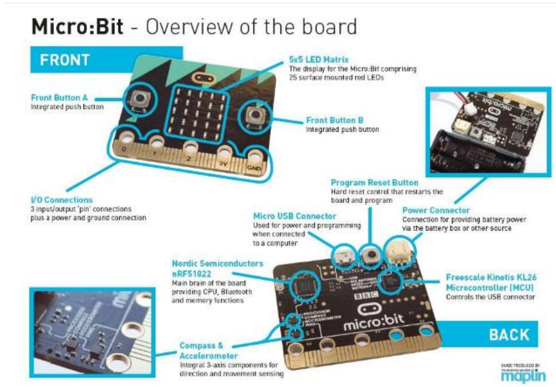
- Pens
- 2 additional cutting pads
- 3 x vinyl film set

Programming module (starter 420€)

- 12 inventor kits **MicroBits**

per set gladly additionally:

- 4 pushbutton switches
- 4 alligator clips
- Piezo sound transducer



To see what code to make: https://makecode.microbit.org/

3D Printing module (starter 450 €)

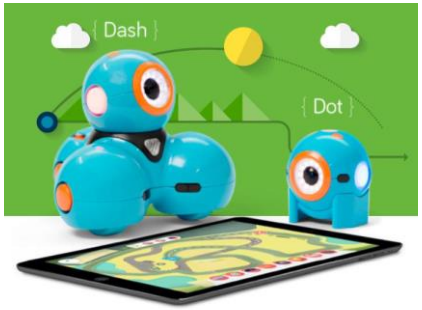
- **Prusa i3 MK3S mini** (380 €)
- **Tools** approx. 50 €:
- 1 spatula
- 1 small side cutter for filament
- 1 small cutter knives for finishing the objects
- 1 tweezer (see soldering equipment)
- 1 ifixit tool set Mako Driver Kit
- **Accessories** approx. 20 €:
- 2 SD cards (from 2GB)
- 1 SD card reader

Variant B: Starter Package plus additional equipment - No separate room - large budget (approx. 16.360 €)

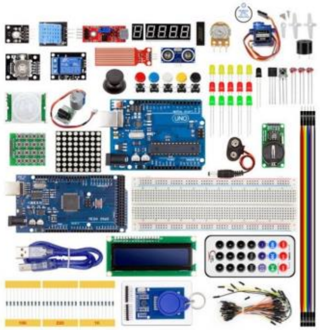
No separate space, but quite a lot of money to invest in Making means that you buy the starter Package of variant A plus even more equipment like more programming devices, at least two 3D printers and a Mr. Beam laser cutter.

Starter Package (2.000 €)

Drones and programming module: (3.380 €)



- 4 x Dash / Launcher from Wonder Workshop: Entry into visual programming with very well managed apps (approx. 850 €)
- 4 x LEGO Mindstorms EV3 (1.520 €)
- 6 Arduino Uno Starter Kit (531 €)
- 6 Raspberri Pi 4 (480 €)



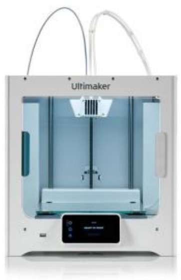
Additional if needed: In case of no Ipads and no laptops at school ***(4.650 €)***

- 4 IPads + 4 Pencil + 4 Cover (2.556 €)
- 6 Laptops (2.094 €)

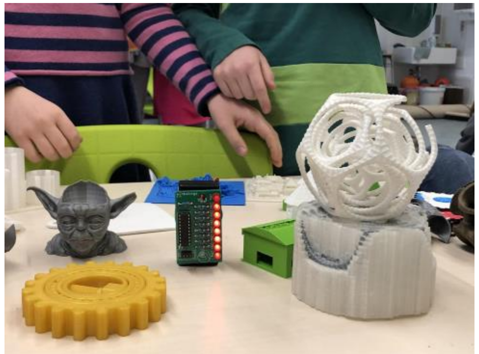
3D Printing module: (7.500 €)

- **1 Ultimaker 2+** : reliable 3D printer with a compact design and easy operation (2.184 €)
- cheaper alternative **Prusa i3 MK3S mini** (380 €) see above

- **1 Ultimaker 3S** - highly reliable 3D printer with dual extruder, auto-calibration and filament sensor for multi-day printing of complex shapes such as classroom demonstration items (4.790 €)



- Basic configuration of **PLA filament**: any color you like (300 €)
- **Tools** approx. 100 €:
- 3 spatula
- 3 small side cutter for filament
- 3 small cutter knives for finishing the objects
- 3 tweezer (see soldering equipment),
- 1 ifixit tool set Mako Driver Kit
- **Accessories** approx. 50 €:
- 4 SD cards (from 2GB)
- 2 SD card reader
- 4 USB sticks (from 2GB)
- **Storage** about 60 €:
- Dry beads (silica gel, desiccant) 1kg to keep opened filament dry in storage boxes;
- 3 IKEA Samla boxes (45l) with lid and closure clips



Lasercutting module: (3.500 €)

- **Mr. Beam II & Air Filter Bundle**: 3.300 € (incl. 10% Edu-Discount)
- **Material** for laser cutting (List of Materials https://bit.ly/2ZIMC7Y): 200 €

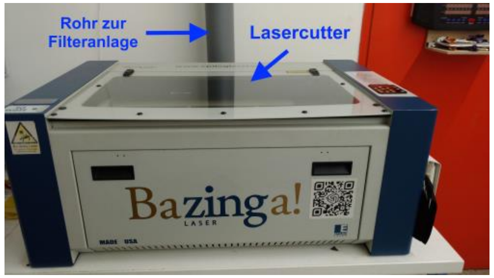
Variant C: Separate room, small budget (approx. 2.400 €)

For this variant you buy the **equipment of Variant A**. Possibly one still needs tables, chairs, shelves, couch, cupboards, a beamer, laptops in addition… which might be found in school already. You may arrange the room in a flexible way in order to be able to successively buy some additional devices as foreseen in Variant D.

Variant D: Own room, large budget (approx. 22.000 €)

Going for variant D you can again orientate on **variant B and C.** You now can consider a sensible arrangement of the devices including new furniture (tables, chairs, shelves, cupboards) in the room and the various workstations for laser cutting, soldering, programming and 3D printing right at the beginning. Thus one can increase the number of devices as well as the number of robots and tablets, if needed.

In case money doesn't matter at all and having the manpower for the machines, you could even buy a Zing or Trotec Laser Cutter (https://bit.ly/2tnZwMy or https://bit.ly/2QHExfD) and a CNC milling machine like the Shaper (https://bit.ly/2ZOz1Mr) or a CNC Milling machine especially for schools https://www.cnc-step.de/graviermaschine/ or CNC Shapeoko https://bit.ly/2V5FkdS.



Chapter 3

THE LEARNING OUTCOME-ORIENTED APPROACH

Every educational path is a journey. Whether it is focused on the acquisition of competences, improvement of motivation and inclusion or improvement of the school performances it should aim at bringing the students from a point A to a point B. The Make In Class approach aims at supporting this journey through the implementation of maker-based activities.

For implementing a complex and multidisciplinary educational methodology as making is, Make In Class partnership (and the European Commission) strongly recommends to apply a Learning Outcome oriented approach.

This approach will allow to replicate this journey with other students, other teachers, in other European countries, reaching the same destination and achieving the same goals.

It is necessary to carefully analyse and describe this “journey”, defining in a very specific way the learning objectives, common quality standards and assessment strategies.

Learning outcomes, or statements of what a learner is expected to know, be able to do and understand at the end of a learning sequence, play an increasingly important role in efforts to improve the quality and relevance of education and training in Europe.

The ‘learning outcomes’ approach shifts the emphasis from the duration of learning and the institution where it takes place to the actual learning and the knowledge, skills and competences that have been or should be acquired through the learning process.

The most general claimed benefits are the following:

1. **Clarity**. The learning outcomes approach helps focusing sharper attention on the objectives of the teaching-learning process (goal-oriented approach).

At the level of the institution or program, this can help foster communication and align curricular designs and instructional delivery across diverse teaching staffs.

At the individual student level, creating course or module that are structured around learning outcomes can help communicate expectations to students about what levels and kinds of performance are demanded, helping them focus their efforts more effectively.

2. **Flexibility**. Learning outcomes specify the intended ends of instruction but leave open the means to attain these ends. This accords considerable flexibility for instructional provision.

At the program level, very different instructional designs and learning environments can be configured to foster the same learning outcomes including for example maker-based approach or modular designs that either break-up coursework or alternate formal study with internships or other work experience.

Similarly, very different kinds of students can be accommodated through an outcomes-based approach. Different instructional paths can be devised to suit the individual needs of learners based on educational and experiential background, levels of knowledge and skills at entry, and personal learning style.

3. **Comparison**. Credible learning outcomes can establish comparable standards through which to benchmark and evaluate the performances of institutions, programs, courses, or individual students.

