STEAM Ahead

Best Practices Guidebook

Co-funded by the
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INTRODUCTION

In the 21st century STEAM has a big presence in daily and professional lives of humans, and there is a high chance that you are already doing more on STEAM education than you might think. To make the next step into the world of STEAM, our toolkit gets you directly underway to turn your classroom into a Makerspace! It does not only provide you with the latest insights on the matter, but also includes examples and practical templates & tools for you to quickly take action and achieve concrete results.

Our toolkit comes in 6 steps, which are divided by chapters. The toolkit begins by helping the reader grasp the core concept of what Makerspaces truly are and why classrooms should be converted into one. It further continues with creating an overview of what you already do and have regarding STEAM and multidisciplinary education. By the time we reach step 5 and 6, we have lift off: we are setting up our classroom as a makerspace!

CONTENTS

Preface: What is Full Steam Ahead?

"Ideal classrooms always change, are a mess & have no teacher desk. They encourage interactions & personalization." **[B. Arnold, 2017].**

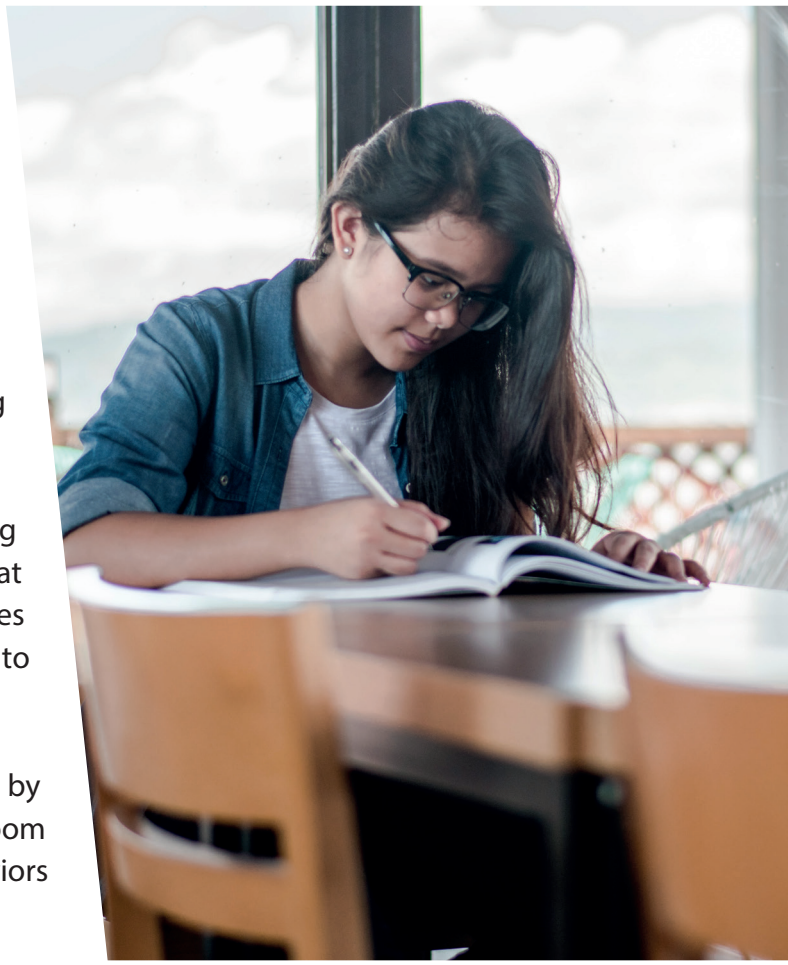
Despite the huge advances in technology, not much has changed when it comes to how we view learning and how we design learning environments.

The transmission model of education is still the name of the game, although in some circles there are signs of its erosion.

It is time to change the direction of teaching/learning by for once and for all turning it around and allowing it to originate from the pupil.

Imagine a classroom where pupils are the ones driving the learning and are empowered to pursue things that matter to them. To let them employ multiple modalities as they are accessing human and digital resources to drive their own learning.

The aims of the Full Steam Ahead project (and by extension, this toolkit) are to change the way classroom management, the curriculum and the pupil's behaviors are developed by introducing STEAM subjects.



