declicin

Lifelong Learning Programme

Building/assembling

a 3D printer

in an educational environment

Compendium of experiences

2012-2014

Summary
This documents describes experiences of building a 3D printer in an educational environment. Learners from six organisations in five European countries have assembled a 3D printer. The training contexts were different in rhythm, level, institutional frame, models chosen. This documents synthesises the approaches chosen by partners and provides their feedback. It will be useful for organisations willing to implement such activities.

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More info on http://declicin.info

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CEPS

1. Participants

The group in Barcelona are 12 youngsters (10 females and 2 males). And the ages are between 17 to 23. The level of education is 5 university, 6 Secondary Education, 1 Professional training center.

2. 3D printer selected

In this project we have to work on building a 3D printer and its use with a youth group. The printer we have chosen is a BCN3D (first edition - http://reprapbcn.wordpress.com/2012/12/14/the-bcn3d-printer-new-reprap/). This printer is part of the project called RepRap OpenSource. The machine uses the principle of operation FDM printed layer by layer any geometry that is within your capabilities or volumetric resolution.

BCN3D printer can work with ABS or PLA layers of height between 0:15 (150microns) and 0.35 mm. It can be used with any 3D printing software offered free but configured with Marlin firmware and software Slic3r. This device allows us to delve into 3D technology impressions and enjoy unique items at very low cost within acceptable time.
Fields of work can range from BCN3D use particular to engineering, to architecture, to artistic projects or own their own reproduction machine.

3. Rhythm of the workshops

The workshops are developed from 10th of may 2013 to 26th july 2013

4. Feedback from the trainers

The possibility of introducing 3D printing, to work with young people across their work motivation, we think is very positive. Generates curiosity and desire to learn because the result is tangible.

5. Organisation of the workflow

The group work one day per week, teachers work more time because they need to prepare the sessions. The organization for the sessions on building 3D printer are a part of the group work with the manual and the kit, piece by piece, and the other part of the group read and prepare the next step with the manual and the rest of pieces. The last step is connecting wires and prepare for the first printing. The evolution of printing different models become from a cubes to calibration to a delicate and difficult pieces, this work was developed individual an in group for solving problems.

6. Share of tasks / skills

The team work was put on play different skills from the group, and others are trained during the process.

- understand instructions in other languages (manual, videos, software).
- translating in to mother tongue (manual, videos, software).
- team work (adjusting building printer, search and identify pieces, helping building, search and find solutions).
- production of the objects (find objects in digital repositories, build they own objects via modelling software).

7. Problems solved

The kit of a 3D printer is not an easy plug and play system. This is delicate and is needed expertise in electronics, calibration and drivers. In internet a lot of manuals, tutorials and forums improving the knowledge, but a big part is essay and error by the building team. The part with more complexity is the equilibrium between the object designed and the flow for print.

8. Skills developed

Different skills are worked by the team during the workshop.

- Communication in the mother tongue (communication into the team and with the teachers).
- Communication and understanding technical text and videos in foreign languages
- Mathematical competence and basic competences in science and technology. (Building, software, electronics).
- Digital competence (search, find and design).
- Learning to learn (focused on all new knowledge they access).
- Sense of initiative and entrepreneurship (in problem solving without the help of the trainers, creating they own 3D objects).

Droit et Devoir

Group composition
2 teams

Size	Male/female	Age	Level	Experience	Context
14 people	Male	31 years to 53 years	- Being job seeker - Be 18 years old - Have maximum lower secondary education certificate (without qualification)	No experience	social and professional integration
6	Male	18 years to 21 years	- Students at university	No experience	Tutoring

3D printer
Rap Man 3.2: Build Manuel
Rap Man 3.2: Printer Kit/Bit from Bytes
Rap Man 3.2: Alibre Inc
Rap Man: Rep Rap Wiki
Axon 2: Use Manuel
Google Sketchup: Tutorial
Python: Programming language
Meshlab Software

Rhythm of the workshops
Two days per week
From March 2013 to May 2013 (First Group)
From September 2013 to January 2014 (Second Group)

Feedback from the trainers
To assemble our 2 printers and print 3D objects allows our trainees' acquire a hands-on experience with mechanics, electronics and design.
More ever they learn how to work in team, how to develop professional attitudes and how to develop competences in order to launch in industry.