At the institutional or program level, such comparisons can be applied to support summative assessments of program performance for accountability purposes, or they can be used to chart progress or benchmark against peers as part of local improvement efforts.

At the level of the individual student, comparisons of assessed outcomes with recognized standards or criteria can form the basis of certified attainment, or they can provide a sound basis for admission or placement either in comparison with other students (normative) or in terms of previously established criteria (summative).

4. **Portability**. In a similar fashion, learning outcomes can form the basis for a system of credentialing student learning that can transcend established programmatic, institutional, and national boundaries.

More importantly in an age of growing student mobility and modularity of instructional provision, learning outcomes frameworks can be used to establish the relative comparability—and therefore transferability—of learning experiences across formal programs. The resulting portability of learning from one setting to another, if designed appropriately, can both increase the capacity and alignment of a multi-institutional system of instructional provision and provide paths that are more accessible for different kinds of students to attain higher credentials.

5. **Enhancing learning**: student has a set of learning outcomes, which provide information about what is expected to know and be able to do and understand having completed a learning sequence, a module, a programme or a qualification. Moreover, they help to orient the learning process itself; and they clarify what to expect during assessment. By achieving Learning outcomes a student can demonstrate that he/she has reached the summit of the learning path.

6. **Learning in real life:** using a maker-based approach, the learning outcomes are able to follow the learning process, through assessments and demonstration of achieved learning in formal and non-formal experiences. They should be used in ways

that foster learners from reaching their full potential.

7. **Facilitating assessment*:*** Learning outcomes can form the basis for grading or for determining levels of student achievement. The assessment aims to gather feedback that can be used by the teacher and the students to guide improvements in the ongoing teaching and learning context; and to measure the level of success or proficiency that has been obtained at the end of a course or instructional module. This can be more effectively accomplished by comparing student work with the learning outcomes.

Tips for teachers

Step 1. Read carefully the official documents provided by the European Commission related to the Learning Outcome approach[1]

It is very important to clearly understand what the European Commission recommends to do in applying learning outcomes. We know that sometimes this approach seems to be far from the daily practice of most teachers, for different reasons, including national guidelines. We strongly recommend to exit from your comfort zone and explore this approach which should be a standard at European level.

Step 2. Create specific learning outcomes for your lessons[2]*.*

The teachers should redefine the Learning Outcomes provided by the Governments (wide and general) in a much more detailed way so to apply them to their contexts and lessons.

In doing this, try to be as clear and specific as you can. Keep in mind that effective learning outcomes are observable, measurable, and at an appropriate level.

Step3. Define the maker-based activity based on the Learning Outcomes identified and vice versa

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1 - European Centre for the Development of Vocational Training (Cedefop), *Defining, writing and applying learning outcomes*, 2017
- Council Recommendation of 22 May 2017
- European Centre for the Development of Vocational Training (Cedefop), *Application of learning outcomes approaches across Europe*, 2016
- EC, *Rethinking Education*, 2012
- EC, Supporting the Teaching Professions for Better Learning Outcomes, 2012
- European Union , *Using Learning Outcomes*, 2011

2 Make In Class Competence Map

Mastering the techniques for analysing and defining learning outcomes gives you the possibility to define the learning outcomes you want your student to achieve and choose the making activity accordingly, or, at the contrary, analyse the maker-based activities available or already implemented in your school, checking how the learning outcomes they involve can be integrated in your lessons. In the Make In Class Competence Map document you can find examples and guideline on how to do it.

Learning outcomes*:*

- help teachers plan an educational path
- help teachers design their lessons and teaching material in more effective way
- give the possibility to adapt the activity to the real needs of the students
- help teachers select appropriate strategies for teaching, based on the objectives to be reached
- help teachers avoid overlapping saving time and resources.

Chapter 4

MANAGEMENT AND FINANCIND OF MAKER LABS

To achieve the success of a makerlab, in a school or in a space outside the educational environment, it is necessary to do a good management of the physical space, the equipment, the activities and the users. This management has to do with the financial and organizational aspects.

If the decision has already been made to create a maker space but we are not clear about the model that we are going to launch, let's see some of the most common models:

- Maker learning space, with a small number of instructors, that is sustainable by requiring relatively little infrastructure or full-time staff. In general they are traditional classrooms, classrooms with computers, vocational training workshops, libraries, converted storage spaces, etc.

- Makers community, small local community, coordinated by volunteers. In this space work active members on their projects and occasionally teach classes, share a certain amount of tools and space, and pay the rent in a spacious room, with relatively low membership fees.

- Coworking space, shared spaces in a large building where many people and small businesses come together to rent a large warehouse space at an affordable price, sometimes sharing teams informally, with a small group that coordinate the activities.

- Workshop in community cultural spaces. They schedule educational activities and their members can access shared tools, workspace, and sometimes storage space.

For a makerspace to be economically sustainable, apart from taking into account the initial start-up budget (see chapter “Setting up the space”), it is necessary to identify what current expenses we are going to incur and what possible income we can count on, to strike a balance between them. In the case of schools, they must have a sufficient budget for initial and subsequent investments in equipment, tools and materials to give continuity to the maker activities programmed. In other makerspaces that depend on associations, NGOs, municipal spaces and other business models, they also have to sharpen creativity to seek financing and income that guarantees their start-up and permanence over time.

Let's see what types of expenses can be predicted in a maker space, as well as types of income to create an economically sustainable business model.

EXPENSES	MAKERSPACES IN SCHOOLS	PRIVATE MAKERSPACES	LOOKING FOR FINANCIAL SUSTAINABILITY
Rent	NO	YES/NO	Assignment of space, shared space, affordable rent.
Space expenses (water, electricity, gas, Internet, mobile data plans, cleaning, repairs, municipal taxes, ...)	NO	YES/NO	shared expenses, expenses included in renting /free space
Insurance (civil liability, etc.)	NO	YES	Avoid extra costs. insurance proportional to space size, type of activity, risk, etc.
Adapting the space	YES/NO	YES/NO	Zoning (panels, decoration, electrical installation (plugs, direct lighting, ...) painting, sound insulation, ventilation,... social space where to share projects, skills and knowledge.

			Furniture: tables to assemble, benches / furniture with wheels for 3D printer / s, fixed cabinets or with wheels, drawers or shelves for storage of materials or projects. Contact to furniture companies for innovative educational spaces for possible discounts.
Wages and taxes (Administrator and Finance, CEO / Executive Director, Maintenance Technician, Participant Management, Graphic Design, Video Editing, Media Broadcast, etc.)	NO	YES/NO	Essential staff, volunteers, collaborators
Trainers	NO	YES/NO	Volunteering, payment to instructors on demand, number of workshops, number of participants, number of hours.
Tools maintenance	YES	YES	Trainers who do basic installation and maintenance review maintenance contracts for equipment.

Consumables (office supplies and materials for maker activities)	YES	YES	Free supplies and materials, educational discounts or free stocks, sponsors
Advertising and marketing (graphical design work, printed materials,digital marketing)	YES/NO	YES	We will limit to essential printing expenses: rollup, brochures, business cards, posters, t-shirts, merchandising. Take advantage of dissemination on your own website and social networks. Attend and participate in educational events, webinars, fairs, etc. Subscription economic web services: educational plans or for NGOs.
Food	YES/NO	YES/NO	Donations, reserve a monthly amount, collaboration of the participants, etc.

The following list of possible income can help you make an estimate to make a maker space sustainable.

INCOME	MAKERSPACES IN SCHOOLS	PRIVATE MAKERSPACES	LOOKING FOR FINANCIAL SUSTAINABILITY
Rental	NO	YES/NO	Constant income: rent part of the maker space (coworking, for storage, ... (lower price than real estate market)
Membership	NO	YES/NO	User income per access, to work on projects. According to the organization's policy, assess: 1. Fee payment for the use of facilities according to types of access to the maker space: per person, per family, monthly, payment per workshop, per time, per machine, discounts for new members, ... assess maximum space occupancy . 2. Free, community service. 3. Donations accepted.
Courses, workshops	NO	YES/NO	Income of participants fees for courses or workshop about the use of machinery, tools and software.

			Estimate: 2 / 3h sessions. € 10 h / student. 5-10 students / coach (workshops with difficulty tools). Take into account cost / hour of the trainer (according to technology).
Grants and donations	YES/NO	YES/NO	This part can be a permanent source of financing, both at the beginning of the project or each year, as part of the income. (*) Digital creation and manufacturing centres are currently highly valued. There are official grants at the local, state or international level. There are also grants from private foundations. (**) Schools do not always have a final budget to install a makerspace. (***) Contact to technology companies to negotiate equipment loan, software donation, etc.
Other income	NO	YES/NO	Assess the possibility of selling maker products, merchandising, materials, selling healthy food and beverages to members, holding events, birthdays, design, engineering and manufacturing consulting, etc.

Source: https://makezine.com/2013/06/04/making-makerspaces-creating-a-business-model/

(*) In each country, each region, even each municipality you can find different ways of financing your maker space projects for educational purposes. The European Commission, national Ministries, regional governments or municipalities have programs with funds for financing devices and equipment for educational innovation, social and digital inclusion programmes, even makerspaces!!