This new strategy in the classroom works by integrating real life situations into curriculum, increasing the results of students in subjects beyond the knowledge of the disciplines, but also soft skills and positive behaviors facing collaborative work, work routines, new challenges, unpredictability, failure in work, and others.

CASE STUDY 1

AEJE SCHOOL
PORTUGAL

A Makerspace at school? A case study from a Portuguese secondary school.

AEJE is a family owned business that operates in the education sector (teaching, training and online consulting). The school first opened their Makerspace in August 2020, during a pandemic and less than a year ago.

Their main reason for opening a Makerspace in school is because the school needs some innovation to the principal's plan. When the principle introduced the innovation plan with the new disciplines to Ana Paula and Gonçalo (AEJE's teachers – who are responsible for the Makerspace), they both thought that Makerspace was needed to accommodate the new disciplines - learning with challenges and combining different fields of study. At that time, they could choose between using conventional teaching models or pursuing something new. And they decided for a new concept, which is to use Makerspace in teaching school subjects.

AEJE decided to use a number of classrooms for Makerspace: one or two combined classrooms were used as the Makerspace office, one old classroom was renovated to contain all the tools and equipment and another room for several computers, office chairs and team workspaces. Gonçalo also added that the tools they have now are required by current needs, so if the future Makerspace, students and teachers require different tools then AEJE must like corresponding to that.

Talking about the setup process, the tools and equipment in the Makerspace right now are inspired by those in other MakerSpaces in Brazil and Germany. Due to their limited budget, they cannot afford like other MakerSpaces but have to look for some cheaper alternatives from Aliexpress for example. Once they have the tools, they had to find out how to evaluate and rate the students through their daily work, learning progress and their viewpoints on the concept. It was a challenging work for them as it was far from the original process.

In order to determine which tools are needed in the early stages of Makerspace, Gonçalo said to buy tools that can be combined while working because they save more space and time. Furthermore, he suggested making a list of existing materials the school has, activities students will do in Makerspace, and additional tools to buy. This will avoid the over-buying. Furthermore, the good starting tools are always scissors and hard glue. As they are traditional tools, all teachers and students know how to use them while modern, new tools take some time to learn.

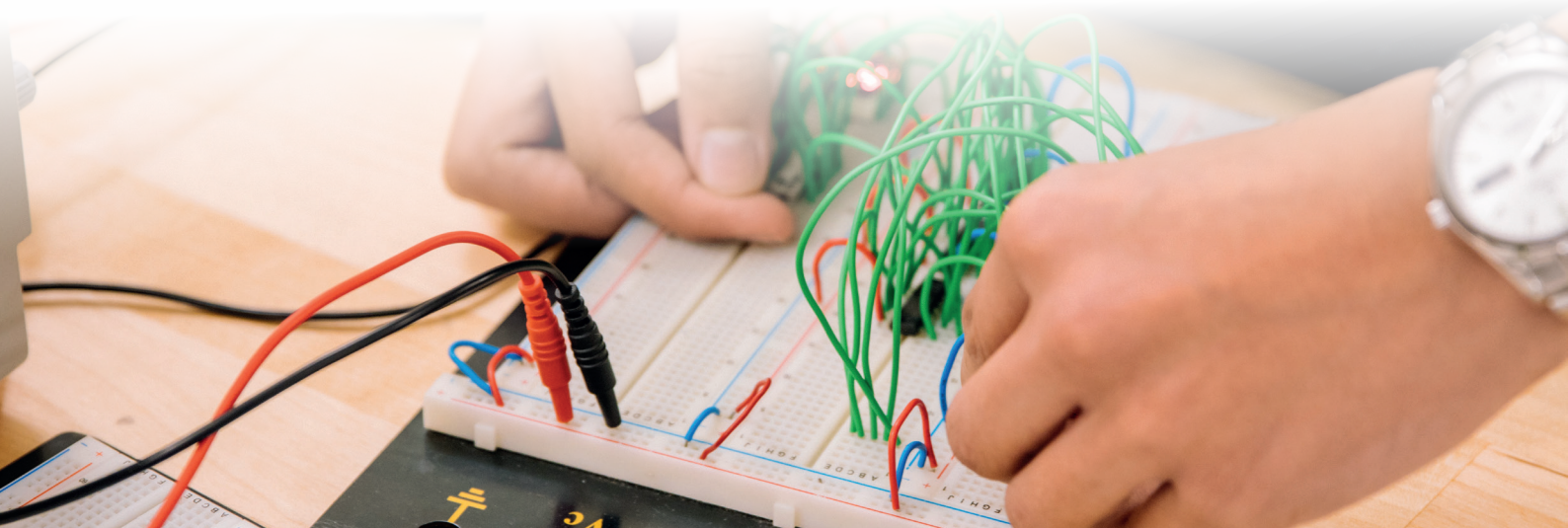
About the budget, they bought all the needed tools and equipment from the money from school. Gonçalo is not sure whether there are any other budget sources. Apart from that, AEJE's Makerspace currently does not involve any external companies or organizations. However, they expect to have a company that can provide some real-life challenges or cases for students and teachers to work on once the pandemic is over. About the connection of Makerspace with the classrooms and teaching subjects, Ana Paula let us know that they have planned some 8-week assignments and projects using the new disciplines and the Makerspace for students when they come back to school. During these 8 weeks, students will also have classes that are still in the old disciplines. Aside from that, they also prepare another teaching plan for teachers which include both the new and old disciplines (since there is 1 new discipline that covers 5 old disciplines), which will look like this: A teacher will give his/her students a problem and students need to answer it by the knowledge of 5 old disciplines. Based on the student's answers and needs, they can use the Makerspace to help them solve the problem completely.

