

Circular Design Digital Fabrication Labs Handbook

Version 1 - 09.08.2019

 **CIRCULAR
DESIGN** Learning for Innovative
Design for Sustainability



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About this handbook

In this world where digital fabrication technologies are constantly evolving and enabling, designs are openly shared, fabrication labs and makerspaces are widespread and accessible to everyone, people can design and make things locally and collaborate horizontally to innovate and create individually, locally and globally meaningful design solutions. Such accessibility creates opportunities on many issues, especially for sustainability and Circular Economy, through enabling distributed design and production, personalization, engaging with a local or online community to collaborate, and so on.

This handbook you are reading is an introductory guide to bring together digital fabrication labs (e.g. FabLabs, hackerspaces, makerspaces, etc.) and the related practices enabled through digital knowledge sharing into design education for sustainability and Circular Economy. This handbook introduces terms of these newly espousing fabrication spaces and the communities around them, potentials of these spaces for sustainability and Circular Economy. The contents of this handbook were used for delivering masterclasses as part of two Circular Design Internships conducted in University of Limerick, Ireland and Universitat Politècnica de Catalunya, Spain.

As partners of the L4IDS Erasmus+ project, we are happy to share the output of our collaboration with you and we would like to thank you in advance for your interest in our work. Together, we have the power to make the world a better place!

1. Introduction

Digital Fabrication Labs are used as spaces of co-creation of knowledge, where students and staff are able to work with real challenges that enterprises are facing in sustainable design. This stage will provide capacity building and reflection spaces to university academics, students and enterprise staff to develop entrepreneurial skills and foster knowledge co-creation.

The participants will explore the Digital Fabrication Labs philosophy and approach to researching, ideation, designing, experimentation, building and making. In addition, the participants will learn the necessary skills (software and hardware) to operate the machines and equipment in the labs and gain expertise in those most appropriate to their project brief.

Goal

To introduce students, partner, companies and academics to the open-source, participatory, experimental and design & build approach within digital fabrication labs.

Objectives

- Develop innovative design solutions for sustainability to the challenges set throughout the internship.
- Explore how digital fabrication tools & methodologies can be integrated into the innovation process.
- Experiment with Digital Fabrication Labs approach by working openly with the widest variety of stakeholders from across the community, business and academic groups.

Working Plan

This handbook will support a variety of interventions at different stages of the internship/module to teach the methodological and philosophical approach within Digital Fabrication Labs.

Outcomes

- This handbook that can be used across all DFLabs.
- Feedback mechanisms from the host DFLab to the DFLab programme design team to develop and improve the toolkit.

2. Digital Fabrication Labs

In recent years new digital fabrication technologies has fostered the development of spaces offering shared access to high-end manufacturing equipment. These spaces are referred to as hackerspaces, makerspaces, techshops and fab labs. To the general public, differences between them might not be clear but they define very different approaches to the community culture and access to manufacturing.

Hackerspaces

Hackerspaces origins are connected to the underground hacker computer communities from the second half of the '90s They started as pure software centred community spaces but later incorporated electronic circuit design/ manufacturing and physical prototyping. They operate as closed communities in which most of them are membership-based and have rigorous invite-only policies.

Makerspaces

First Makerspaces opened in the mid-2000s. They are publicly-accessible places to design and create, provided with digital fabrication technologies and all sort of analogue equipment. They normally use an always-open workshops policy and are welcome to more diverse creative community than hackerspaces. Makerspaces are often related in the context of creating spaces for children to discover these technologies.

TechShop

Techshop is the name of a chain of for-profit spaces started in 2006 in Menlo Park, California, that calls themselves "America's First Nationwide Open-Access Public Workshop". TechShop offers public access to high-end manufacturing equipment in exchange for membership fees. On November 15, 2017, with no formal warning, the company closed and announced they would declare bankruptcy under Chapter 7 of the U.S. bankruptcy code

(immediate liquidation). There is no indication this has occurred. As of December 2017, a group was finalizing the acquisition of the assets and debt and planning to reopen some locations under the name TechShop 2.0.

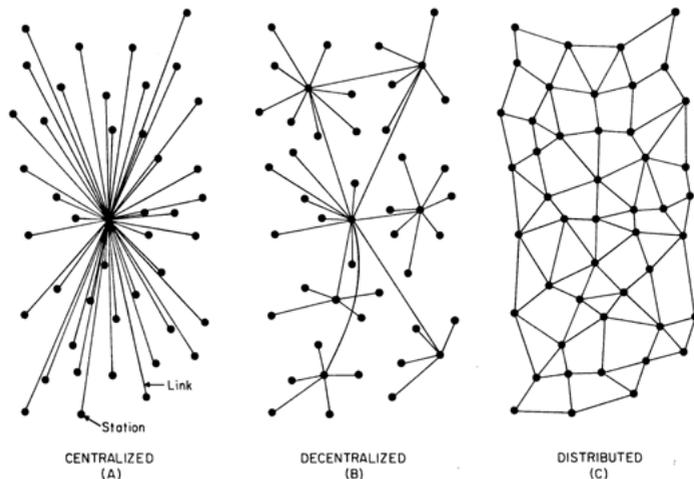


Figure 1. Centralized, decentralized and distributed networks by Paul Baran (1964)

Fab Lab

A Fab Lab is a technical prototyping platform for innovation and invention, providing stimulus for local entrepreneurship. To be a Fab Lab means connecting to a global community of learners, educators, technologists, researchers, makers and innovators, a network that spans 1000 Fab Labs, 30 countries and 24 time zones. Because all Fab Labs share common tools and processes, the program builds a global network, a distributed laboratory for research and invention.

Being an active member of the Fab Lab global network gives any Fab Lab a great capacity for research and invention

partnerships as well as a vast pool of technical knowledge and human resources on digital fabrication and related fabrication technologies. It is important to note that the Fab Lab network does not enforce any particular affiliation, legal structure or business model so each fab lab has its own capacity to create and develop local partnerships and opportunities.

This distributed network configuration (see Figure 1) allows an unprecedented capacity for technological expertise and invention.