(**) Not always it is possible to count on a specific budget so that, why don´t you try different initiatives like donations or transfers of materials between schools, crowdfunding through online platforms, or sponsorships? In fact, the most desirable situation would be to get a self-sustainable makerlab. It is more or less easy to set up a maker space, the challenge is that this space will be self-sustainable after one, two or more years. https://www.edutopia.org/blog/6-strategies-funding-makerspace-paloma-garcia-lopez

(***)

- Technology companies, equipment transfer, software donation, etc.

- Foundations of private companies with social purposes that promote attention to vulnerable groups, gender equality, inclusive technology

- Awards from companies that recognize the educational and social value of projects with technology, which promote digital competence, etc.

- Business awards for innovative educational projects, competitions that reward social inclusion projects, etc.

- Large and small companies that agree to collaborate as sponsors of specific spaces or events. In exchange for including your logo or mention the name of the company agree to collaborate with an economic amount.

It is important that you explain to private companies that your initiative could be important for them. The key is to get that your maker space project could be part of their corporative volunteering project or part of their marketing aims.

Another strong argument to stimulate the granting of funds for projects based on maker activities is to explain how important is this methodology on reducing early school leaving. It is important to highlight this, to organizations that can finance educational and social projects. They are looking for "good projects", we mean sustainable, educative, social and inclusive makerspace projects; those that explain it clearly, detailed and structured way, how it will improve inclusion and reduce early school leaving:

- **Title:** Short title, clear, that gathers the key aspects of the project.

- **Target audience:** Who is it specifically for? Success because Italy is new, inside local objectives /vulnerable people.

- **Description:** What are the actions to be performed? the type of activities, technologies, educational objectives and competencies, content of the activities, timing, human resources and materials available.

- **Objectives:** What do the workshops or projects contribute to young people from vulnerable groups? Highlight key aspects such as inclusion, education, youth, technology, or employability, among others.

- **Differential value:** What educational and social differential value does our project have, compared to others competing for financing?

- **Use of funds:** What will the funds be invested in?

- **Dissemination plan:** What dissemination will be made of the project? If possible include a powerful graphic design, marketing plan (explain how it will be disseminated in the immediate environment and in the educational or social field, taking into account the importance of digital media.

- **Sustainability:** Explain how the use of the maker space will be sustainable to help potential dropouts.

- **Transferability:** What significance will our project have? Can our space maker project for educational purposes be replicated in other educational centres? How?

Write a well structured, complete and clear dossier with your makerspace project, focusing in the list of aspects provided. Include the organization background, previous projects and experience related to the project.

Managing maker activities and users

A makerspace is a shared use place where a wide variety of activities are scheduled that require the use of equipment and tools. These activities can be the delivery of workshops, a programming club, space / machinery reservation for personal or group maker projects, etc. for this reason, it is necessary to establish a model for the coordination of staff, the management of space reserves or the collaboration between schools and other makerspaces or fablabs.

Staff coordination

It is convenient that there are different roles within the staff that is in charge of the maker space for it to function properly. Students and users will recognize different roles:

1. Administrative role. General Administration and Management

a. Bookings

b. Materials

c. Finance

d. Logistics

2. Technical role. Specialized in the available machinery:

a. 3D Printer Operator

b. Milling Machine Operator

c. Laser Machine Operator

d. Maintenance of tools and support material

3. Instructor role. Teacher profile and / or experience in one or different technologies.

Booking system

Each makerspace needs to organize the reservation of space, machinery and work space according to their size. For this, it is advisable to establish a booking system to optimize times and achieve an activity efficient and plural. A booking system allows,

- optimize supply and demand,
- avoid collapses on key dates,
- promote equal opportunities for people, groups and activities.
- It also allows that the maker space service will be guaranteed to students, teachers and research groups.

Reservations can be considered as spaces of time that a user / group acquires and entitles them to the exclusive use of a certain machine and workspace, necessary for the preparation and post-production of their work related to digital manufacturing.

How?

It is advisable to establish an online reservation through a form on a website or an existing educational platform.

Due to the different duration of projects and maker activities, it is advisable to manage the reserves in a particular way for each machine or task. For this, time bands are established, time is optimized, and the user can complete its work satisfactorily.

The reservation form can be used to collect data, both from the work to be carried out and from the students and teachers who use it. By listening to the user and knowing their concerns and abilities, the service can be improved.

When?

The use of the makerspace should be priory for students during school hours, even allowing a time slot at the end of the school day so that they can access, in the same way that they would access the school Library.

Something to be valued is to offer this service to the neighbourhood, where the school is located, after school hours, to enhance the relationship with the social environment.

If all users can book in advance, it is advisable to establish a monthly booking calendar. In this way, if the maker space has a lot of use, everyone has new opportunities, setting the reservation counter to zero when that period has passed.

How long?

It is advisable to limit the maximum reservation time to prevent massive reservations and possible jams on critical dates and in order to give opportunities to all users. In other words, establish a maximum number of reservation hours per day, fortnight or month; Example:

- Individual Reservations: max. 2hrs. / day - with simultaneous machinery allowed - and 5hrs. / weekly
- Group Reservations: they are managed in a particular way depending on the use to be made.

Example of reservation with different time zones:

- LASER CUTTING MACHINES: It can be reserved in 1/2 hour sections
- 3-AXIS MILLING MACHINE :: It can be reserved in 1-hour sections

- 3D PRINTER: It can be reserved in sections of 2 hours.

Schools and maker spaces collaboration

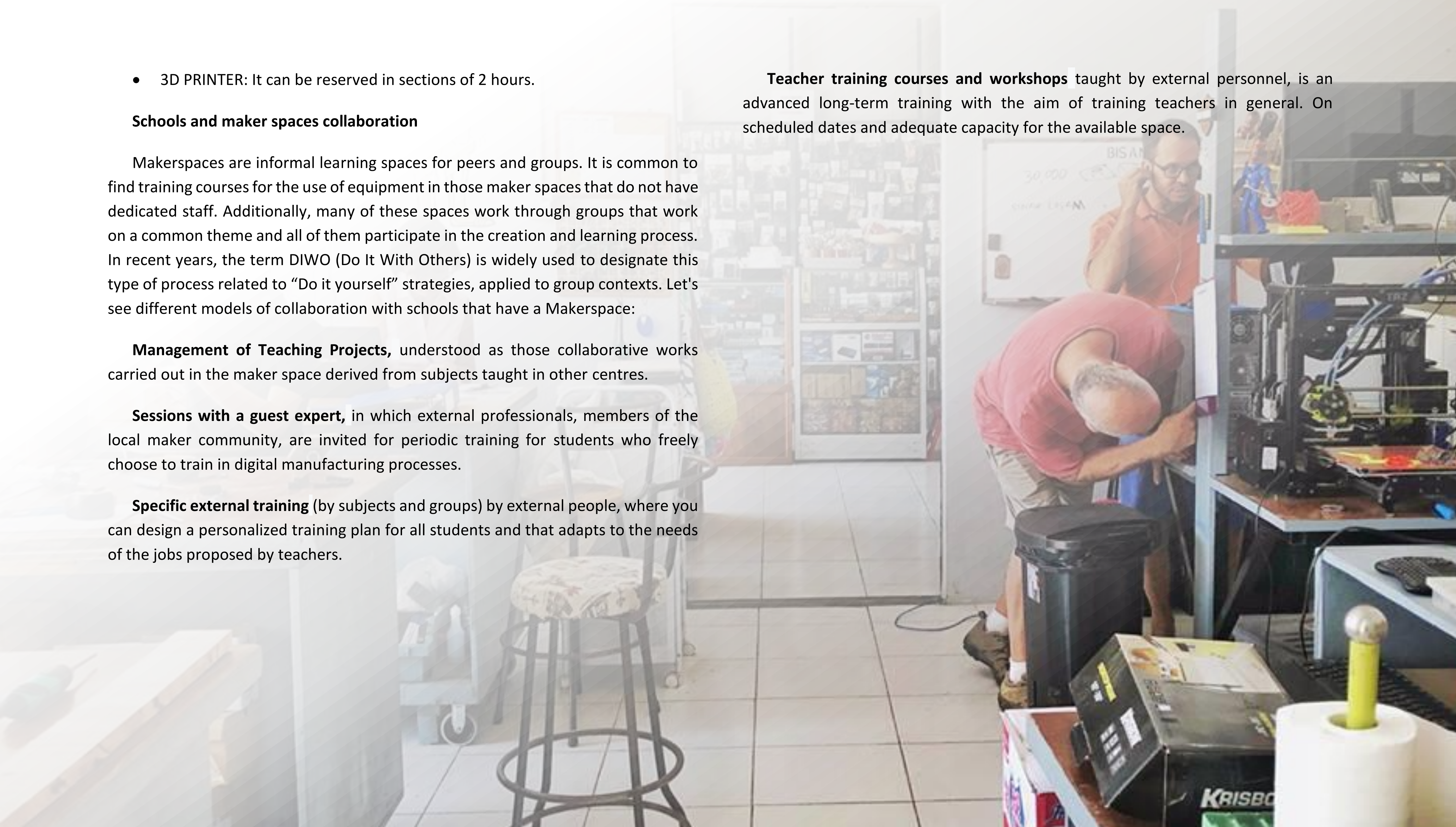
Makerspaces are informal learning spaces for peers and groups. It is common to find training courses for the use of equipment in those maker spaces that do not have dedicated staff. Additionally, many of these spaces work through groups that work on a common theme and all of them participate in the creation and learning process. In recent years, the term DIWO (Do It With Others) is widely used to designate this type of process related to “Do it yourself” strategies, applied to group contexts. Let's see different models of collaboration with schools that have a Makerspace:

Management of Teaching Projects, understood as those collaborative works carried out in the maker space derived from subjects taught in other centres.

