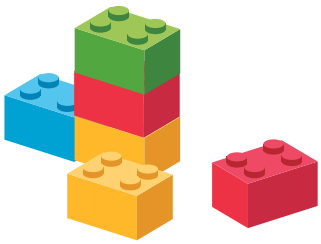
Helsinki

Tinkering to take on the world

– joy and innovation in learning

OPETUSHALLITUS RAHOITTAA HANKETTA



Edited by Leenu Juurola and Antto Wirman

Graphic design and layout by Susanna Mukkala

Published by City of Helsinki, Education Division

This material is published by the project Tinkering to take on the world – joy and innovation in learning, funded by the Finnish National Agency for Education.

Translation by Grano Oy / Multidoc

Edita Prima Oy, Helsinki, Finland 2019

www.helsinkioppii.fi/en/education-and-support/improve-your-skills/

Preface

What would you like to make today? Have you come up with a device to make everyday life easier and would like to make it using coding and 3D printing? Would you like to design something completely new for your dollhouse? Or what kind of characters would go on adventures in an animation film created by you?

Maker culture, or tinkering, combines making by hand with various tinkering technologies and the innovation process, enabling you to carry out unique projects that you find the most interesting. Making is an adventure – if you want to design and make something you have never done before, you will need skills that you do not yet have and you will come across situations that you have never faced before. Makerspaces are active places: enthusiastic pupils create, experiment, invent, learn and share new things. The community is an important factor, because others can help you learn about a new technology, and brainstorming together often leads to more innovative ideas. New technologies, such as 3D printing, micro controllers or green screen filming inspire and enable completely new types of projects.

Through the 'Tinkering to take on the world – joy and innovation in learning' project, maker culture was introduced in schools in Helsinki. This handbook comprises the key results of the project. The pupils and teachers of six schools in Helsinki took part in planning the makerspaces and activities through design workshops, where plans were refined through a so-called Edukata design process. **In part 1, we learn about the Edukata model and find out how a participatory design process can be utilised with pupils when designing makerspaces.**

Based on the ideas of these design days, a design agency produced an interior design concept for each project school. The plans were implemented by utilising old furniture and equipping the spaces with maker tools, such as 3D pens, vinyl cutters, microcontrollers and 3D printers. **Part 2 will shed light on the Makerspace Helsinki concept and the planning and implementation of makerspaces and their activities.**

Makerspaces and the new working methods were introduced with the help of a maker trainer. The trainer visited the schools to hold maker workshops for pupils and teachers, and the new premises were taken into use at schools, both during lessons and break-time maker clubs. **Part 3 describes in more detail what maker activities mean in practice and what kinds of projects can be implemented by tinkering.**

Happy making!

Helsinki, 27 May 2019, Leenu Juurola and Antto Wirman

Contents

1.

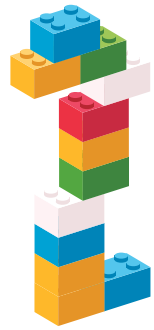
Edukata – a participatory design process for designing a makerspace

Katri Lehtovaara, Master of Arts, Schoolday Designer Oy
Virve Vakiala, class teacher, Master of Arts (Education), MBA

The Edukata model is based on research, development and experience

Edukata is a participatory design model, widely tested with teachers and pupils, developed for the education sector by Aalto University. With the help of Edukata model, teachers may guide participatory design processes in a school environment in cooperation with other teachers and students. The model is based on an empirically tested, research-based design method developed by the Learning Environments workgroup of Aalto University's Media Lab: professor Teemu Leinonen, designer Anna Keune and learning psychologist Tarmo Toikkanen.

Through the Edukata model, the participants will develop learning, operations, learning environments or services. The whole design process is based on a certain scenario: an innovative and challenging idea or vision of what learning and teaching, for example, could be like in the future. Through the model, these scenarios are changed into descriptions of how the planned activities can be implemented in practice. *(Keune, Leinonen, Toikkanen, 2014.)*



Edukata as a tool promoting the participation of children and young people

The curriculum of basic education highlights a school's community activities and school development. In addition to the teachers, the school's pupils also have a key role in planning and development. School work must be organised based on student participation, by listening to the students and by reinforcing these factors (basic education curriculum 2014).

Design methods offer an excellent basis for developing a school together. The methods encourage participants to face the challenge, come up with ideas about solving these challenges and further refine these ideas. The design process itself is a vital phase: it highlights the significance of interaction and working and acting together. The design methods also provide strong support for a pupil's role in the

transition from a user to an active developer.

Design education means learning about design and its different forms. Design education helps a child see the wide scope of design and understand their own influencing possibilities as a designer of their own environment; design is not limited to just designing objects, but instead it can be used to influence many kinds of factors, such as physical or social operational environments. Design education familiarises the pupils with the stages of design process and design thinking, which also helps develop creative problem-solving skills.