3. Circular Fabrication

There is a need to reinvent our cities and their relationship to people and nature by re-localising production so our communities are generative rather than extractive, restorative rather than destructive, and empowering rather than alienating, where prosperity flourishes and people have purposeful, meaningful work that they enjoy, that enables them to use their passion and talent.

We need to recover the knowledge and capacity on how things are made in our cities, by connecting citizens with the advanced technologies that are transforming our everyday life.¹

From linear to circular

How we might move away from importing most things into local regions and export our waste, following a linear model of extraction, transport, production, distribution, consumption and waste, and instead, introduce a circular model, where all resources flow in a closed-loop system within the region itself.

FAB City

FAB City takes the ideals of the Fab Lab - the connectivity, culture and creativity - and scales it to the City. It is a new urban model of transforming and shaping cities that shifts how they source and use materials from 'Products In Trash Out' (PITO) to 'Data In Data Out' (DIDO). This means that more production occurs inside the city, along with recycling materials and meeting local needs through local inventiveness. A city's imports and exports would mostly be found in the form of data (information, knowledge, design, code).

The Fab City project will help civic leaders to develop locally productive cities in collaboration with local communities, companies and institutions, revitalising manufacturing infrastructure and incentivising a new economy. Fab



Figure 2. Linear manufacturing model from the XVIII Industrial Revolution from Fab City Whitepaper

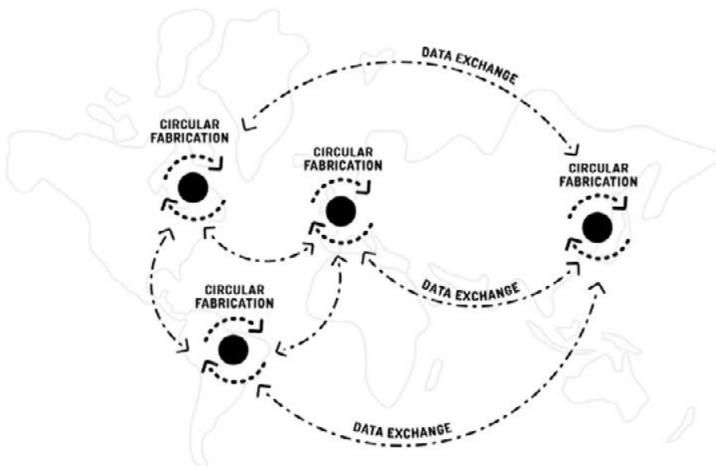


Figure 3. Circular manufacturing model from Fab City Whitepaper

Lab and makerspace based innovations could be a source for solutions to connect to real problems in cities, opening opportunities for businesses, research and education through projects. With its inherent zero waste and carbon reduction goals, linked to education, innovation, skills development and the creation of employment opportunities and livelihoods through the relocalisation of manufacturing, the FAB City approach can contribute to achieving a range of city objectives.

Strategies

- **Advanced Manufacturing Ecosystem:** Being part of a global network of cities that share knowledge and best practices on urban solutions emerging from citizens, companies, educational institutions, and governments. Local networks of Fab Labs and mid-scale production centres connected to the larger global network of supply chains, sharing knowledge, best practices and projects.
- **Distributed Energy Production:** With the advent of domestic batteries and efficiency improvements in solar and other means of clean power generation, energy distribution itself will face enormous changes. Distributed grids will change the role of households and businesses in power, water and resources distribution.
- **Cryptocurrencies for a New Value Chain:** Cities creating their own trade markets connected to a global economy, using a multi-currency and value system based on the blockchain and similar technologies.
- **Food Production and Urban Permaculture:** Urban farming will scale up from experimental practice to large scale infrastructure. Local production of foods at domestic, neighbourhood and city scales will create a closed-loop system for food production and

harvesting.

- **Educating for the Future:** Incorporating a stronger emphasis on learning-by-doing in education systems and curricula, and engaging all levels of education in finding solutions for local needs through digital fabrication technologies, and sharing them with global networks.
- **Building the Spiral Economy:** Reduce the amount of imported goods, food and resources like water or energy. Increase the use of recycled raw materials for the production of objects in cities. Create added value in every iteration of a new product.
- **Collaboration between Governments and the Civil Society:** Local government and civic organizations, start-ups, universities, and other organizations must work together in order to make a cultural shift that promotes the empowerment of cities and their citizens.

Recycling and additive manufacturing

Precious Plastic

The world is submerged with plastic, from the heights of Himalayas to the depths of the Atlantic ocean we have tons of toxic plastic laying around.

Precious Plastic is a plan that will allow people, anywhere in the world to transform plastic waste into valuable things. Precious Plastic has been developing machines to recycle plastic waste, locally. The machines are developed using basic tools and materials. All the blueprints are shared online with open source licenses. This way people around the world can build them. Once the machines are built people can start experimenting, creating and producing new products from their local plastic waste. The primary goal is to recycle as much plastic as possibly can.

» preciousplastic.com/en/videos/

3D Fuel waste byproducts filaments

Coffee Filament

A coffee filled 3D printing filament made using waste byproducts from coffee roasting to create a special 3D printing material with visibly unique print finishes. Smells like a luxurious latte while printing.

» eu.3dfuel.com/products/wound-coffee-filled-filament

Beer Filament

A beer-filled 3D printing filament made using waste byproducts from the beer-making process to create a special 3D printing material with visibly unique print finishes. Smells like barley grain while printing.

» eu.3dfuel.com/products/buzzed-beer-filament

Hemp Filament

An industrial hemp 3D printing filament made using the waste from industrial hemp processing. Industrial hemp requires no herbicides/pesticides for growing. Smells like lawn clippings while printing.

» eu.3dfuel.com/products/entwined-hemp-filament

Trash Filament

Garbage based 3D printing filament made using upcycled Municipal Solid Waste(MSW). Because of this process, each spool of Landfillament sequesters .909lbs of CO₂e (carbon dioxide equivalent) which is the equivalent amount of greenhouse gas emitted by a car driven 1.1 miles.

» eu.3dfuel.com/products/landfillament-garbage-filament

Recycled Plastic Filaments

Recycled plastic-based filaments are currently available in different variations, using different material waste streams, and different colours. The companies Refil, and Filamentive propose a variety of standard options ranging from rPET, to rPLA to rABS, all having similar or exactly the same 3D printing properties as it's virgin counterparts.