Sessions with a guest expert, in which external professionals, members of the local maker community, are invited for periodic training for students who freely choose to train in digital manufacturing processes.

Specific external training (by subjects and groups) by external people, where you can design a personalized training plan for all students and that adapts to the needs of the jobs proposed by teachers.

Teacher training courses and workshops taught by external personnel, is an advanced long-term training with the aim of training teachers in general. On scheduled dates and adequate capacity for the available space.



HEALTH AND SAFETY – SECURITY IN EDUCATIONAL MAKERSPACES

(from a MOOC course created by Raspberry Foundation "BUILD A MAKER SPACE FOR YOUNG PEOPLE https://www.futurelearn.com/courses/build-a-makerspace/5/steps/522461

See also:

- Make: Magazine's common safety rules for school makerspaces
- The *Safe Workshop* poster by William Gurstelle

How will I keep my makerspace safe?

To ensure the safety and wellbeing of your makers, there are a number of considerations, from the location and layout of the space itself, to tools and equipment, to safety guidelines and training for everyone involved. Here is a review of safety guidelines you will want to take into account.

How can I create a safe makerspace?

1. Check for any existing rules or guidance that your school or organization already has in place. Science and Design Technology classrooms will often have a set of rules as well as a risk assessment. Speak to the adults who regularly educate in these spaces to learn about these and to find out about common risks.

2. Once you have a better understanding of the hazards and typical guidance for usage, develop a set of rules for your space. Have them checked by the manager or person responsible for health and safety at your school or venue.

3. Make sure that you have a first aid kit in your makerspace, and undertake training in how to use and administer first aid. There are lots of courses, both online and in-person, that your employer can arrange for you to attend.

4. Don't be shy — publicise your rules! To foster an environment of personal responsibility, it's a good idea to put up some safety rules in a clearly visible place, e.g. on a wall, where everyone can refer to them. It should also be a requirement of entry to the makerspace that people agree to abide by the rules of the space.

5. Conduct a **risk assessment** of the space, its tools, and the activities that will be taking place in it. Create a checklist of questions to ask yourself every few weeks:

- Do you have things to handle any situations that might arise?
- Do you have procedures in place for injuries or emergencies?
- Are there any special materials or chemicals in your makerspace that need special treatment or action in the event of a mishap?

6. Before every session in your space, check all safety equipment. Are any goggles cracked? Any holes in gloves used for handling hot things? Make sure that damaged equipment is properly logged for repair or disposal and removed from the space or made inaccessible.

7. Consider what sanctions there will be for people who misbehave or ignore the rules of the makerspace. For example, when soldering with young people, you may want to operate a zero-tolerance policy with regards to unacceptable behaviour to ensure complete safety for everyone.

What do my makerspace participants need to know?

1. A health and safety briefing should be mandatory before anyone can use the makerspace or any new piece of equipment in it. To track this information, you can have participants sign an agreement to say they understand and will abide by the rules of the workshop. The legitimacy conferred by signing a behaviour contract often gives attending the makerspace an added sense of gravitas and excitement.

2. There should be a strong emphasis on personal responsibility to remain safe in the space and keep others safe too. Safety in the workshop is everyone's responsibility. This includes reporting any damaged equipment, spillages, or unsafe behaviour.

3. A short quiz or role play activity can be used to test understanding and reinforce your message. You can also refer to the rules chart regularly to keep students refreshed on their responsibilities. For example, focus on one of the makerspace rules each week, and then praise students who behave well and in accordance with this week's rule — this helps to reinforce desired behaviours in the long term.

Common guidelines to consider

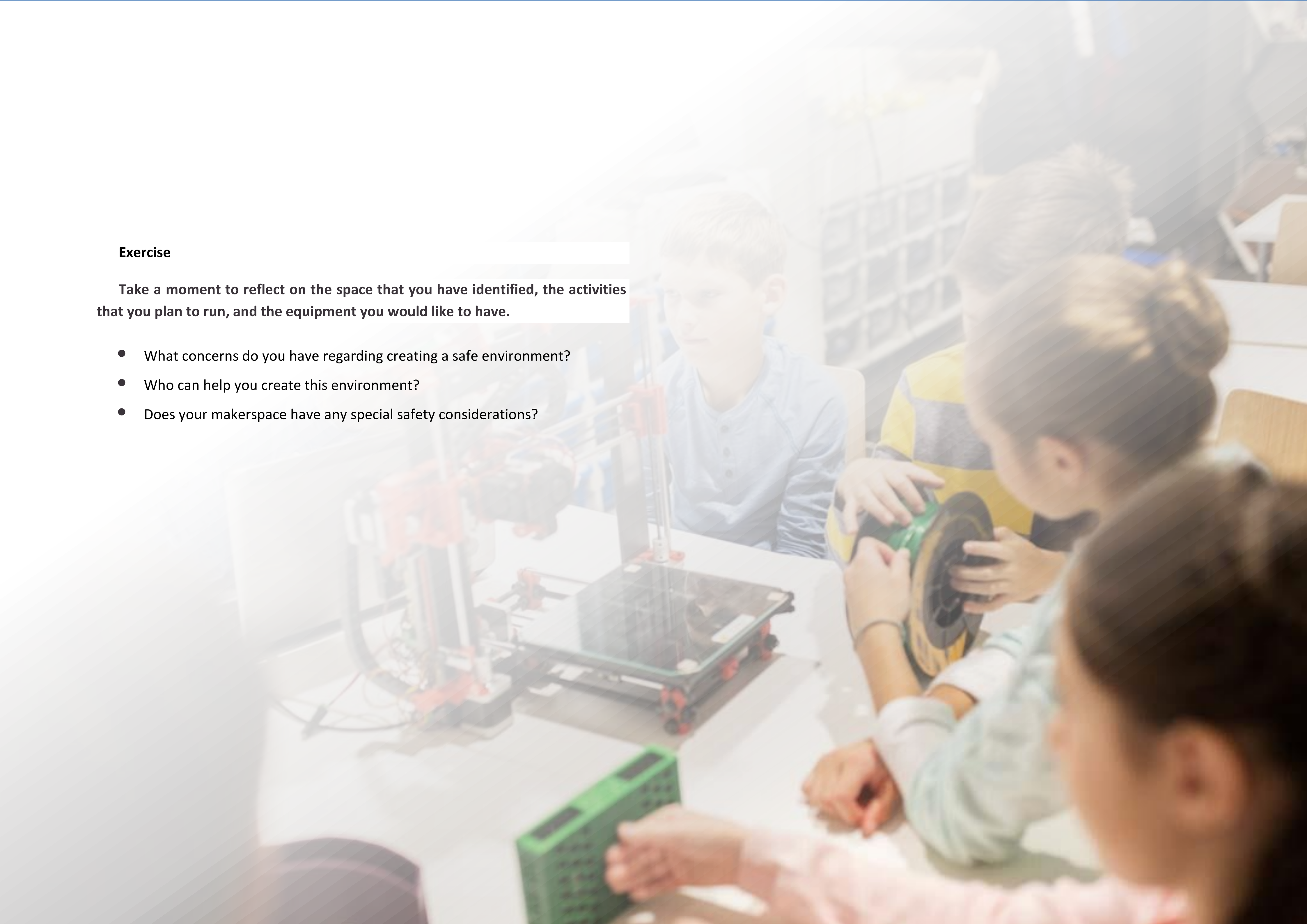
- Simple materials are best to get started with. Cardboard, duct tape, and lollipop/popsicle sticks are excellent for prototyping in the early stages, sourcing them requires minimal funding, and using them needs little training and oversight. Feel free to get fancy materials such as acrylic or plywood with older or more experienced makers, but you don't need much to get started initially.
- Consider your users when choosing equipment, as well as the added responsibility of using that equipment both for you and the students. Choosing the right equipment model can be key. For example, some 3D printer models are designed to be hacked/customised and have open sides and easy access to hot parts, while others are designed for use in school environments and have built-in safety features (e.g. a lid that won't open when components are hot).