As for the teacher roles in this Makerspace, it is said to be completely different. The first difference is that students will play a major role in the learning process. They take a problem from a teacher and decide how to solve it. Only when they need some guidance or support, will the teacher join. The second difference is discipline in teaching. Ana Paula believes that this new concept requires a lot of discipline from teachers as they must ensure their students achieve their learning goals through studying in-class while they have to monitor / supervise the student activities in Makerspace.

Of course, there were some pitfalls that Ana Paula and Gonçalo, as well as the school, have encountered in the beginning. They told us that when they decided to implement this idea, not many schools in Portugal at that time had this model so they did not have any sources of reference. Everything was built from scratch. Besides, their teaching plan covering the use of Makerspace and new subjects was only approved around September 2020, even though the Makerspace was built a month earlier. This means they only had 3 months to do some research and figure out how to adapt to this new concept before starting to apply it into classes in January 2021. They managed to come up with lots of ideas and interesting project for students. However, the school was closed two weeks later due to the national lockout. All of their plans are halted or postponed and they have to come up with other plans for distance teaching.

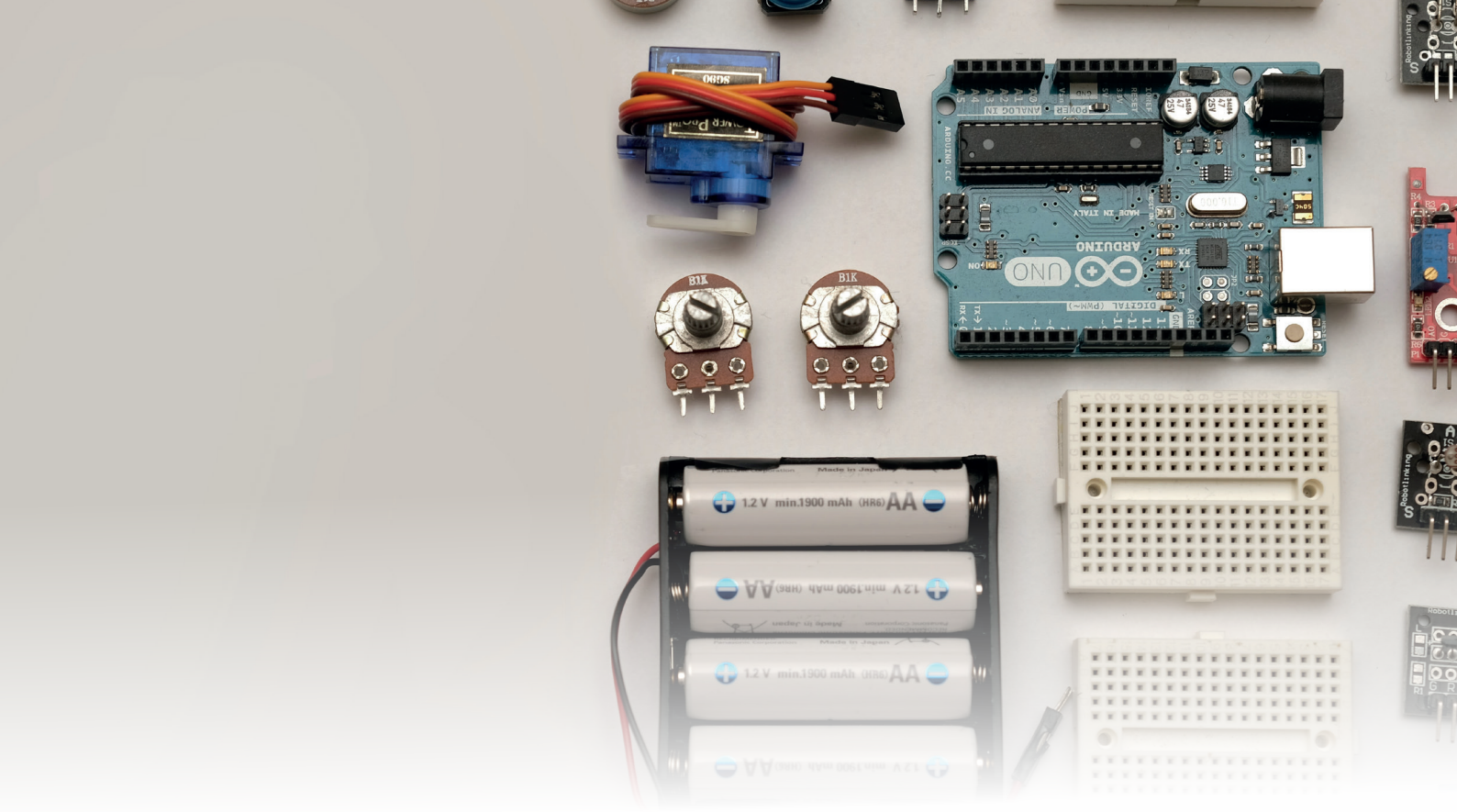
One of the greatest benefits of running Makerspace at school is that students are extremely excited about it. Ms. A said that the students were really enthusiastic about working in Makerspace to solve the problems raised by the teachers. And once they are able to solve the problems, they are extremely happy. This makes her and other teachers in general really pleased to see the positive responses from having students play the leading role in deciding how to solve the problem. Both Ms. A and Mr. B hope that they will be able to see better results like this when they can return to normal school.