- » www.re-filament.com
- » www.filamentive.com

Glass-filled Filament

Glass-filled PLA 3D printer filament is a first-of-its-kind engineering-grade filament that can be used on any machine capable of printing standard PLA.

- » eu.3dfuel.com/products/glass-filled-pla

(Recycled) Home Filament Makers

The near-perfect sustainable solution for the plastic problem is using municipal waste streams as material input, and combining a filament maker and a 3D printer to create (functional) products as output. Theoretically, you could make high-quality products from your household waste. However, as municipal single-use plastic waste consists of a variety of different types of plastic with different melting temperatures, mixing them will not be an option. Let alone the inconsistencies caused by food waste or other, using your own waste to create 3D printer filament is much harder than it seems.

However, there are a few options on the market available that create, for instance, new 3D printer filaments from broken 3D prints or 3D printer waste, like Qactus in Chile, Perpetual Plastic that recycles used beer cups on festivals, or ReFlow from the Netherlands, who are set in developing countries such as India to recycle and 3D print locally.

Hereafter, there are home or office filament makers

available, which will turn any type of monostream granules to a relatively consistent filament, this can also be made of recycled granules. Companies that offer these setups are Filabot, Filastruder, FelFil, and for instance 3devo.

- » qactus.cl
- » www.perpetualplasticproject.com
- » reflowfilament.com
- » www.filabot.com
- » www.filastruder.com
- » felfil.com
- » 3devo.com

Recycling and Other FabLab Tooling

Sheet Materials, for CNC Milling, Laser Cutting and/or Other

Other materials, such as sheets, are also available on the global marketplace, of which most are easily processed through either (CNC) milling, vacuum forming or even laser cutting. A great variety of (specifically plastic) sheets are found at Smile Plastics, UK. Another great library for materials, albeit some are in development and some are actually produced, is called MaterialDistrict, if you tick the “renewable” box when looking browsing for materials you can find many different options. Though of course, there are many larger alternatives such as Alibaba (search specifically for recycled plastic sheets).

- » smile-plastics.com
- » materialdistrict.com

Recycled and Sustainable Fabrics

More companies offer fabrics that either use recycled materials, or are generally sustainably produced. Waste2Wear, for instance, is a company that focuses solely on plastic recycling (mostly PET bottles) and produces a

range of different fabrics. Of course, again MaterialDistrict is a great resource for sustainable fabrics.

➤ www.waste2wear.com

(Semi-)Finished Parts, Prototypes and DIY

Of course, everyone interested in building sustainable products should take a look at least three different websites.

First of all, Instructables is an immense resource for any type of product that has been once built by someone, and where the process of the build is captured, it offers DIY's, how-to's, build plans, 3D models, electronic schemes, pictures, movies and a very involved community. If you add the term "recycling" or "recycled" in its search bar, you will find loads of different builds - while another option is to search for the thing you would want to build anyway, say a "wind turbine", and start building it from sustainable materials, using the libraries already mentioned previously.

Secondly, especially looking at 3D printing or CNC laser cutting yourself, there are many great online libraries available where you will find loads of (adjustable) 3D and 2D models, a great one is Thingiverse, but there are many others.

Lastly, if you don't have the time, have access to your own 3D printer, or have no access to a Fab Lab easily, there are community websites where you can upload your 3D model, and someone near you who does have the proper tools and experience, will produce it for you against a fee, a website like the worldwide service 3DHubs, or Shapeways is a great resource for hired tools, but there are some others too.

➤ www.instructables.com

➤ www.thingiverse.com

➤ www.3dhubs.com

➤ www.shapeways.com

Distributed infrastructure

Distributed Energy Production

- Tom Odoyo's Wind Power Generator, at Fab Lab Nairobi.
 - » www.shopbotblog.com/2010/10/my-wind-power-generator/
- Wind turbine at Lorain County Community Fab Lab.
 - » blog.wolfjeschonnek.de/?page_id=38
- WindpowerWriter The goal of this project is 3D-printing a fully functional Wind Turbine (WT) at a small scale, using commonly available printing technologies and materials.
 - » www.makesea.com/web/claimer/windpowerWriter

Distributed Sensing

- Smartcitizen is a team created in Fab Lab Barcelona who believe data is critical to inform political participation at all levels. Smartcitizen develops tools for citizen action in environmental monitoring and methodologies for community engagement and co-creation.
 - » smartcitizen.me
- Aircasting is an open-source, end-to-end solution for collecting, displaying and sharing health and environmental data using your smartphone.
 - » aircasting.org

Distributed Energy Storage

- Second Life Storage is an online community about DIY energy storage solutions.
 - » secondlifestorage.com
- Jehu Garcia's DIY Powerwall Project is an open-source version of Tesla's Powerwall energy storage solutions.

» kit.com/jehu/jehu-s-diy-powerwall-pcb-project

Distributed Networks

- FabFi is an open-source, city-scale, wireless mesh networking system initially developed at FabLab Jalalabad, Afghanistan.

» web.archive.org/web/20111119205258/http://fabfi.fabfolk.com/techsummary/

Endnotes:

1: Fab City Fab City is a new module for locally productive and globally connected self-sufficient cities.

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Diez, Tomas. "Personal Fabrication: Fab Labs as Platforms for Citizen-Based Innovation, from Microcontrollers to Cities." *Digital Fabrication*: 457-68. *Nexus Network Journal*. 2012

Diez Ladera, Tomas. "The New Production Ecosystem. Personal, Distributed, Open Fabrication." *CCCB LAB RSS*. CCCB, 04 Apr. 2013

Vicente Guallart. *The Self-Sufficient City: Internet has Changed Our Lives But it Hasn't Changed Our Cities, Yet...* ACTAR Press, Anaheim, CA, USA. 2014

4. Crowdfunding

Crowdfunding is the practice of funding a project or cause by raising money from a large number of people, typically through the Internet. It is a form of peer-to-peer fundraising that harnesses the power of social networks to raise awareness and draw donations from around the world for online campaigns.

Although this financing option is typically used by startups, small companies and individuals, crowdfunding is a viable financing mechanism for companies of all sizes and maturity levels.