Organisation of the workflow
Morning theory and practice afternoon

Share of tasks
Tasks are shared between trainees. There are who called the documentation and those involve mounting and assembly of the printer, who uses the printer software and those print the finished objects and finally changes tasks between trainees end again.

Problems solved
a) Assembly is quite difficult but very well documented
b) Calibration problem at the first but problem solved
c) Each moving the printer you must tighten and check all
d) Finishing problem but problem resolved

Skills developed
a) Assembling a 3D printer
b) Installation, configuration and use of software 3D printer
c) Autonomy, organizing, listening, creativity, group work, sharing.
d) Motivation

e) Personality

Theoretical knowledge applied
a) Basic electronics and mechanics
b) Basic geometry
c) Basic 2D and 3D drawing
d) Flowing software: axon 2, sketch up, mesh lab, ske inforge; python, netfabb, autocad

Links with the industrial environment during the process
Polytechnic Faculty of Mons (U-Mons), microelectronics department: our trainees built the 3D printer with students of the university
Collaboration with an industrial high school, so that our trainees take courses in drawing 2D and 3D.
Their student can print their home works with our 3D printer.
Few private customers lead broken parts for printing.

Greta du Velay

Group composition
The group involved in the building of the 3D printer was composed by 8 young learners (6 males/2 females), aged from18 to 25 years old.
The learners, with mental disabilities, had a low educational level. They are recognised as disabled workers and are supposed to be able to find a job in an open, non protected environment. They participate in a training program in the Greta du Velay to achieve this objective.

3D printer selected
Foldarap :http://reprap.org/wiki/FoldaRap/fr
The reasons for this choice are: the simplicity of the structure, the portability of the machine, the reduced number of printed pieces that compose it. A part of the building instruction was in French and the inventor of the machine was easily accessible. Also it seemed easy to build.

Rhythm of the workshops
3 hours per week (from January 2013 to May 2013)
In total around 25 hours have been needed for the group to finish it.

Organisation of the workflow
At the beginning of the workshop, everybody could work on the 3D printer. Each group had a role: building parts, electronics parts, soldering parts...
The first tasks are simple and consists of:
- Getting information about printer on the dedicated wiki (list, text, image, video)
- Research on appropriate components
- First installation to test the assembling
- Final screwing.

Then it requires a smaller group of students (4) to work on the mechanical parts (belts, motors, shafts, rods). The process is more complex:
- Getting information about printer on the dedicated wiki (list, text, image, video)
- Research on appropriate components
- Taking measures and checking angles and parallels
- First installation to test the assembling
- Test of tension straps, threaded spindles
- Searching the resistance points
- Final assembly

Then comes the electrical part also with a small group of learners, the steps requires more advanced skills (basic knowledge of electricity, good motor skills):
- Getting information about printer on the dedicated wiki (list, text, image, video)
- Research on appropriate components
- Stripping / tinning
- Connecting / screwing
- Using a multimeter

The last part is the plugging of the printer, the last checks and the calibration of the machine. The skills used are many: in addition to those mentioned above, the capacity to detect malfunctions, analyse then and correct them. The computer tool is used at this stage with the following software: Slic3r and Pronterface that develop a good knowledge of platforms:
- Looking for information in the wiki
- Installation of libraries and software
- Elaboration of procedures for testing motors, nozzles...

- Identification of problems
- Analysis
- Correction
- Communicating (at this stage, it is possible to ask for help or advice from the community through forums, chat, Skype...)

Share of tasks
A first group of 3 people has checked all parts. Then, the work was divided in two groups according to their skills, one devoted to the mechanical part to assemble the aluminium structure with plastic parts, the other working more on the electronic tasks (discrimination of different components, soldering, isolate, connecting...). When the machine was fully assembled, it became difficult to work together around (as it is small). Only three people have participated to the first tests of the firmware, to calibration purposes at the last axes settings. In the meantime, learners not involved with the 3D printing have learned to use a 3D program (Tinkercad) or practiced programming Arduino.
During this period also learners could make practice periods in companies. It reduced the number of learners being together at the same time in the workshop.