With future plans, Ana Paula wants to help other teachers at school know how to use all of the tools in Makerspace in their teaching subjects. As a result, they can easily add it to their lesson plans as well as assist students whenever needed while they are in the Makerspace room. Gonçalo wants to have a laser cutter and some robotic tools for Makerspace, because they could help students solve some problems faster.

For other schools that want to set up Makerspace for the students, Ana Paula and Gonçalo have some advice for them. The first and foremost thing is to start small. The reason is that there are many tools and preparation that schools need to learn and study, so if their plans are too big or too ambitious, it will be more difficult (and sometimes even demotivating) for them to achieve. Just take it one step at a time. They also warn that Makerspace may be a whole new concept for some teachers and some of them may find it difficult to incorporate into their curriculum at first. When it comes to this, the consistent, easy-to-understand guide and training courses are required. They also asked other schools to find ways to adapt existing teaching methods and subjects with this new concept. It is an important step because if it is done poorly, not all teachers will incorporate Makerspace in their teaching plans. Finally, schools should equip a variety of tools for their Makerspace as it will help students' creativity and learning progress and avoid objective learning.



CASE STUDY 2

UMHAIGL SCHOOL
TURKEY



Makerspace in a school – always a good idea!

What were the main reasons for you to set up a MakerSpace at your school?