Edukata is a model of participatory design, which means that the design process involves people whom the end result will likely affect. Participation here means that everyone is being heard and that everyone can affect the end results. The ideas of all participants are equally valuable. At the same time, the expertise of all process participants can be utilised in the best possible way. Listening to the participants can be done in many ways. In its simplest form it may refer to asking for comments, but, from a wider perspective, it could mean involving others in the development of the design process. Nevertheless, it always includes working together with others. *(Keune, Leinonen, Toikkanen, 2014.)*

The Edukata model

- a design process progressing in stages
- involves people in a joint design process
- takes into account the needs and hopes of users
- involves the different user groups in the design process
- utilises shared brainstorming methods
- highlights the significance of interactivity, sharing and cooperation
- encourages participants to face challenges: the model helps them easily solve everyday challenges and avoid familiar patterns in order to see things from a wider perspective

Edukata model in the design of a makerspace

The use of the Edukata model was piloted in the design process of makerspaces in autumn 2018 in six different schools as a part of the 'Tinkering to take on the world – joy and innovation in learning' project. The pupils who took part in the so-called Design days were 2nd–9th graders.

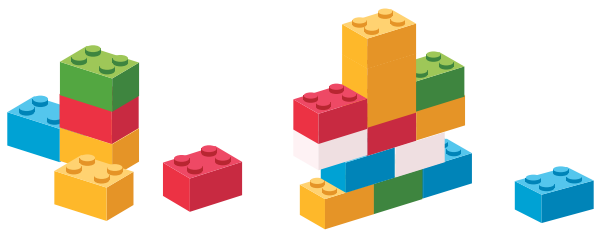
The Edukata work progresses in stages. In the design process of maker learning environments, the model is used as follows:

1. Trend working: Reviewing the desired and likely future, especially from the perceptive of a maker learning environment. The future working helps understand what kind of learning and activities the space should enable so that the skills learned at school will meet the needs of the future. Based on future working, various objectives for the space and its activities will be established during the workshop. In order to focus on the future, image cards based on Sitra's megatrend cards (Sitra 2017) will be used to anticipate the future.

2. Scenario work: An image of the desired future of the makerspace of dreams will be created with the help of creative working methods. The pupils may choose whether they implement their plan by building a scale model with Lego, drawing or using the AR interior design programme.

3. Enrichment: The participants, under the guidance of an instructor, will enrich the scenarios created in workshops from the perspectives of design challenges and design opportunities.

4. Preparing the scenarios: Refining the verbal and/or visual descriptions of the desired operations of a makerspace of dreams to support the further design process of various operators. The workshop will result in scenarios created by the student groups that will be used as descriptions for teachers, interior designers and architects regarding what kinds of activities, learning and social interactions the space should enable.



Structure of the Design day

Preparations

- The Design day is an intensive planning day. Reserve five lessons for it (45–60 minutes each). If possible, the days should be planned and implemented together with a work partner, as pupils may require very different kinds of assistance and guidance during the day. Download the AR interior design software onto tablet devices and test that it works. Learn how to use the software in advance. Arrange the tables for group working, 4–5 persons in a group.

Equipment and supplies

- a data projector and a computer for a PowerPoint presentation (download at www.helsinkioppii.fi/en/education-and-support/improve-your-skills/)
- iPads or other tablet devices with AR interior design software (e.g. 3DBear)
- about 20 sheets of white cardboard, A3 paper or flipchart paper
- coloured pencils, erasers, long rulers and Blu Tack.
- plenty of Post Its in different colours: red, green, yellow and blue.
- Lego and Lego bases
- Megatrend cards, 18 in total (appendix 1) one deck for each group.

Programme of the Design Day

Time	Content	Materials	Working method	Slides
60 min.	Welcome! What does design mean? What is a makerspace learning environment and what can you do there? + Future working	Images of the makerspace environment and activities + Image cards: Sitra's megatrends (appendix 1), future table	Teaching discussion group working	1-14
break				
45 min	Brainstorming makerspace operations	Cardboard, Post Its	Work rotation in groups	15-16
break				
45 min	Brainstorming and visualising a makerspace in groups	AR interior design software and tablets, Lego or cardboard and drawing equipment	Group working. The students may choose the working method.	17-19
break				
45 min	Participatory design with the Edukata design method	A blank A3-sized piece of paper for each group, Post Its in different colours (red, green, yellow, blue)	Work rotation	20-23
break				
45 min	Adjustments based on the feedback received + Presenting the groupwork + Learning evaluation with the survey form	Group results, printed surveys	Group working	24-25

You can download the PowerPoint presentation at www.helsinkioppii.fi/en/education-and-support/improve-your-skills/.

The first lesson: Objectives of the Design Day and future work

Duration: 60 minuuttia | Slides: 1-14

Objective:
The students will have an understanding of what design means, how it is linked to their own life and how design thinking can be utilised for planning different things or environments. The students will understand what kind of premise a makerspace is and what could be done there. Future work will help increase understanding of what kinds of skills are needed in the future and what kinds of learning spaces and activities this requires.