Problems solved
A wiki is available to guide the construction process. The French wiki is less complete than English, so learners has to translate some information and they became familiar with some English words.
The wiring diagram of the engines on the motherboard was wrong. We had to try several times to find the right one.
Some "stop stops" were not filled in, we had to place them ourselves, without explicative scheme.
Problems to fix the printed piece: we spent a lot of time to test the ideal temperatures, with different materials to put on the surface of the trail.
Establishment of a protocol to set the "z offset" (distance between the nozzle and the bed): we print four points on either side of the platen to be sure of the flatness of the whole thing.
At the end, the plastic parts of the printer have melted (by being exposed behind a window in the beginning of the summer period). Everything had to be reprinted and we had to re-assemble the FoldaRap.

Overall comment:
The construction went very well. Students are highly motivated and eager with the outcome. Beyond the skills used and learned during this period, the tangible experience of teamwork around an ambitious project was unanimously perceived as pleasant and rewarding.
The main difficulty was to organise the work sequences. As the project was developing, only 3 or 4 people could work around the printer. So we had to organise other related activities so that the whole group could work around 3D printing.

Skills developed
Interpretation of a plan
Welding
Assembling
Work in collaboration
Test sockets
Calculation
Foreign language (English)
Software knowledge (Slic3r, Pronterface)
Logical processes (imagine, lay on paper, 3d model, print, test, check, solve problems...)
Fine motor skills
Manual dexterity
Use of appropriate tools
Workstation maintenance

Nieuwland Automatisering BV (NL)

Participants
The group had 24 participants.3 Female and 21 Male. The age was between 19 and 52. All the participants in the group have a medical indication, meaning they are entering the project through the regional health care services. The average education is secundary vocational education. Two participants have an Ict education.

3D printer selected
Ultimaker 3 D printer was selected. This printer has the production capacities the group wanted it to have. It can work with more then one single material thus allowing more experimentation and production of different objects. It also is a well designed and tested 3D printer. This implicates that there no are hardly any start up problems with the machine. Besides the hardware component, the software component was an important factor in the decision. The availability of open source software for this printer is an advantage of this machine. The group used mostly the internet to collection the information necessary for the decision. Also the made a visit to a fablab in Utrecht to get information from users.

Rhythm of the workshops
October 2012 to April 2013

Feedback from the trainers
The 3 D printer was a very good addition for the participants of the project in Alphen aan de Rijn. Besides being an attraction for new participants, the 3 D printer project enabled the participants to encounter new technique and offered them a change of deepening their curriculum.

Organisation of the workflow
A team was formed with the target of selecting, buying and building a 3 D printer and to print objects. The printed objects should be fitted for use else where in the project so the printer must be able to produce good usuable products.
So the team had to select the printer as if it should be used in a commercial environment. The next step after the selection was the assembling and fine tuning, installing the software and then test printing some objects. After the selection phase and the assembly phase came the production phase. In this phase, individual partcicpants should be able to design and print an object.

Share of tasks
The following tasks were performed by members of the team accordingly to their talents:
- reading and translating the manual to the
- construction team memebers
- researchers for the right software and installing it on the computers
- fine tuning the printer after its first prints
- production of objects
- adjustment of the project website and presenting objects on it

Problems solved
After assembling the 3 d printer and installing the software it turned out that the printing of objects was not accurate enough. So the team had to check every part of the printer and the software in order to find out the cause of the malfunctioning. It turned out that the printerhead was not installed in a proper way. After rebuilding that part a process of fine tuning the printerhead started and the problem was solved.

Skills developed
The team developed some skills. However, the group exist of people with serious mental handicaps and diseases. For some the presence during the workshop was an archievement. For others the technical part of construction the machine was a new skill developped. Working in a team as such was a novelty for most of the participants. So the most skilled developped were related to that interaction in the team

Theoretical knowledge applied

- knowledge of the printing process of certain objects
- best printing materials necessary for certain objects
- knowledge of different types of printers
- knowledge of different types of software

Links with the industrial environment during the process

The printed objects should be used in an other department of the Spoor 11 project. The Spoor 11 project has a department for packing sweets. So small containers for sweets, special designed containers and such products should be designed to be cheap, fast to print and use as a commercial product to improve the sales of the sweets.