School Principle Mehmet Türkmen and project Coordinator Aslı Öcal answered:

UMHAIHL provide 4 high school years for young people between 14-18 years old. As an educational strategy we support Project-based education and inquire based learning at Grade 9 and Grade 10 which are the first two years of the school. After 2 years of Project-based training, in 11th and 12th grades students are mostly focused on the University entrance studies related with their future jobs. ((Mehmet Türkmen,Principal)

International students from 70 countries enroll in our school by passing the written and oral exams in their own countries, while Turkish students show outstanding success in the central exams held by the ministry. As UMHAIHL, we equip these outstanding students with the competencies that will enable them to reach their dreams and support their goals. (Mehmet Türkmen,Principal)

Our school has 3 Science Labrotaries. Lab classes run along with the curriculum. All students use school labs during their science class ours. But some students who would like to go further on their researches needed larger and more equipped makerspace to realize their brilliant ideas. This is the most important need of a Makerspace at school. We thought that we need Makerspace at our school give them opportunity to conduct wider researches and create more advanced study area that they can work all processes from idea to product. (Mehmet Türkmen,Principal)

Another reason for creating Makerspace to carry out Turkish Ministry of National Education 2023 Vision at school. 2023 Vision Document by Ministry defines educational changes to be made in content and applications are described as follows: Design – Skills Workshops are established in all schools , Curriculum is organized according to the interest, ability and temperament of our student. By this means, the makerspace established in our school has contributed in terms of supporting the ministry vision. . (Mehmet Türkmen,Principal)
Moreover; we believe that STEM education has a crucial role to create critical thinkers, inquirers,problem-solvers which we think are the most important skills for future jobs. (Aslı ÖCAL, Project Coordinator)
In addition, we aimed to create such a space for the primary schools in our neighbourhood and make it available to them with the guidance of our students. We aim to contribute to the creation of a STEAM climate and sharing science by opening our Makerspace to the use of younger students in other schools around us. (Aslı ÖCAL)

Which were the main options and which type of MakerSpace did you choose? (in every classroom/ a special dedicated room / digital elements or not, etc.)

We choose special dedicated area for the Maker Space. We thought that the storage area under the ground floor of our school could be designed as Maker Space. It was an empty, cold space before. Now it is full of brilliant ideas. We aimed and succeeded in bringing this area into the field of education. (Rasit DAY, Technical Coordinator)
How did you learn more about the MakerSpace concept to actually go ahead and set it up?
We ran several researches and also we make so many cooperations with Univesities, Ministries, local authorities during the concept creation. (Sema ERDAL, PROGEP Team Member,Social Science Coordinator)

How did you equip the MakerSpace and what elements/tools/machines do you consider to be really necessary?

First we set up a commission from teachers who will design such a Makerspace and guide students there. This commissionis now called "PROGEP" which is the initials of Project Development Unit at school. With this group of teachers we run several visits to the universities and science centers around our town and make researches related with the needs. We made observations visits to the İstanbul Technical University Fablabs We had the teachers working in this commission receive STEM education. Now we see that all the materials we bought are used and none of them are taken unnecessarily. We can list some of them as follows;

- 3D Printers
- CNC Machines and Laser Cutters
- Microcomputers and their byproducts,
- Vacuum plastic forming machine,
- Drill, hand tools, soldering tool, measuring equipment etc. (Aylin ERDOGAN, PROGEP Coordinator

How did you arrange the financing of the MakerSpace it?

We get funding from Ministry of National Education, the majör funding come from them but of course we need a lot more. Then we create a sponsorship team and a Sponsorship file including students' achievements and our needs. We contact with local authorities, NGO's and companies to make this Maker Space Happen. (Mehmet Türkmen,Principal)

Are any outside organisations involved in the MakerSpace, for instance by supplying challenges or as sponsors? If yes, structurally or in a project-based way?
Structurally Ministry of National Education and our Municipality is our main stakeholders for the budget. We make collaborations with VET schools in our town in a project-based studies. We set up new cooperations through programmes such as Erasmus+,Etwinning etc. (Aslı ÖCAL, Project Coordinator)
How is the MakerSpace connected to other classrooms and other courses?

In our school, Maker space activities are planned as club or workshop activities during extracurricular times. Every student at the school can participate in the announced workshop programs and trainings. In addition, students who would like to prepare projects for national and international science, mathematics and stem competitions can develop their projects here in their extracurricular times. (Derya HAKÇİL, Progep Team Member)

What is the role of teachers in your MakerSpace? Is this a changed role, and if yes, how did you let them adapt to this?