People contribute to crowdfunding campaigns because of the campaign purpose, rewards and/or the presentation creativity. A compelling circular design project can benefit from a well-run crowdfunding campaign, especially if it capitalizes on these three levels.¹

Fab Labs are great environments for raising funds through crowdfunding as they have the necessary tools not only to build your first prototypes but to rapidly iterate when receiving first backers support and feedback about your product or service. Also, the local community of makers, creatives and entrepreneurs that normally consolidates around Fab Labs will be helpful in the initial stages of your crowdfunding campaign.

From tapping into a wider investor pool to enjoying more flexible fundraising options, there are a number of benefits to crowdfunding over traditional methods:

- **Reach:** By using a crowdfunding platform, you have access to thousands of accredited investors who can see, interact with, and share your fundraising campaign.
- **Validation of Concept:** Presenting your product or service to the masses creates an excellent opportunity to validate and refine it. As potential investors begin to express interest and ask questions, you'll quickly see if there's something missing that would make them

more likely to invest.

- **Efficiency:** Crowdfunding has the ability to centralize and streamline your fundraising efforts. By building a single, comprehensive profile to which you can funnel all your prospects and potential investors, you eliminate the need to pursue each of them individually.

Just like there are many different kinds of capital round raises for businesses in all stages of growth, there are a variety of crowdfunding types:

- **Donation-Based Crowdfunding:** It is a crowdfunding campaign in which there is no financial return to the investors or contributors.
- **Rewards-Based Crowdfunding:** It involves individuals contributing to your business in exchange for a “reward,” typically a form of the product or service your company offers.
- **Equity-Based Crowdfunding:** It allows contributors to become part-owners of your company by trading capital for equity shares.

Crowdfunding Platforms

- *Kickstarter* is a platform where creative projects raise rewards-based crowdfunding. These projects can range from new creative products to tech and design products, to pre-selling of these products and services.
↗ www.kickstarter.com
- *Indiegogo* approves donation-based crowdfunding campaigns for almost anything - music, hobbyists, personal finance needs, charities and whatever else you could think of except investment.
↗ www.indiegogo.com
- *Fundable* is a fee-based crowdfunding platform that offers both rewards-based crowdfunding and equity-

based crowdfunding for small businesses.

» www.fundable.com

- *Crowdfunder* is a platform for raising investment (not rewards) and has one of the largest and fastest-growing networks of investors.
» crowdfunder.com
- *Crowdrise* is a place for donation-based crowdfunding for causes and charity.
» www.crowdrise.com
- *Quirky* is a place to collaborate and crowdfund for royalty-based crowdfunding.
» quirky.com

Open-source software to start your own crowdfunding site

- *Selfstarter* is ideal for rewards or donation-based crowdfunding single projects.
» www.selfstarter.us
- *Catarse* is ideal if you want to start a Kickstarter or Indiegogo competitor.
» www.catarse.me
- *Virtuous Gigants* crowdfunding wordpress templates. Create a crowdfunding site using Wordpress and one of these templates.
» ignitiondeck.com/id/themes/?ref=2

Example Crowdfunding Cases on Circular Design

Reusing

- *The World's First Plantable Coffee Cup*: A coffee cup that has native seeds embedded within the material to be used for reforestation in your local communities.

-
- ↗ www.kickstarter.com/projects/reducereusegrow/the-worlds-first-plantable-coffee-cup
 - *BETTER RE, Upcycling Power Pack reusing smartphone batteries*: BETTER RE - an Upcycling Power Pack to 'BETTER REuse' your old smartphone batteries, with infinite lifespan and expandable capacity.
 - ↗ www.kickstarter.com/projects/betterre/better-re-upcycling-power-pack-reusing-smartphone

Remanufacturing

- *ChopValue - Recycled Chopstick Products*: Recycled chopstick products made and designed in Vancouver. ChopValue provides free recycling bins to anyone who is interested in joining the collection program. When a new user signs up on chopvalue.ca, a new pick up point appears on the map; the ChopValue team then receives a notification and arranges the pick up free of charge on a weekly or biweekly basis. What started as a product development exercise, soon became an opportunity for our research team to get Vancouverites involved in value-added bamboo research - entirely based on solid waste as a resource.
 - ↗ www.kickstarter.com/projects/1855845953/chopvalue-recycled-chopstick-products
- *Recycled Wine-Barrel Longboards*: Innovative recycling. Hand-crafted works of rideable art bringing new life to a story-rich material: the Marlborough wine barrel.
 - ↗ www.kickstarter.com/projects/1699345908/recycled-wine-barrel-longboards-new-zealand

Recycling

- *World's First Professionally Recycled 3D Printing Filament*: Dimension Polymers has created the first professionally engineered 3D printing filament

made from recycled plastic. Dimension Polymers has developed the first professionally engineered 3D printing filament made from recycled ABS plastic. Our campaign is launched with the purpose of introducing our unique, precision filament to the marketplace.

» www.kickstarter.com/projects/952621887/sustainable-3d-printing-filament

- *Plastic Bottle And Can Cutter*: Thousands of people in different countries, every day are looking for new solutions to resolve the problem with plastic waste recycling (PET bottles, cans, etc.). This plastic bottle and can cutter allows reuse and recycle plastic bottle and cans, turning them into convenient universal handy ropes.

» www.kickstarter.com/projects/1926431950/plastic-bottle-and-can-cutter

Endnotes:

1: Nederland Circulair! Transitioning the Netherlands towards circularity.

» www.circle-economy.com/tool/nederland-circulair

Additional Resources

- A Kickstarter's Guide to Kickstarter
» kickstarterguide.com
- Kickstarter Creator Handbook
» www.kickstarter.com/help/handbook
- Indiegogo's The Essential Guide to Crowdfunding
» learn.indiegogo.com/the-essential-guide-to-crowdfunding/
- Fundable's Crowdfunding Guide
» www.fundable.com/learn/resources/guides/crowdfunding-guide

-
- Fablab Connect. Crowdfunding Campaign Tools and Resources
 - » www.fablabconnect.com/crowdfunding-campaign-tools-and-resources/
 - The Crowdfunding Bible
 - » crowdfundingguides.com/
 - Kickstarter Future Fab Lab
 - » www.kickstarter.com/blog/kickstarters-future-fab-lab-and-more-at-the-2016-world-makerfair

5. Masterclass & Tutorials

Masterclass

The potential of the fab lab network and its capacity for operating in circular design processes may be difficult to be perceived by newcomers as digital fabrication technologies are normally understood as discreet equipment run individually. Students may not be aware of concepts such as open innovation or distributed fabrication so we recommend imparting an opening masterclass about Fab Labs and Circular Fabrication as early as possible in the internship. Chapter 3 - Circular Fabrication can be used as a guide for this masterclass.