- Tools and machinery need to have enough space to be operated without endangering the operator or other people in the space. If lots of your students want to use a machine, then give some thought to a queuing system that avoids overcrowding when you're planning the making session. People need to concentrate when working with tools and machinery. They can be easily distracted by conversation or proximity of others wanting to watch or use the machine, which could lead to injury.
- Keep workspaces clean and tidy, and encourage students to follow a strict cleanup procedure. Minimise the number of wires running across workspaces or floors by using extension cords and covering them to avoid risk of tripping.
- Remember, you're responsible for the tools and equipment your students use — don't give them defective or risky gear! Any frayed cabling or damaged power tools should either be discarded, or repaired by a professional.
- Your makerspace should have adequate ventilation to minimise the risks posed by vapours from spillages or other incidents. Soldering also creates fumes that can be hazardous, so ensure that this activity only ever takes place in a well-ventilated space. Make sure you can get to and open a window or door to let fresh air in (and students out), should you need to.
- Specialist clothing may be required when working with certain tools or in certain conditions. For example:
    - **Masks** should be worn when sanding, soldering, and handling any chemicals that might give off vapours or particles (e.g. spray paint, bleach, acetone, isopropyl alcohol, varnishes, and oils).
    - **Protective eyewear** should be plentiful, ideally hanging up and highly visible when you enter the space. Scratched/damaged eyewear should be discarded if it impedes vision.
    - **Aprons**. Depending on your application, you might want some slightly thicker or liquid-proof aprons. When working with simple craft materials, a regular pinafore should be fine to protect clothing.
    - **Gloves** should be worn when handling chemicals, hot materials, or power tools, especially anything that may give off sparks. Simple gardening gloves will work just fine. (No plastic!)
    - **Footwear**. Make sure everyone has shoes on at all times, as there are many hazards to bare feet in a workshop environment, including chemicals, debris, and dropped tools.

Exercise

Take a moment to reflect on the space that you have identified, the activities that you plan to run, and the equipment you would like to have.

- What concerns do you have regarding creating a safe environment?
- Who can help you create this environment?
- Does your makerspace have any special safety considerations?



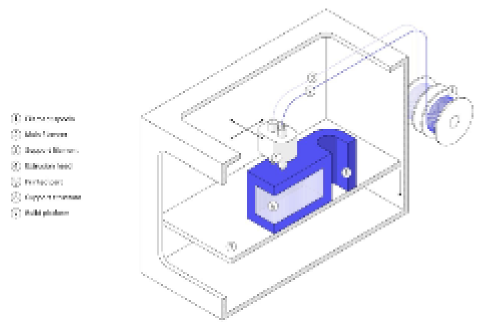
Chapter 6

HANDS-ON ACTIVITIES

Following you can find some suggestions for practical activities. More details about this activities and other suggestions can be found in the IO1 Make In Class Competence Map (http://www.makeinclass.eu/results/)

3D PRINTING - all you need to know

The basics - What is 3D printing?; How does a 3D printing work; A brief history of 3D printing; Benefits & Limitations of 3D printing; Applications of 3D printing; 3D printing vs. Traditional Manufacturing; 3D Printing Processes; The different types of 3D printing; Fused Deposition Modelling (FDM); Stereolithography & Digital Light Processing (SLA & DLP); Selective Laser Sintering (SLS); SLS vs. MJF; Direct Metal Laser Sintering & Selective Laser Melting (DMLS & SLM); Metal 3D printing technologies compared; How to select the right 3D printing process; 3D Printing Materials; Design for 3D printing; What is the best software for 3D printing?; Start 3D printing; What 3D printer should you buy; Useful resources



Time Allocated to Activity: 30/60 hours

Tools/Equipment Needed: 3D printer, maker based space

Level: Beginner/Intermediate

Experiences: Already experienced activity with our students

Number of Students: 20

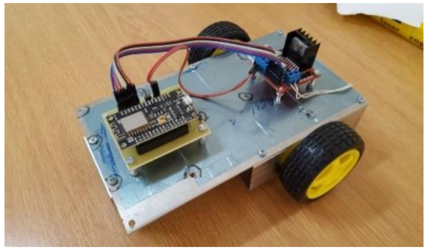
Competences: *Communication in foreign languages, Competences in science and technology, Digital competence: Digital electronics, Maker topics*

Individual/Group/number of people - small group or individual activity

Useful Links: https://www.3dhubs.com/guides/3d-printing/#basics https://youtu.be/raSAhXb2ea4 https://youtu.be/VBK_4ruKC8s

Manufacturing a Model Car

Create a car model starting from producing a technical drawing of the mechanical components using a CAD software. All the mechanicals and electrical parts of the car model have to be constructed and assembled to form the model and testing can commence. This involves the movement of the model the controls and the linkage between the model and the students mobile.



Time Allocated to Activity: 70 hours

Tools/Equipment Needed : Metal Sheet Workshop, CAD stations, Electronics Laboratory

Materials Metal Sheets, Electroncis, Microcontroller, Electric Motors

Level: Intermediate

Experiences: No Previous experience required

Number of Students: 10

Competences (Summary): *English, CAD knowledge, maths calculations, multiple material knowledge, basic electronic & programming, basic workshop practice*

Individual/Group/number of people: Can be done in groups of 2/3 but ideally it is done individually

Creating a Package Dyeline / Packaging Design Process

Step-by-step guide to create a packaging, focusing on creating the Dyeline What is a dyeline and how do we create one? How do we develop a dyeline? Why features will the dyeline require?

Time Allocated to Activity: 5 to 10 periods

Tools/Equipment Needed: Computer Graphic, Cutter, Ruler, Scissors

Materials: Cardboard

Level: Intermediate

Experiences: Competences in science and technology, Digital competence

Number of Students: 20

Competences: *Competences in science and technology, Digital competence*

Individual/Group/number of people: small group or individual activity

Useful Links: TTP TECHNOLOGY SRLS (https://ttp-technology.it/) https://drive.google.com/open?id=1aBZk3PxdmlYFawaYuewCnHVT_dm36TJG https://youtu.be/mjCq9AL94rI

Skyline 3D modelling

Description of Activity : The students will develop a printable 3D prototype of their neighbourhood or city skyline. With this activity, students can recognize their near environment and identify the elements they consider relevant to create their urban landscape reflecting historical, geographic, touristic or cultural aspects.

Time Allocated to Activity: 40 hours

Tools/Equipment Needed: Computers for: Internet navigation, digital presentations, video editor, basic 3D modelling, postprocessing for 3D printing. Smartphones (video recording). 3D printer.

Materials: Plastic filament (PLA, TPE, PC)

Level: Basic and Intermediate

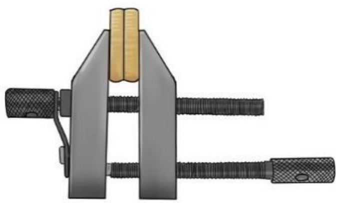
Experiences: No Previous experience required

Number of Students: 20-25

Competences: *Digital competences: Navigate, search, filter and manage information, English, create digital contents, basic 3D modelling skills. Apply maths calculations, geometry and physics principles, plastic filaments knowledge.*

Individual/Group/number of people: can be done in groups of 3/4.

Toolmakers' Clamps



A quick release clamp which securely holds two objects together for machining such as drilling, milling etc. This clamp has a function that can be released without losing previous settings.

Time Allocated to Activity: 30 Hours

Tools/Equipment Needed: Lathe, Milling machine and Drilling Machine

Materials: Bright Mild steel and threaded rod

Level: Intermediate

Experiences: Basic knowledge of machine shop safety

Number of Students: one for every project

Competences: *English, CAD knowledge, maths calculations, multiple material knowledge, basic electronic & programming, basic workshop practice*

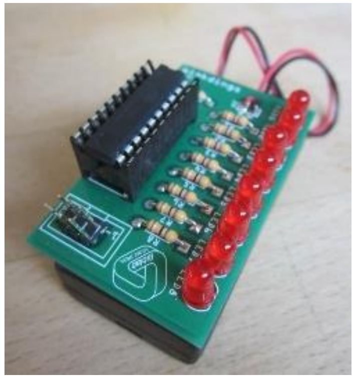
Individual/Group/number of people: this project can be done Individually or as a Group but preferably Individual

Useful Links: https: //www.youtube.com/watch?v=1tRgONkbEdM&list=PLURt-tUo1BKssiyUtrDkkO2uYhyVfeZFd&index=2&t=1711s

https://www.youtube.com/watch?v=6UPUoVbqDKQ&list=PLURt-tUo1BKssiyUtrDkkO2uYhyVfeZFd&index=3&t=419s

https://www.youtube.com/watch?v=SYWHjK22eVU&list=PLURt-tUo1BKssiyUtrDkkO2uYhyVfeZFd&index=4&t=0s

The WinkDing



We solder a "Winkdings", a simple POV device (POV = Persistence of Vision), with which you can paint in the air. We learn the basics of current, electronics and soldering.
First we build a small circuit with an LED, which we make glow. Then we do a simple soldering exercise. The Winkdings is something like a single-row LED display, whose displayed pattern or symbol only becomes visible through movement. Here the effect of Persistance of Vision (POV) is used. Each child gets his own circuit board, which he equips with various components, such as LEDs, micro-controllers and resistors, during the event, and soldering them himself. For this purpose, each child has its own soldering station.