Teachers who would like to work in Makerspace became a member of a PROGEB which is a commission of teachers to run this Makerspace. Our teachers, who are in the improvement team of PROGEP, plan and announce the training and activities to be held throughout the year at MakerSpace. The PROGEP team member continues to be a member as long as the teacher does not leave his job at our school. For the new member, the necessary trainings and meetings are given to adapt. (Aylin ERDOGAN, PROGEP Coordinator)

What would be your recommendations for other schools who are keen to set up a MakerSpace?
After completing the preliminary studies on the needs of the schools and the field desired to work with their students and teachers, it should be decided what kind of Maker Space to set up. Otherwise, a standard MakerSpace might not meet the needs of students and teachers.
Additionally we recommend them to set up close cooperations with related stakeholders and try to be part of the STEM Education Network for the updates. (Aylin ERDOGAN, PROGEP Coordinator)

What are some of the pitfalls of setting up or running a MakerSpace?
According to us, one of the challenges of setting up and running MakerSpace is its diverse and multidisciplinary nature. Of course, there is also a financing issue, sustainability of the activities related with the finance. (Aylin ERDOGAN, PROGEP Coordinator)

What would you say now are the main benefits of running a MakerSpace?

"TO DO" and learn by doing; It gives the opportunity to experience the opportunities created by new technologies and materials with first-hand experience and triggers the creation and production from the basic motives of human beings. It makes the learning experience permanent, puts students at the center and reveals their vast potential. Makerspace support them to develop their inquiry, problem solving, research, thinking and communication skills. (Aylin ERDOGAN, PROGEP Coordinator)
Moreover if there wouldn't been Pandemic our students would have been leading the young students at our neigbourhood in Makerspace which will develop our students Scientific leadership skills and active citizenship. We hope after the restrictions we will go on our activities. (Aslı ÖCAL, Project Coordinator)

What are your further ambitions with the MakerSpace?

MakerSpace eliminates the destructive distinction between academic and social learning models. Because the same tools and methods can be used in a physics lab, auto repair shop, art studio or R&D office. For this reason, we imagine and aim that there is no longer a distinction between young people as winners and losers, and instead, wonderful projects that bring different disciplines together are carried out. (Aylin ERDOGAN, PROGEP Coordinator)

CASE STUDY 3

PROJECT FRYSKLAB

Photography from FryskLab. https://www.frysklab.nl/

A Makerspace on the wheels

FryskLab is an initiative of Fers (the service provider for public libraries in the Province of Friesland, The Netherlands). Friesland is a rural province in the northern part of the Netherlands and FryskLab, housed in a library truck, is Europe's first official library FabLab. It has a team with a very diverse background, ranging from IT, arts management and library service management. The goal of Fers is to explore how a mobile FabLab contributes to the creative, technical and entrepreneurial skills development of children and young people. In the end the project should contribute to an increase in the innovative capacities of the province of Friesland as a whole.

The motto of the FryskLab project isn't without reason knowledge-making and sharing of the future. The role of the library is that of facilitator, both in terms of physical capabilities (machines, tools, etc.), but also in the development of training and support. The principle here is that we look at FabLabs and makerspaces as the place where physical and digital use and knowledge-sharing converge. After all, users have the obligation to document their projects, after which they become available to others. In this development Fers is a Dutch and European frontrunner.

The FryskLab project was officially started in January 2014, after noticing that, especially in the US, libraries started to see the potential of working together with FabLabs and makerspaces or creating their own. The team at Fers received space and time to see if it could bring this development to the rural province of Fryslân. FryskLab uses the FabLab environment to bring 21st Century Skills to primary and secondary education. With a dedicated educational program. The project tries to tackle specific local challenges.

The FryskLab truck

FryskLab is accommodated in a truck that formerly served as a traditional book mobile. The dimensions of the truck are 10.33 x 2.55 x 3.85 (LxWxH in meters) and the truck weighs 13.000 kg's. FryskLab is mainly driven by two retired book mobile drivers. The FryskLab truck can comfortably host groups of 10-12 adults or 15-20 children/teenagers. If the weather is nice it is also possible to set up an open-air working environment outside of the truck. This has been done numerous times and is always an huge success. People are attracted by the new technology and playful setting in which they can tinker and experiment. It is also perfectly possible to bring working equipment inside schools or libraries to create an inhouse workshop environment. Since the truck has everything on hand it is easy to bring tools and equipment inside.