Tutorials

Step by step tutorials on the different digital fabrication technologies and required design software are the most useful way to train newcomers. Digital fabrication training differs much from software training which nowadays can be done mostly using online resources. We write extensive guides about how to operate our equipment but it is intended to be used as a reference once the students have attended a physical introductory tutorial first. Example tutorials can be found on page 27 onwards.

Health and Safety

Each tutorial should start with a comprehensive Health and Safety introduction not only about each specific equipment but also regarding space, fire safety, evacuation and emergency procedures. We have included a general guideline of what this guide should contain on page 27.

Schedule

It is a better strategy to schedule a regular calendar of equipment tutorials and offer them to everyone in your community rather than organizing them around the students' schedule. First, it is more efficient as you will be able to fill all the places more easily -we don't recommend

more than 14- Second, it is a good way of creating more heterogeneous classes. On a negative note, sometimes there could be a big skill gap among class members so we mostly recommend this for short introduction tutorials.

Hackathon

Hackathons are any event of any duration where people come together to solve problems, it is important to note that it does not have to involve technology. Training workshops during the hackathon are a great parallel track especially for newcomers but also for all participants.

Fab labs are a great facility for conducting hackathons as they can provide big spaces for gathering, seating and presentation areas to work in groups and digital fabrication equipment for workshops and prototyping.

Themed hackathons can be used in an early stage of the internship as a collective ideation process around a real-world problem, also to generate research on a specific theme or collectively problem solve a clearly identified challenges within a larger project. Finally, hackathons are great for building local communities around a theme.

The following information has been compiled from the fantastic Joshua Tauberer's Hackaton guide:

Don't expect to have actually solved a problem by the end of the hackathon. Real-life problems are hard! Think of the hackathon as a pit-stop on a long journey to solve problems or as a training session to prepare participants for solving problems.

Welcoming newcomers

The hardest thing about running a successful hackathon is being welcoming to newcomers and helping them get involved in an activity.

The hackathon organizer must make sure that everyone

has something to do. One way to do this is to have a list of project leaders ahead of time: people you know are coming with particular projects that you can guide other participants to.

You can also hold non-project activities — workshops, described below — which are easier for newcomers to join.

You could also consider pairing newcomers with mentors or holding a pre-event session just for newcomers. Wikimedia hackathon learnings

Hacking

The hacking track is for participants to dive into problems. Often groups of 2-5 individuals form around a project, such as building a new product or service, writing a document, or collaboratively investigating a problem.

Hacking begins with project introductions. Participants that bring projects to the event have an opportunity to briefly (1-minute max.) explain what they are working on at the very start of the event so that other participants can join that project. At the end of the event, a wrap-up session gives each project a chance to demonstrate some accomplishments.

A themed hackathon is one in which the projects are confined to a particular problem. Themed hackathons are able to attract subject matter experts. There is a common problem in themed hackathons: Subject matter experts can readily identify problems in their field but cannot always turn those problems into workable projects. Other participants may be ready to apply their skills but not know anything about the hackathon's theme. Bridging that gap requires careful planning ahead of time.

Training

If you have a significant number of newcomers, having training workshops is a great way to give them something to do that they will be more comfortable with than diving into hacking. You can run workshops to introduce participants to the subject of the hackathon or to particular technical skills useful for the hackathon. Workshops can also be places to have a discussion about issues in the field related to the hackathon. Workshops should be interactive as much as possible.

Run the workshops in a second room if at all possible. 45-90 minute workshops are a good length. If you have more than one workshop, leave 15-30 minutes free between workshops to allow for the first leader to close up and the second leader to set up.

Code of conduct

Hackathons have a history of not always being welcoming to women and minorities. We need to change that. You can be a part of that change by adopting a code of conduct for the event. A code of conduct is not just about enforcing rules. It sets community norms and sends a signal to would-be participants that you are trying to create a welcoming environment. And, of course, if there is a problem at your event having a code of conduct ahead of time will help you resolve the issue.

↗ How to Run a Successful Hackathon: <https://hackathon.guide/>

Example: Health & Safety Tutorial

Fab Lab space functions as a collectively supported resource; ask yourself how you can improve it as well as use it.

- Use of the workshop is a privilege, which can be revoked for any violation of any of these rules.
- Only individuals who have been instructed on how to use the workshop are allowed to operate machines.
- Report all accidents, injuries, machine damage and missing supplies right away.
- Anyone willfully or carelessly violating any of the shop policies will be subject to appropriate disciplinary actions and may be banned from using the area.

In case of emergency steps

1. Stay calm
2. Shut off power
3. Get help
4. Address injuries
5. Report to staff

Emergency equipment and information to provide

- First Aid
- Emergency Ambulance Service
- Closest hospital
- First Aid boxes location
- Fire Extinguishers location

Example: Vinyl Cutter Tutorial

General

This guide describes the procedure for using a Vinyl Cutter, which is a cutting machine with a knife tool that cuts different thicknesses and grades of vinyl, flock, card, paper or similar. Popular applications would be to produce window stickers from adhesive vinyl or transfers that can be used to put graphics on clothing, with a suitable heat press. Vinyl cutters can even be used with ink pens to produce graphics as with an older style plotter, or with inkjet printing to both imprint and cut material according to a user's specifications.

This is to serve as a general guide but will include specifics using a Roland Camm-1 GS-24, which is quite a popular model of vinyl cutter, particularly with Fab Labs and makerspaces. This model of Roland is recommended as part of standard Fab Lab Inventory and standard equipment for the Fab Academy. The Roland is an inexpensive machine, costing a little less than \$2000 (see <http://www.rolanddga.com> for more details).