Time Allocated to Activity: 3 hours

Materials: ATTiny2313, IC Socket 20 pins, LED 5mm red, resistor 47 Ohm, resistor 10 kOhm, connector 2x3 pins, battery box for 2 AA batteries (with switch), Additionally velcro strip (PCB on battery box), 2 AA batteries

Level: Intermediate

Experiences: A basic knowledge of soldering and electric circuits is required

Number of Students: max 15 depending on how many soldering stations are available

Competences: The student acquires the skills to assemble, solder and program a simple circuit board.

Individual/Group/number of people: This project has to be done as an individual or as a group of two students

Useful Links: https://wiki.fablab-muenchen.de/pages/viewpage.action?pageId=11272244

Piepsthing the game

We solder a "beeping", an interactive sound game device and learn the basics of electricity, electronics and soldering.

First we build a small circuit with an LED, which we make glow. Then we do a simple soldering exercise and build the circuit for a simple game on a pin board and explain how it works. In the course each child will solder his or her own interactive sound-game device. The beeping is a game circuit that enables an interactive sound and color-memory game. Each child gets his or her own circuit board, which he or she equips with various components such as LEDs, buttons, micro-controllers and loudspeakers during the event, and also soldering these components themselves.In addition to acquiring the skills to assemble and solder a simple circuit board, each participant also has the added value of the memory training game.

Time Allocated to Activity: 3 hours

Materials: Circuit board, Attiny4313, IC-Sockel, LED1- LED8, R1; R3, R4 R2 button Capacitor, Buzzer, Battery holder 3AAA, ISP

Level: Beginner - Intermediate

Experiences: A basic knowledge of soldering and electric circuits is required

Number of Students: 8 - 14

Competences (Summary): In addition to acquiring the skills to assemble and solder a simple circuit board, each participant also has the added value of the memory training game.

Useful link: https://wiki.fablab-muenchen.de/display/WIKI/Piepdings

Manufacturing A Packaging

Create a MOCK UP packaging, 5 basic steps for creating a cardboard packaging: briefing, concept, mock-up, market test, deployment

Time Allocated to Activity: 20/40 hours

Tools/Equipment Needed: pencils, papers, cardboard, scissors, glue, set square, cutter, computer, graphic design software (Adobe Illustrator)

Materials: cardboard, paper

Level: Advanced

Experiences: Every school year our students experience this type of activity following these simple steps

Number of Students: 20

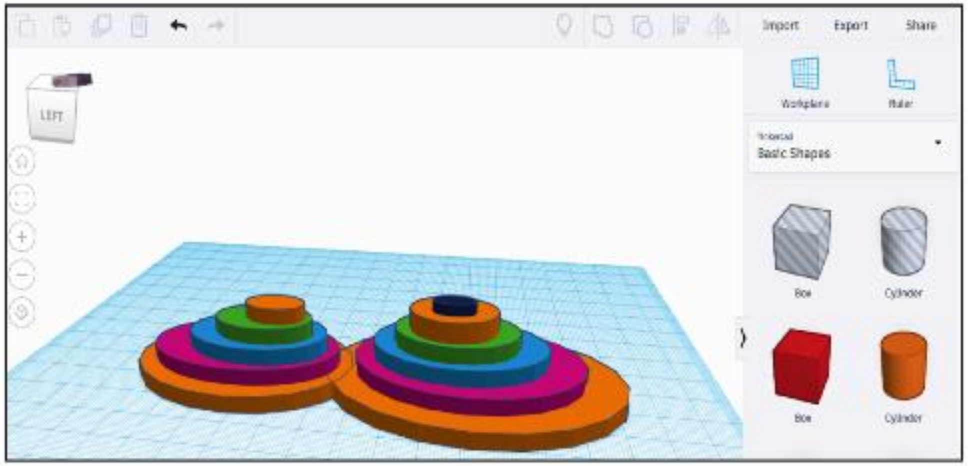
Competences: *Communication in foreign languages, Competences in science and technology, Digital competence, maths competence: graphic design software skills, manual skills, technical drawing skills, maths skills, creative skills*

Individual/Group/number of people: the activity can be done in group of 2/3 students and individually

Useful Links: https://blog.pack.ly/it/progettare-packaging-professionale-5-step/

Elevation model – lower grades

The students work out the topic of the elevation model by creating a three-dimensional model from a two-dimensional map with contour lines and printing it with a 3D printer. Here you can individually experience the meaning of the height layers and the height profile with the CAD software.



Time Allocated to Activity: 5 h (without printing)

Tools/Equipment Needed: PCs (with internet connection), TinkerCAD account, 3D printer with 3D printing material

Materials: 3D printing materials

Level Beginner

Experiences: no special skills needed

Number of Students: 2 to 30

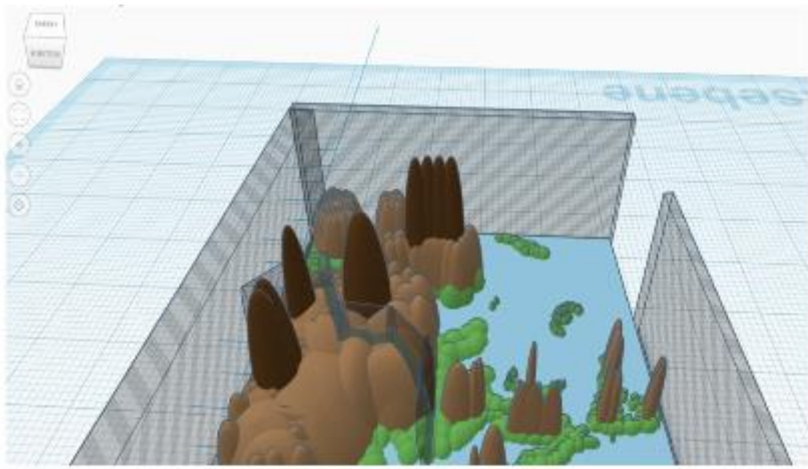
Competences (Summary): *The student learn how to rethink two-dimensional to three-dimensional bodies. They learn also the basics of 3d modelling and printing.*

Individual/Group/number of people: This project can be done as indiviual and as a group.

Useful Links: http://gymnasium-neubiberg.de/index.php/Höhenmodelle.html

Elevation model – higher grades

Describtion of Activity: The students design a grid from the United States with appropriate heights. So the group of students can later look at the influence that altitude has on the climate, vegetation and land use. The students can see the height of the landscape parts from the colour in the atlas. In addition, individual elevations on the map help them to design their model.



Time Allocated to Activity: 5 h (without printing)

Tools/Equipment Needed: PCs (with internet connection), TinkerCAD account, 3D printer with 3D printing material

Materials: 3D printing materials

Level: Beginner

Experiences: no special skills needed

Number of Students: 2 to 30

Competences: *The student learn how to rethink two-dimensional to three-dimensional bodies. They learn also the basics of 3d modelling and printing.*

Individual/Group/number of people: This project can be done as individual and as a group.

Useful Links: http://gymnasium-neubiberg.de/index.php/USA_3D.html

Title Build a toy car

Description of Activity: The goal is to build a car that slides through a track made of wood, pushed only by the gravity. The participant has a kit of pieces (wood, screws, tape,...) and besides has to build a car using a 3D modelling software and 3D printing that slide down the track and get to arrive at the end of the track. The objective is not only do a fast car but also best looking. The toy car could be improved with electronic components (spoilers, a motor, lights,...) Based on Project Based Learning methodology (PBL).

Time Allocated to Activity: 40 hours

Tools/Equipment Needed : Wood Workshop, Computers for: 2D and basic 3D modelling, postprocessing for 3D printing. 3D printer, laser cutting. Computers for digital presentations.