The mobile FabLab is first of all equipped with digital fabrication tools: 3D printers (Ultimaker Classic, six Ultimaker 2 Go's, Builder and Up Plus) and a 3D scanner, laser cutter, vinyl cutter, 3Doodler pen and assorted hand tools. For designing-, documentation- and programming purposes we bring ten Macbook Airs and fifteen Dell laptops, plus an Apple TV to give presentations with. We use open source computer boards such as MaKey MaKeys and Arduinos and introduce visitors and students to electronics with littleBits kits. Strawbees are used to protope with 3D design using straws (bought cheaply from IKEA) and laser cutted connection parts. We use a wide variety of software including Scratch, Doodle3D, Cura, Repetier, 123Design, Inkscape, Photoshop Elements, Tinkercad, SketchUp Make, Sculptris, and Mozilla Webmaker. FryskLab features it's own 4G networking router, which makes it possible to connect to the Internet almost anywhere. The truck also has a set up battery-packs with which it can run stand-alone for a maximum of four hours. When electricity is available 220 volts is sufficient to power all the necessary machines and lighting and heating.

Aan Kootstra works at Fers as a Digital Domain Specialist, and is the lab manager of FryskLab. "With our mobile lab," he explained, "we want to contribute to the innovative capacity of the province. Technology will play an increasingly important role in our society. With the democratization of technology machines are becoming more affordable and in affordable range of citizens. Libraries can play a major role in familiarizing citizens with this technology."

At the moment Fers is in talks with a large number of educational institutions (from primary schools to university level) to realize three so-called life-long digital fabrication learning courses based on the aforementioned themes. The result should be a high potential of skilled young talents for local companies which will benefit the local economic development that is lacking in qualified staff. This dedicated local focus is necessary to realize a sustainable (library-related) FabLab. Often we see examples of libraries setting up labs which are little more than a display for 3D printers and related machines. We however think the potential for digital fabrication in relation to libraries is much higher than just that. It's about, quoting David Lankes:"the mission of librarians to improve society through facilitating knowledge creation in their communities".
https://www.fablabs.io/labs/frysklab

CASE STUDY 4

FROM A CDT TO MAKERSPACE

Finland has its own version of a "makerspace": craft class. Originally, there was one craft class for boys and one for girls. Later, there were classes for different materials, especially for wood and textiles, which are deep-rooted concepts in the Finnish crafts mindset. To reclaim craft class for pupils, or "makers", we must determine teachers' and pupils' mindsets concerning collaboration, differing interests and sharing. Craft is a compulsory learning-by-doing subject for pupils in grades one through seven, with activities based on craft expression, design and technology (CDT).

This research is part of a national endeavour to develop innovative CDT as a basic education subject. The paper explores two pilot case studies in which technical and textile work teachers taught together in a shared learning environment, rather than in traditionally separate learning environments. The aim was to develop criteria for a new kind of learning environment that would promote learning to develop innovations and pupil's innovation competencies. The first study used a mixed methods approach, including systematic observation, inquiry and pair interviews of five co-teaching teams in primary school, to test the new teaching culture.

The second study used an experience sampling method in the form of a mobile application to reveal various parts of pupils' design and making processes in a school setting. The key finding is that collaborative teams can support teachers' and pupils' innovative learning activities when the work is supported by shared spaces, practices and new tools.

The paper concludes by relating preconditions for implementing makerspaces in the context of formal comprehensive education to learning outcomes, traditional workshops, learner differences and pedagogical innovation processes. In CDT, the learning environment is also considered a working environment because of the tools and machines used as a part of the pedagogical working processes. This adds to the conversation concerning safety issues in the form of criteria for safe and secure CDT makerspaces. In this way, safety culture is a relevant part of spaces for making. Safe and appropriate movements between basic workplaces and workstations/work areas/separate workshops impose certain conditions on building technology and managing noise, dust, machining waste, chemical emissions and heat treatment. In the formal school context, productive actions should follow the current curriculum and prepare for the future.