The Vinyl Cutter is connected by Type-B USB Cable to a computer, adjacent.

In order to run a cut job, we are going to need a number of packages installed. Including an appropriate USB driver, CutStudio (software from Roland, needed to operate the cutter), and optionally a plugin for your preferred drawing package, for instance Adobe Illustrator or Corel Draw. These are preinstalled on the PC in the Fab Lab, so that users may prepare drawings in advance if they so wish.

Steps:

- Preparing Vector Graphics
- Preparing the Vinyl Cutter
- Sending from CutStudio
- Applying/Transferring Graphics

Preparing Drawings

In Illustrator, open a file or create a new file from the `File` menu.

Make a file with a portrait artboard - 610mm wide * 1000mm tall. The 610 (or roughly 24") width is the horizontal dimension, and you can alter the height of the document for taller graphics. Note that the bottom left of the Artboard is the origin position, which we will define when 'Preparing the Vinyl Cutter'.

Outline any typography in the drawing, and draw any cut lines as closed vector polylines. Line colour may be used to determine cutting order while cutting.

Use Illustrator's Image Tracing Functions to convert JPGs and other raster objects to vectors.

When your drawing is ready to use the plugin in Illustrator to send selected graphics to the CutStudio standalone program. The large Roland Button sends the selected geometries.

Preparing the Vinyl Cutter

The Vinyl Cutter can accept sheets or rolls. For rolls, use the holder that mounts at the back of the machine - the roll rests on bearings and allows the machine to pull on the material without resistance. Pull the material through, and align the wheels at both over the material and within the highlighted areas (marked with white). Press the lever to fix the wheels. Select Roll or Sheet, and press Enter. The head now moves across and scans the width of the material. And moves to the origin position. You can use the directional buttons to move the material, and the knife up, down, left and right.

Hold the test button to cut a pre-programmed "t" graphic, for testing. This allows you to quickly find the correct GF setting for the loaded material. For instance, the

supplied material cuts well at 30 GF. Press 'force', then select the 'GF Strength', and press 'enter' to try different settings.

Hold the origin button to set the current knife position to the bottom left limit. Note that this reduces the usable area of the loaded material and that cutting will happen above and right of the origin.

The cut job will be started through the software.

Sending from CutStudio

There are limited drawing tools in the CutStudio program, but you should find enough to Arrange, Scale and Mirror the graphics as necessary. When ready, press the Cutting icon to set up a cut job.

There are options in this dialogue to assign colours to different cutting forces and depths, and a number of other settings. Leave these as 'Same as Machine' to use the settings you applied when setting up the machine in the previous step. You may also press Change if necessary to access the Print Setup from this Cutting Panel.

If you are happy with those settings press OK to start cutting.

Applying/Transferring Graphics

Accompanying a vinyl cutter there are often rolls of transfer tape, and some materials - for instance 'Float On' - which is a volatile compound that vapourises at a low temperature shortly after being sprayed. Using this spray over the adhesive part of sticker vinyl makes the cuts repositionable. Transfer Tape is very useful when creating stickers - cover the front of the artwork, so that you can expose the sticky reverse of the vinyl sheet, then, attach and position directly on the surface, remove the sticker, and remove the transfer tape, taking care to rub in the edges and the graphic so that nothing comes away unintentionally. Have a sharp tool at hand to help lift the remaining cuts away.

Example: Laser Cutter Tutorial

General

A laser cutter is a type of CNC machine, for engraving and cutting a selection of materials. A laser beam is produced by, for instance, a Carbon Dioxide bulb or, in some lasers, directly from a diode. LASER is an acronym, 'Light Amplified by the Stimulation of Electronic Radiation' which is a potential hazard of laser cutting machines.

Before starting, note where the emergency stop buttons are, where the fire extinguisher is placed and where nearest exit is. In order to. And if you notice that any of the panels or wires are loose, contact a staff member. Do not use the machine.

Materials

Paper, card, plastics, timber and textiles - In timber, the Trotec can cut up to 6mm only; the Lasersaur a little less. Some materials, are pretty suitable for engraving, like various types of glass, or stone, but are not possible to cut. The laser cutters at *Fab Lab Limerick* cannot cut Metals, PVC or Polycarbonate.

PVC cutting releases Chloride gases, which are highly toxic and carcinogenic. Fumes will immediately damage the surrounding parts of the machine.

Laser Cutters are extremely versatile. And generally, Fab Labs will encourage experimentation, bringing in and trying your own materials. It's a good idea to check with popular laser cutter manufacturers or online fora, to see if materials are safe, and then proceed with your test.

Lasersaur

The Lasersaur has a bed size of 1220mm x 610mm with the power of a 100 Watt laser output that gives it the ability to cut and engrave large sheets of material. Lasersaur is an open-source laser cutter with the ability to cut paper, card,

plastics, wood and textiles at a high velocity and accuracy.

Preparing Files

1. Open any 2D drafting software like Illustrator, Inkscape, Autocad or Draftsight (freeware).
2. Draw your bed dimensions (1220mm x 610mm). Draw your required design/shape to be cut/engraved. It is good practice to make all lines continuous polylines.
3. Put cut lines in one colour and engraving lines in another colour, this is how Lasersaur differentiates between different lines.
4. If you are using a CAD program, save your file (you may need to save the file as an old version (~2004) so your SVG software can read it).
5. Open your CAD file in software like Adobe Illustrator or Inkscape, both of which can produce compatible .svg files
6. Save your drawing as a .svg file

Operating the machine

1. Open the Lasersaur door, place material and then close the door again.
2. Take note of Lasersaur safety, emergency stop button, where the fire extinguisher is placed and where the nearest exit is. Connect your laptop to the Lasersaur via ethernet cable. Turn on Laser, with the switches, which are marked UPS, ON/OFF, and EXTRACT.
3. Open your Web browser (chrome is best). Type 192.168.1.253 (IP address) into your address bar. Lasersaur App should appear in browser. (It can take up to 60s for laptop to connect to Lasersaur).
4. Import your SVG file. Pick layers you would like to cut

and assign specific power to those layers - the first box is feed rate (mm/min) and the second box is power (%).