Materials: Wood, plywood board, cardboard, glue, screws, screwdriver, tape, etc. Plastic filament (PLA, TPE, PC). Electronics components, Microcontroller, Electric Motors

Level Basic and Intermediate

Experiences: No Previous experience required

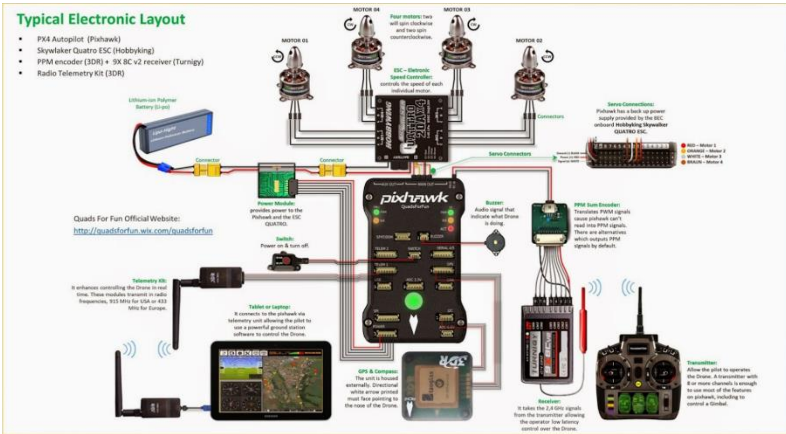
Number of Students: 20-25

Competences: *Basic materials knowledge, basic workshop practice, apply maths calculations and geometry, physics principles, plastic filaments knowledge, digital competences: digital presentations, 2D and basic 3D modelling skills, basic Lasse cutting, basic 3D printing, basic electronic & programming.*

Individual/Group/number of people: Can be done in groups of 2/3 but ideally it is done individually

Exploring Drone components

Main components within a drone and their functional role



Time Allocated to Activity: 20/40 hours

Tools/Equipment Needed: Digital electronics, Drones

Materials: Digital electronics, Drones

Level: Intermediate

Experiences: build, Connect, Programming firmware

Number of Students: 20

Competences (Summary): *Competences in science and technology, Digital competence*

Individual/Group/number of people: small group or individual activity

Useful Links: https://www.youtube.com/watch?v=K05UwsiqZ_E

Chapter 7

EVALUATION

According to the objectives of the Project Proposal for the Pedagogic Handbook, the proposed evaluation criteria should give an evidence about the effectiveness of the maker based activity as educational methods to support inclusive strategies for disengaged students, dropout students, potential dropouts, students with low performances and migrant students. As the schools, among others, should also deal with the learning aspects required to prepare students for the workplace, this project proposes a methodology that relies on maker based spaces such as FabLabs, co-working spaces and their technologies, where students can act as they were in real working environments. Curricula should be developed and monitored through dialogue and partnerships among teaching staff, students and labour market actors, drawing on new methods of teaching and learning, so that students acquire relevant skills that enhance their employability.

HARD-SKILLS

As already widely argued within the project document called IO1 Make In Class Competence Map, each maker based activity positively affects also hard-skills. Teachers have to evaluate students also by adopting traditional criteria oriented to measure their level with respect the hard-skills. After all, it would not be so difficult to observe a minimum of consistency in assigning votes, thus, pragmatically, agreeing between colleagues and applying the recommendations of the national curricula. Usually, the school regulation provides guidelines as, for example, the analytical grid that is justified for analysing the type of errors made and the specific qualities of an elaborate. The current school systems, in several countries, have also introduced the concept of formative assessment into the pedagogical environment, meaning by this not an immobile, punctual and sometimes crippling verification of a state of affairs, but an activity that provides the teacher with feedback connected to a school intervention that takes into account the results according to the subsequent teaching activity.

This does not exclude moments of summative evaluation: but the initial and intermediate evaluation should have a function mainly from the didactic (operative) point of view: be “formative”, “diagnostic”, “prognostic” and “therapeutic”, “programmatic” and “planning”. **This means that the evaluation should be mostly “process” and not just “product”.**

In this project approach, and according to what has been said before, we strongly suggest to the teachers to prepare several assessments through the entire process of the maker based activity, for example at the end of each didactic unit/module it is composed of.

SOFT-SKILLS

The proposed approach considers relevant to monitor and measure the student knowledge, composed of soft skills, in order to have an evidence for student engagement, motivation and empathise aspects; that is, when soft skills are performed low, they are always symptoms of potential dropouts. Soft skills indicate a set of intangible personal qualities, traits, attributes, habits and attitudes that can be used in many different types of jobs; in particular, students exhibit the soft skills within maker based spaces where activities are structured and conducted as in real workplaces.

Traditional teachers evaluation criteria are focused on hard skills, that are mainly related to the knowledge of school topics (i.e. they focus on *hard-skills*) and they give little evidence towards aspects about student personal and social abilities to effectively deal with real working environment (i.e. *soft-skills*). It is now widely accepted that soft skills like creativity and entrepreneurship for innovation, or other soft skills such as communication, team working, interpersonal relations are just as important for the expanding employment sectors as hard skills. Examples of soft skills include: critical thinking, problem solving, team working, communication, work ethic, continuous improvement, creativity, adaptability, etc. The term is also used in contrast to hard-skills that are considered as more technical, highly specific in nature and particular to an occupation, and that can be (generally) taught more easily than soft skills. As far as we know the following definitions for soft-skills are well accepted in the literature.

Definition 1: Skills that are cross-cutting across jobs (see Job-specific skills) and sectors (see Sector-specific jobs) and relate to personal competences (self-confidence, discipline, self-management) and social competences (teamwork, communication, emotional intelligence).

Definition 2: A set of intangible personal qualities, traits, attributes, habits and attitudes that can be used in many different types of jobs. As they are broadly applicable they are also seen as transferable skills, even if the idea of transferability is often questioned because individuals learn to perform tasks in particular contexts and may not be able to apply them to others.

The evaluation criteria relies on the following table that works as a guideline for teachers/expert in order to make as much as possible easy to score students against their soft skills. In particular, the first two columns from the left give a characterization of the specific soft-skill to be measured. The correlation between soft-skills and learning outcomes makes clearer the impact of each soft skill against competencies.

The last two columns of the table cope with the score level for the student specific soft-skill.

The process used by teachers to gather scores should not be so different from the one adopted for hard-skills. Therefore, we strongly suggest the use of the following methods:

a. questionnaires, oriented as much as possible to figure out and to measure the “performance indicators” and “learning outcomes” related to the soft-skills as described in the tables below;
b. observation, for example setting up mini hackathon that force students to put in practice most of the relevant soft skills in order to achieve the objectives and to produce the results;
c. tests, they should be more oriented to practical execution and/or repetition of some experiments;
d. presentation, at the end of each unit and/or at the end of a project-work, the teacher should ask to the student to prepare a short presentation or a pitch as s/he was within a real working environment.

The timeline for the evaluation process should be clearly described to the students, by the teacher, in advance and according to each “Hands On Activity”.

SOFT SKILLS DESCRIPTION	LEARNING OUTCOMES	PERFORMANCE INDICATORS	SCORE LEVEL
CRITICAL THINKING The ability to find information in the literature, to distinguish between primary and secondary sources, to find information on the Internet, to use various research methods and evaluation techniques required for the project fulfilment (eg. resources in OER project platforms)	1. **Recognize** the need for information and determine the nature and extent of the information needed 2. **Find effectively** and efficiently needed information. 3. **Analyze** and understand the economic, legal, and social issues surrounding the use of information, access and use information ethically and legally. 4. **Evaluate and synthetize** the information found on the Internet. 5. **Organize**, manage and present information. 6. **Effectively use** information to accomplish a specific purpose.	**Excellent ability** in the process of searching information on the network by recognizing, effectively finding, analysing, evaluating, synthetizing and organizing in order to effectively use information for a specific purpose	9-10
		Proficient ability in the process of searching information on the network by recognizing, effectively finding, analysing, evaluating, synthetizing and organizing in order to effectively use information for a specific purpose	7-8
		Basic ability in the process of searching information on the network by recognizing, finding, synthetizing and organizing the basic information for a specific purpose	5-6
		Poor/Low ability in the whole process of searching information on the network by recognizing, finding, synthetizing and organizing the basic information for a specific purpose with the support of the tutor.	3-4
		Unsatisfactory ability in the whole process of searching information on the network by recognizing, finding the basic information for a specific purpose with the support of the tutor	1-2
PROBLEM SOLVING To work out ideas in order to put in practice creativity for transforming resources/inputs according to the desired project objectives.	1. **Be able to ask** thoughtful questions to understand an assignment 2. **Be able to find effective solutions** to problems using also proper digital technologies. 3. **Be proactive** and willing to take reasonable risks 4. **Show initiative** 5. **Have planning and time management** skills in order to achieve the best solutions and best results.	**Excellent ability in problem solving** by asking proper and thoughtful questions in order to understand the assignment/problem/situation, by finding effective solutions for all the problems that arise, by selecting, combining and using digital technologies to solve technical and non-technical problems according to their needs and assess their effectiveness, by showing initiative and proactive attitude, by managing time and by planning activities.	9-10
		Proficient ability in problem solving by asking proper and thoughtful questions in order to understand the assignment/problem/situation, by finding effective solutions for most of the problems that arise also using digital technologies to solve technical and non-technical problems according to their needs and assess their effectiveness, by showing proactive attitude, by managing time and by planning activities according to some given guidelines.	7-8
		Basic ability. **in problem solving** by asking proper and thoughtful questions in order to understand the assignment/problem/situation, by finding effective solutions for some of the problems that arise, also using some digital technologies. Difficulties in following guidelines for planning activities.	5-6
		Poor/ law ability in problem solving by just asking simple questions in order to	3-4