A makerspace that integrates the current workshops of textiles and technical work with digital modelling and fabrication could offer a place to develop shared practices (Study I). The digital application (ESM) added a new dimension to community support, but was also necessary to support assessment and pupils' self-regulation.

Advanced use of the ESM application connected the concepts of making to a wider context and opened a discussion from the pupils' own perspective. However, making, manufacturing and material technologies gain more weight in practise than design and problem-solving, not to mention self- and peer-reflection and assessment (Study II). Thus, a makerspace must have places for pupils to share work (e.g. ideation, self and peer assessment, idea testing and prototyping).

This also seems to be an aspect of instructional practices (e.g. how teachers nurture pupils' interests and motivation). On this basis, makerspaces can be used in creative ways to shift the focus from material technologies to problem-based design processes that utilise different technologies with shared practices as means and tools to create solutions.

The results imply that the pilot makerspace with professional co-teaching could be one way to transform CDT learning from the tradition of textile and technical work to a teaching and learning approach that facilitates pupils' innovation competence.

Teachers consider a good CDT learning environment to consist of appropriate collaboration and division of teacher labour, as well as an environment and tools that support pedagogical innovation processes and pupils' self- and peer- assessment. The future-oriented CDT makerspace can be seen primarily as a "state of mind" that involves a re-evaluation of both teachers' and pupils' current practices. On this basis, the makerspace should be a space and a mental state for cultivating design and innovation, instead of mere production. An important precondition for a makerspace is a space that can facilitate a creative atmosphere and pupils' scaled innovations to construct a safe whole.

CASE STUDY 5

SCHOOL21
UNITED KINDGDOM

Multi-level and Multi-disciplinary Makerspace

School 21 is a school in Stanford, London, that is hard to describe in conventional terms of "primary", "secondary" or "high" school – they are pioneering a new 4 to 18 school approach for pupils from all backgrounds. The goal of the school is the prepare young people for the future by rebalancing academic skills, well-being and Design based thinking.

The school also hosts a Makerspace that combines several different areas with "The Quad" in the middle. The different workshop areas have equipment and tools for 3D printing, media and photography, fine arts, and design manufacturing. The curriculum of the school is constantly adjusted to fit the agile methods of working and project development, with a big focus on the interdisciplinary approach.

The big space in the middle of the Makerspace – The Quad – is used as a multi-disciplinary making space. It hosts several workshop tables for heavy-duty work but can also be transformed into exhibition or presentation space with only a few adjustments needed. It is also used during day-to-day Art & Design classes, and School 21 hopes that in the future, they can use this space to attract university students.

The Makerspace is also equipped with a 3D Design/Sculpture Studio, where pupils can make prototypes and products using resistant materials. The same space is also used for pottery and sculpture classes. Next to the studio, in another room, a laser cutter and engraver, vinyl cutter and 3D Printer are stored for students to further bring their design to life. The school states that they are constantly on the lookout for ideas on how to invest in the digital manufacturing facilities as they integrate new technologies into our curriculum.

Last but not least, the computer suite is equipped with 24 iMacs and three high-capacity PCs that are all equipped with industry standard Adobe Creative Suite. Digital Media Studio is also home to students taking part in specific projects involving the use of technology such as robotics, filmmaking or photography.

ADDITIONAL RESOURCES

FULL STEAM AHEAD RESOURCES

Full Steam Ahead project offers resources on different topics related to the Maker Movement and STEAM. Below, you will find a collection of resources, compiled within FSA project – we hope that after being inspired by the Best Practices Guidebook, you will be encouraged to take the next step and use our first resource to turn your classroom into a makerspace, or deep diver into the world of STEAM and browse our other resources.

Resource 1
FSA The Classroom as a Makerspace toolkit

To make the next step into the world of STEAM, our toolkit gets you directly underway to turn your classroom into a Makerspace! It does not only provide you with the latest insights on the matter, but also includes examples and practical templates & tools for you to quickly take action and achieve concrete results.

Resource 2
FSA European Pupils Resource Pack

Resource 3
FSA Pupil-Driven Social & Professional Network Toolkit

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