5. Home Lasersaur using the software, and press play to cut.
6. Do not open Lasersaur without first stopping the cut process.
7. When cutting is complete, remove your design and enjoy assembling it!

Trotec

This guide is for the Trotec Speedy 400.

Steps

- Drawing
- Vector and raster drawings
- Setting up the Laser, preparing material
- Sending to the Trotec

Drawing

Quick Checklist for Illustrator:

- The Document/Artboard size should be 1000mm x 610mm (landscape)
- Cutting lines - 0.001 pts (thickness), RGB Magenta (255,0,255 or FF00FF)
- Engraving vector lines - 0.001 pts, RGB Red (255,0,0 or FF0000)
- A black fill or a rasterized/jpg object is processed as a Raster Engraving using the settings chosen when sending your print.

Setting up the machine, preparing material

Power on the machine using the key located on the control panel of the machine. Turn this gently to the right and release. You should hear the machine power-up. Ensure that the door/lid of the machine is closed. The machine now starts an automatic calibration, moving the bed to its lowest position, and using the end stops to automatically home the laser head. Use the buttons on the control panel to bring to bed up - stopping about 3 cm below the laser head.

Load your material, aligning to the rulers and pushing it gently to the top left. This is the origin point.

Now take the 'Focusing' tool, which is kept by the control panel. This gauges the correct distance between the laser head and the top surface of the machine. with the black handle facing to the right, place the brass part in the slot at the side of the laser head. Bring the bed up slowly now, until the material knocks off the focusing tool.

Sending to the Trotec

1. If your drawing is ready, click File > Print to send from Illustrator.
2. Now click 'Setup > Preferences' to open a dialogue box, where you have options about document size, material selection and resolution and raster processing.
3. At the top, this dialogue box includes options to minimise your drawing - ie. if checked, just the extents of the drawn geometry will be sent, or, unchecked to send the entire extents of the Artboard.
4. There are options for material selection - a general folder, and then a specific material (eg. Wood > 4mm Birch Ply), and options for half-toning images, if you are raster engraving - options: Ordered Dithering, Jarvis, Floyd-Sternberg, Stucci, Black and White, Colour, for resolution - default: 333 dpi, and additional options

like Invert, Flip, Enhanced Geometries. At the moment leave these other options unchecked.

5. Print your drawing - The large 'JC' button at the bottom of the window, and then "Print", and "Print".
6. Open the JobControl software.
7. On the right-hand side, there is a jobs queue. Drag your job from the list onto the cutting area in the centre of the screen. You can order the job queue by date/time to make this easier to find.
8. If not already connected, press the connect button on the right-hand side - it has the USB connector symbol.
9. If ready, click the ready button, to start the laser.

Example: CNC Router Tutorial

General

This is a guide to the various steps of using the ShopBot CNC Router. If you have not received the Induction on the machine, including the Health and Safety presentation for the machine, you may not use this machine. Please refer to our workshop safety information in regard to using the CNC router.

To prepare drawings for use with the ShopBot, we use a software called V-Carve Pro, a proprietary software made by Vectric for use specifically with the ShopBot.

Software VCarve Pro

Steps

- Opening VCarve Pro
- Setting Toolpaths

Opening VCarve Pro

Click the shortcut, or use the start menu to start the V-Carve Pro application. At the first screen, there are options to “Create a new file” or “Open an existing file”. In this case, we have a .DXF format file, so we will choose to open that. Whichever your choice, the program will now load into the same Job Setup screen.

On loading your drawing, you are first presented with the Job Setup page. Fill out the settings as follows:

- Job Width to 2440mm,
- Job Height to 1220mm,
- Set the Material Thickness (In this example, 18mm),
- Uncheck the Use Offset option,
- Make sure that the XY Datum position is set to the bottom left as shown,

-
- The units are in millimetres,
 - And you have not selected “Scale design with job size”.

Click “OK”.

Setting Toolpaths

Select geometries from your drawings and use one of the options on the right-hand tool panel to generate toolpaths for your GCode file. Generally, most 2D cuts can be achieved with one of the following toolpaths:

- Profile (linear profile, with options to automatically offset the toolpath inside or outside, based on the bit size)
- Pocket (produces toolpaths to remove the interior of a closed shape, to a depth specified)
- Drill Hole Pattern (a pattern of points/centre points to layout multiple drill holes)
- V Carve Toolpath

Select the depth for the toolpath (For V-Carve, setting the depth is optional).

Select ‘Tool’ from the ‘Tool Database’.

Select whether to cut ‘Outside’, ‘Inside’ or ‘On’ the line.

Select whether to add ‘Tabs’, then assign a thickness and a width. Click ‘Edit Tabs’ to locate them.

Click ‘Calculate’.

Then you may need to click ‘Close’, or you may be presented with the 3D view screen. Click the drawing name on the tab at the top of the view window to return to the drawing. You can repeat this process until you have added all the necessary toolpaths for your job.

When you have set all your Toolpaths

Click 'Preview Toolpaths', on the right-hand panel, the bottom left icon, which allows you to animate each of the profiles in turn, and get a 3D preview of the expected result, including depths, cut-through and tabs. Changes made to profile settings, need to be 'Recalculated' to be incorporated. Click 'Reset Preview' and run the animation again.

Summary of toolpath estimates, the next icon, gives you the time for each profile and in total.

Now click the save icon on the same panel. This saves an SBP file containing the toolpaths for the router. Having 'Output direct to the machine' allows you to Load the Part file in the ShopBot Controller automatically after saving. Be sure you have loaded and fixed the material, zeroed the machine in X & Y, changed to the desired bit, and zeroed the machine in Z before you allow the cut to begin.

Hardware ShopBot

Setting up the Shopbot for cutting

1. Power on the Shopbot CNC and the PC.
2. Change the tool if necessary. Use the wrench and the spanner attached to the machine to loosen the nut and collet. (Ensure the internal collet diameter is the same as the bit to be used.)
3. Place the material on the bed, aligned to the Origin position (bottom left)
4. Zero the machine in X and Y:
 - (Manually) using the control panel (Shortcut: K), and the arrow keys to position the toolhead over the (0,0) point. On the control panel click 'Zero Axes' button (blue), check 'X-axis' and 'Y-axis' and

accept.