		understand the assignment; the student is not able to find effective solutions for most of the problems that arise. Lack of planning activities.	
		Unsatisfactory ability in problem solving – the student s not able even to ask simple questions in order to understand the assignment; he/she is not able to find any type of solution for all the problems that arise. Lack of planning activities.	1-2
TEAM WORKING The ability to build relationships of participation and cooperation with other people. It involves sharing resources and knowledge, harmonizing interests and contributing actively to reach the objectives of the organization.	1. **Communicate** clearly information and ideas 2. **Interact** effectively among the team members 3. **Manage conflicts** and decision making to reach an agreement that satisfies everyone with the aim of achieving the same proposed goals 4. **Use** effectively a wide range of **team processes** (brainstorming, structured organization, roles division, meetings, etc.) 5. **Conduct a self-evaluation** as team members and identify specific areas for improvement	**Excellent ability in team working** by communicating clearly all the information and ideas, by interacting effectively among the team members and by managing all the conflicts in decision making, by using effectively a wide range of team processes and by making a self-evaluation as team members to identify specific areas for improvement.	9-10
		Proficient ability in team working by communicating quite clearly most of the information and ideas, by interacting effectively among the team members and by managing most of the conflicts in decision making, by using effectively a wide range of team processes**.**	7-8
		Basic ability in team working by communicating not always very clearly basic information and ideas, by interacting among the team members who are able to manage just some of the conflicts in decision making, by using some of the team processes**.**	5-6
		Poor/ law ability in team working by communicating not very clearly basic information and ideas just with the help of the teacher/tutor, by interacting with difficulty among the team members who are not able to manage the conflicts in decision making.	3-4
		Unsatisfactory ability in team working by communicating confusingly some information and ideas just with the help of the teacher/tutor, by interacting with great difficulty among the team members who are not able to manage the conflicts in decision making.	1-2
COMMUNICATION The ability to transmit ideas, information and opinions clearly and convincingly both verbally and in writing, while listening and being receptive to the proposals of others.	1. **Communicate** transparently as a result of increased congruence or confidence. 2. **Practice** active listening. 3. **Present** clearly and confidently to an audience. 4. **Monitor and manage** communication patterns in a group. 5. **Communicate** expressively and effectively in face-to-face and online settings. 6**. Communicate** expressively and effectively in written communication.	**Excellent ability in communication** by communicating transparently, by practicing active listening, by presenting ideas and contents clearly and confidently to an audience, by monitoring and managing communication patterns in a group, by communicating expressively and effectively in face-to-face, online and in written settings.	9-10
		Proficient ability in communication by communicating quite transparently, by practicing active listening, by presenting ideas and contents quite clearly and confidently to an audience, by monitoring and managing communication patterns in a group, by communicating quite expressively and effectively in face-to-face, online and in written settings.	7-8
		Basic ability in communication by communicating and by presenting ideas and	5-6

		contents not always very clearly to an audience, by communicating not very expressively and effectively in face-to-face, online and in written settings.	
		Unsatisfactory ability in communication by communicating and presenting ideas and contents confusingly to an audience, by communicating confusingly in face-to-face, online and in written settings	3-4
		Poor/ law ability in communication by communicating and presenting ideas and contents very confusingly to an audience, by communicating very confusingly in face-to-face, online and in written settings	1-2
WORK ETHIC The ability to perform the activities, duties and responsibilities in order to achieve and finalize the project objectives .	1. **Perform** the activities, duties and responsibilities 2. **Respect** the timeframes, tasks and resources required 2. **Respect** the working equipment and the safety rules in lab environments 3. **Meet** the deadlines 4. **Update** the process and techniques in use. 5. **Collaborate** to solve problems	**Excellent ability in work ethic** by performing all the activities, duties and responsibilities, by respecting the timeframes, tasks and resources required, by respecting the working equipment and all the safety rules in lab environment, by meeting all the deadlines, by updating the process and techniques in use, by collaborating to solve all the problems	9-10
		Proficient ability in work ethic by performing most of the activities, duties and responsibilities, by respecting the timeframes, tasks and resources required, by respecting the working equipment and the safety rules in lab environment, by meeting the deadlines, by updating the process and techniques in use, by collaborating to solve most of the problems	7-8
		Basic ability in work ethic by performing the basic activities, duties and responsibilities, by respecting just some of the timeframes, tasks and resources required, not always by respecting the working equipment and the safety rules in lab environment.	5-6
		Poor/ law ability in work ethic by performing just some of the activities, duties and responsibilities with the help of the teacher/tutor	3-4
		Unsatisfactory ability in work ethic by performing just a few activities, duties and responsibilities just with the help of the teacher/tutor	1-2
CONTINUOUS IMPROVEMENT The ability to observe how the created product performs after deployment and the ability to figure out weaknesses and strengths in order to improve the product	1. Set goals and measurable objectives. 2. Find a quality variation's root cause. 3.Determine the timeframes, tasks, responsibilities and resources required to achieve the improvement goals identified. 4. Measure weaknesses and strengths in order to improve the result according to the expected performance indicators	**Excellent ability in the continuous improvement** by setting goals and measurable objectives, by finding a quality variation's root cause, by determining the timeframes, tasks, responsibilities and resources required to achieve the improvement goals identified, by measuring all the weaknesses and strengths in order to improve the result according to the expected performance indicators	9-10
		Proficient ability in the continuous improvement by setting goals and measurable objectives, by determining the timeframes, tasks, responsibilities and resources required to achieve the improvement goals identified, by measuring most of the weaknesses and strengths in order to improve the result according to the expected performance indicators	7-8
		Basic ability in the continuous improvement by setting basic goals and some	5-6

		measurable objectives, by determining some of the timeframes, tasks, responsibilities and resources required to achieve the improvement goals identified, by measuring weaknesses and strengths just with the help of the teacher / tutor.	
		Poor/ law ability in the continuous improvement by setting a few goals and tasks just with the help of the teacher / tutor.	3-4
		Unsatisfactory ability in the continuous improvement by setting some goals just with the help of the teacher / tutor.	1-2
CREATIVITY FOR INNOVATION The ability to contribute with new creative ideas that can improve the activities performed	1. Apply new methods for completing required tasks 2. Improve one's ability to respond practically and creatively to problems and opportunities. 3. Use frameworks and strategies to generate a supportive environment for creativity and innovation, e.g. exchange ideas in online forums, facilitate team processes in an atmosphere of mutual respect and support, etc.	**Excellent creativity for innovation** by applying all the new methods for completing required tasks, by responding practically and creatively to all the problems and opportunities, by using frameworks and strategies to generate a supportive environment for creativity and innovation	9-10
		Proficient creativity for innovation by applying most of the new methods for completing required tasks, by responding practically and creatively to most of the problems and opportunities, by using frameworks and strategies to generate a supportive environment for creativity and innovation	7-8
		Basic creativity for innovation by applying some basic methods for completing required tasks, by responding practically and creatively just to some basic problems and opportunities with the help of the teacher / tutor.	5-6
		Poor/ law creativity for innovation by applying simple methods for completing required tasks just with the help of the teacher / tutor.	3-4
		Unsatisfactory creativity for innovation by applying no methods for completing required tasks	1-2
ADAPTABILITY The ability to adapt to different environments and to different people	1. Portray the value of diversity and be able to adapt to different people 2. Interact flexibly and adaptively in new environments 3. Employ sensitivity and empathy in interpersonal relationships	**Excellent adaptability** by portraying the value of diversity and by adapting to different people, by Interacting flexibly and adaptively in new environments, by employing sensitivity and empathy in interpersonal relationships	9-10
		Proficient adaptability by portraying the value of diversity and by adapting to different people, by Interacting quite flexibly and adaptively in new environments, by employing sensitivity and empathy in interpersonal relationships	7-8
		Basic adaptability by portraying the value of diversity and by adapting to some people and to some new environments also with the help of the teacher / tutor.	5-6
		Poor/ law adaptability by adapting to a few people and to a few new environments just with the help of the teacher / tutor.	3-4
		Unsatisfactory adaptability by not adapting to different people and to new environments even with the help of the teacher / tutor	1-2

CONCLUSION

As Anatole France says “Nine-tenths of education is encouragement”, and this the scope behind this Erasmus+KA2 project. In order to reduce students’ dropouts, teachers need to encourage students to participate in activities. This booklet is a practical tool that was designed to assist teachers who want to motivate near dropout Secondary School learners with practical methods. The Make In Class project aimed to guide teachers to take another step towards the integration of theory with suitable practical projects.

Educators are encouraged to follow this hands-on booklet, which was created by other experienced teachers specialised in different sectors, and learn to implement a series of Make In Class intellectual outputs related to every topic being delivered.

This booklet was structured so that even inexperienced teachers can easily follow this guide. Teachers will find the basis for practical examples that are inspired by real-life experiences.

We hope that, with this project of integrating activities in the school, curricula will change teachers’ approach to deliver lessons and that education towards the drop-out students will become more of a playful approach than simply purely academic. Through this approach, students can still acquire professional skills, transversal competence and soft skills.

In the end teachers need to encourage students to develop a passion for learning because, as Anthony J. D’Angelo states,

“Develop a passion for learning. If you do, you will never cease to grow.”