TimeLab

Participants

Printer	nb. of participants	Male / female	Age	Level	Experience
Ultimaker -1	6	Female	20-30 years	All participants have a job	None or little
Prusa i3	4	2 girls, 3 boys	14-17 years	Secondary school	None or little

3D printers selected

There are loads of 3D printers, all of which have advantages and disadvantages. They offer a wide range of options in materials to print, sizes of printable objects, usability, speed and quality. 3D Printer kits are far cheaper than "ready to print" devices. They arrive as kits to be assembled by the end user.

Building a 3D printer can be a full DIY experience and we recommend to choose a model that has already been built by someone in your community/school/organisation. Members of our community as well as our lab manager already had experience in building Ultimakers and Prusa's. Below you will find the basic information needed for getting started.

Prusa i3 €600

www.reprapworld.com (based in the Netherlands)

English manual can be downloaded from supplier website

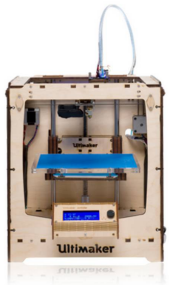
http://reprap.org/wiki/Prusa_i3_Buyers_Guide

Ultimaker €995 + Controller €80

www.ultimaker.com

English manual can be downloaded from supplier website

Controller: SD card printing



	Prusa i3	Ultimaker 1
Desktop space	400 x 400 x 400 mm	357 x 342 x 388 mm
Build volume	200 x 200 x 170 mm	210 x 210 x 205 mm
Speed	Depends on stepper motors	30 – 300 mm/s
Quality		0.02 mm

Useful resources

Make: 3D Printing

Developed by MAKE Magazine, introduces a wide range of 3D printers and their capabilities. ISBN: 978-1-457-18293-8

Make: Ultimate guide to 3D printing (a supplement to the bi-monthly Make magazine)

Makezine.com (ISBN: 978-1-457-18302-7)

The workshop

Space

When you are planning to build a 3D printer with a group of people, find a place that allows you to spread out your tools, machine parts and documentation. The space should have wifi to allow easy online access in case you need to look up extra information or view a youtube video etc.

Tools and materials required

- Screw drivers
- Cordless screw driver with a 2mm hex bit
- Soldering iron
- Pliers
- Cutter knife

- Hex keys (1.5, 2 and 3 mm)
- Tape measure
- Soldering tin
- Wires
- Laptop
- Wifi
- Projector and screen
- USB stick
- Plenty of power sockets for laptops, projector and printer
- Pen and paper
- Metric calliper

Working in teams
Analyse your manual and try to find an already built printer and divide the activities in such a way that teams can be formed. Teams that can work simultaneously. For the Prusa i3 – we split the workload as follows:

1. **Team A**
   - x-axis and z-axis
2. **Team B**
   - y-axis, extruder, heated bed
3. **Team C**
   - installing software onto electronics board

Activities when team A and B are finished

- *soldering wires onto motors*
- *soldering end stops*
- *assembly of all components*

Coach / tutor
Make sure that you have one or two supervisors / teachers / trainers that have a good knowledge of software and computers. We found that building the hardware of the printer is relatively easy for youngsters, but that the software part is the hardest challenge. In order to get optimal results, a great deal of tinkering is required. A poorly calibrated extruder can have adverse effects on the prints.
On both occasions (building the Ultimaker in 2012 and building the Prusa in 2014) we arranged for a team of trainers to help the participants build the printer. We find it helpful to include people in the process that have already experience in building the exact type of printer that you are planning to build. Be aware that 3D printer models are rapidly changing and that each new version is slightly different from the previous.

Manual / documentation
Try to find the manual for the right version of printer that you are building. In our case we downloaded the free English manuals from the webshops that we bought the kits from. We have experienced no problems with understanding the language, but comments were made that there weren't enough pictures in the manuals. Therefore we emphasize the importance of having a working example present during the workshop so that participants can take a closer look at the example.

Feedback from the participants
We learned from the teenagers who built a 3D printer in just one day that this activity was really fun and different from what they normally do in school. They enjoyed making the video as well. Unfortunately there was not enough time to design their own objects and print them, so we downloaded 3D designs from www.thingiverse.com.We invited them back to the lab the week after the 3D printer was completed to work with the 3D printer that they had built themselves.

Video
A stop motion video was made to document the process of building a Prusa i3 with young people. The video can be found online on timelab's youtube channel "timelab Gent"
Find the video here: http://youtu.be/4FxzDGvJB_8