- (Or Automatically) using the Endstop Sensors - this generally easier to do, and is better for consistency. However, be aware that the machine will start to move as soon as you press the button on the screen, and the bed should be completely clear before running this routine.

5. Zero the machine in Z using the Zero Plate

- On the SB3 software, this is the button with the symbol of the machine and a 'Z' on it, or in the menu, select 'Cuts > Zero Z-axis with Plate' (Shortcut: Z2), remove the clip and plate

6. Part File Load, dialogue boxes, warnings

7. Start the extractor and PPE

8. the green button on the remote to start the spindle

Example: 3D Printer Tutorial

3D printing is a form of additive manufacturing technology where a three-dimensional object is created by laying down successive layers of material. Some popular 3D printers in DFlabs, fab labs and makerspaces are:

Reprap Mendel

The Reprap Mendel is an open-source 3D printer that can print most of its own components. It can produce objects up to 210mm x 190mm x 140mm with layer accuracy of 0.2 to 0.3mm. It can print a large variety of plastics including PLA, ABS and Nylon. More info about the Reprap Mendel at Reprap.org community website.

Ultimaker 2

Factory-built open-source 3D printer. Ultimaker uses an additive manufacturing technique called Fused Filament Fabrication to lay down material in layers. The max build size is 230 x 225 x 205 mm with layer accuracy of 0.06mm to 0.2mm.

Wasp 2040

The 2040 is a very popular delta printer produced by Wasp in Italy. The Wasp also prints by Fused Filament Fabrication, in a variety of plastics. The print volume of the Wasp is 200 x 200 x 400mm, with high accuracy and a default layer height of 0.1mm.

Materials

Most popular materials for 3D printing are PLA, ABS and PETG. PLA, short for Polylactic acid, is the most common material that is used for FDM 3D printing. Unlike petrochemical-based plastics, PLA is considered to be biodegradable and eco-friendly. This material is extremely affordable and thanks to its properties, is suitable for a wide range of applications. ABS (Acrylonitrile Butadiene Styrene) has a long history in the 3D printing world. This material was one of the first plastics to be used with industrial 3D

printers. Many years later, ABS is still a very popular material thanks to its low cost and good mechanical properties. ABS is known for its toughness and impact resistance, allowing you to print durable parts that will hold up to extra usage and wear. PETG is a Glycol Modified version of Polyethylene Terephthalate (PET), which is commonly used to manufacture water bottles. It is a semi-rigid material with good impact resistance, but it has a slightly softer surface which makes it prone to wear. The material also benefits from great thermal characteristics, allowing the plastic to cool efficiently with almost negligible warpage. There are several variations of this material in the market including PETG, PETE, and PETT.

Preparing Drawings

Download a 3D Object

Thingiverse has many 3D files ready to download and print for free. The file type you need for printing is a .stl file.

Draw a 3D Object

If you would like to draw a 3D object, any 3D drawing software can be used including Sketchup, Rhino, Solidworks, 123D Make, etc. Sketchup can be downloaded for free and is a good software for a beginner to start with. Sketchup Tutorials are available here. The only requirement for a 3D software is that it can produce a .stl file type. If the base software cannot do this, install a plugin. The plugin for SketchUp is available on the SketchUp extensions warehouse here. Once you have your specific 3D object drawn export the .stl file.

Fix an STL File

The .stl file needs to be a completely solid object. If the drawn object has gaps between its faces it may not print properly. Netfabb can be used to fix 3D models with small gaps between faces. Upload your model to their online service, fix and download the model again.

Slicing with Cura

Cura is a slicing software, which takes your 3D model (.stl) slices it up and creates a file (GCode) that the printer can read. Ultimaker Cura is produced by Ultimaker and is free to download. It is simple to use, and the specific settings needed for our printers can be got from us when you call in.

Adding Wasps as New Machines in Cura (version 3.0.1+)

In the file menu, go to Settings > Printer > Add Printer. Then, in the dialogue box, Add a non-networked Printer under Custom. Select Custom FDM Printer, and then enter your printer name at the bottom, and click Add Printer to finish the setup process. This generates a generic printer with many default values, and we just need to change the dimensions now to suit the Wasp 3D printers. The new profile will be generated, and the Machine Settings dialogue will open automatically. Change the Maximum Width (mm), Maximum Depth (mm) and Maximum Height (mm) settings. For the Wasp 2040, these should be 200, 200 and 400 respectively; and for the 4070, these should be 400, 400 and 700. Change the Build plate shape to Elliptic, and Origin at Centre is enabled, and, in the right-hand column, the Material diameter to 1.75. Click Finish to confirm. Now just make sure, when you are preparing files for the Wasp, that this printer profile is selected under Settings > Printer or the printer name is displayed at the top of the settings panel on the right-hand side.

Configuration Files:

With our the Wasp 2040 printer, we use a Spitfire Black hotend - for which Wasp has supplied the following configuration profile for Cura: Spitfire LT PLA.curaprofile. To load a preconfigured profile in Cura, go to Settings > Profile > Manage Profile, then Import, and choose the location of the above files.

Other Slicing Programs

Slic3r (which is free, and Open Source) and Simplify3D (\$149 USD) are other software that takes your 3D model (.stl), slice it up and create a file (GCode) that the printer can read.

Printing

Bed Preparation

The first layer of printing is very important. If this layer does not adhere to the bed properly your print is likely to fail. PLA is easiest to print. Use acetone and a tissue to wipe down the bed. Give the bed a light spray with Hairspray if required. With other plastics such as ABS, you will need additional adhesives to bond to the bed. ABS juice can be painted onto the bed to create good adhesion.

The Wasp Printers require Pritt Stick, or glue stick to provide additional adhesion to the bed. Ensure that the print area gets an even coating, and consider brims and rafts as other techniques to improve the bed adhesion of your print.

RepRap Mendel

From Cura save your file onto the MicroSD card and insert into the printer. To control the Mendel directly by serial port(USB), you will need to install a driver and a control software called PronterFace.

Ultimaker 2

With the Ultimaker 2 sending the file to print is a quick and easy job. From Cura save your file onto an SD card. Slot the card into the front of the machine and select Print or Preheat and then your file for printing.

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