Equipment:
Post Its, megatrend cards (18 pcs for each group, see the appendix 1), Blu tack and a sheet of cardboard for each group, with the future table drawn on it.

Course of the lesson:
A joint discussion with the help of the PowerPoint presentation (25 minutes)
Discuss with the students about what design is.

- What does the word design bring to mind?
- What kinds of things in their environment have been designed?
- What familiar items have been designed?
- Explain how the methods of design are utilised in modern working and what kinds of other methods will be used during the course of the day (future working, joint planning, design methods).

Show the slides to briefly demonstrate what makerspace is, what it can be used for and what kinds of different roles one can take in the space.

Future working (35 minutes)
Present future working with the help of the slide show. What do the pupils think the aphorism by John Schaar means? What could a school of the future look like and what kinds of skills should one learn there?

A deck of picture cards is given to each group. The pupils will familiarise

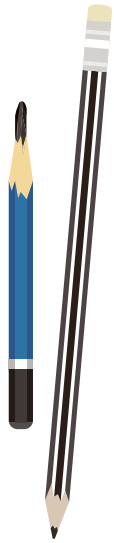
	Desirable	Undesirable	Likely
SOCIETY			
ENVIRONMENT			
HUMANS			
TECHNOLOGY			
ECONOMY			

themselves with these cards and discuss as a group what a desired, undesired and likely future look like. The groups' assignment is to discuss and place the cards onto the future table using Blu Tack. Finally, a shared conversation about observations will be held.

- What does the desired future look like? Which cards were placed in the undesired column?
- What kind of future do you believe is likely?
- How does this view of the future affect skills that should be learned at school? What kinds of spaces support learning and practising these future skills?

Second lesson: Brainstorming makerspace operations

Duration: 45 minuuttia | Slides: 15-16



Objective:
The objective is to come up with as many ideas as possible about what one could do in a makerspace and what kinds of operations could be held there. The students will understand their own role in the planning and implementation of the operations and will have an understanding of how they could utilise their own strengths and existing skills in these operations.

Equipment:
A3-sized paper (6 pcs), Post Its, pencils.

Preparations before the lesson:
Write the titles on the A3 papers (one on each paper):

- What kinds of things I want to design?
- What would I like to know how to make?
- What kinds of skills can I teach to others?
- What kinds of devices, equipment or materials do I want to use?
- When do I want to tinker?
- Who will look after the space?
-

Course of the lesson:
The students will be divided into six small groups. The groups will rotate from table to table and write down their ideas on Post Its, one idea per one note. It is important that enough time is reserved for each table. The teacher should encourage the students to come up with new ideas and be creative.

When everyone has written down their ideas about all the questions, the small groups will group the ideas together. After this, the ideas will be presented to the whole group. The ideas collected will be placed on the classroom's wall so that everyone can see them.

Third lesson: Brainstorming the makerspace

Duration: 45 minuuttia | Slides: 17-19

Objective:
The students will come up with physical elements of a makerspace of their dreams based on the previous work and make a design for the space using Lego, drawings, or AR spatial modelling. It is important to understand that there are no limitations for the ideas during this first stage, but instead all ideas are equally valuable and allowed. Students are encouraged to express themselves creatively and boldly.

Equipment:
Lego, Lego bases, large sheets of drawing paper, colour pencils, tablet devices with an AR spatial modelling software (e.g. 3DBear), ready and tested.

Course of the lesson:
The students will work in 2–3 people groups and make a plan for the space using Lego, by drawing or with an AR spatial modelling software. Groups could be formed based for example on which working method interests each student. Alternatively, groups will be formed first and, after this, the groups can decide amongst themselves which working method they will choose. The groups will draft their plans.

The fourth lesson: Brainstorming the makerspace through participatory design

Duration: 45 minuuttia | Slides: 20-23

Objective:
The plans will be enriched through peer feedback. The students will learn to both give and receive feedback. The method encourages participants to face the challenge, come up with ideas about solving these challenges and further refine these ideas. The design process enhances the significance of social interaction and working and acting together. These methods also support a pupil's role in the transition from a user to an active developer.

Equipment:
A3-sized blank sheet of paper for each group, plenty of Post Its in different colours: red, green, yellow, blue.

Course of the lesson:
One student will be selected from each table, they will remain behind to present the plan. Other group members will rotate around the classroom and see the plans of other groups.

During the first rotation, the students will focus on positive, encouraging feedback. The students will answer the question: What is something good about this plan that should be kept? This feedback will be written on a blue Post It note, which will be stuck to that group's A3-sized paper. It is important that only one thing be written on one note during every feedback stage.

Ideas for giving encouraging feedback:
I really enjoy how...
I think this is a good idea because...
You have done a really great job because...
It's a really smart idea to...
This part is great because...

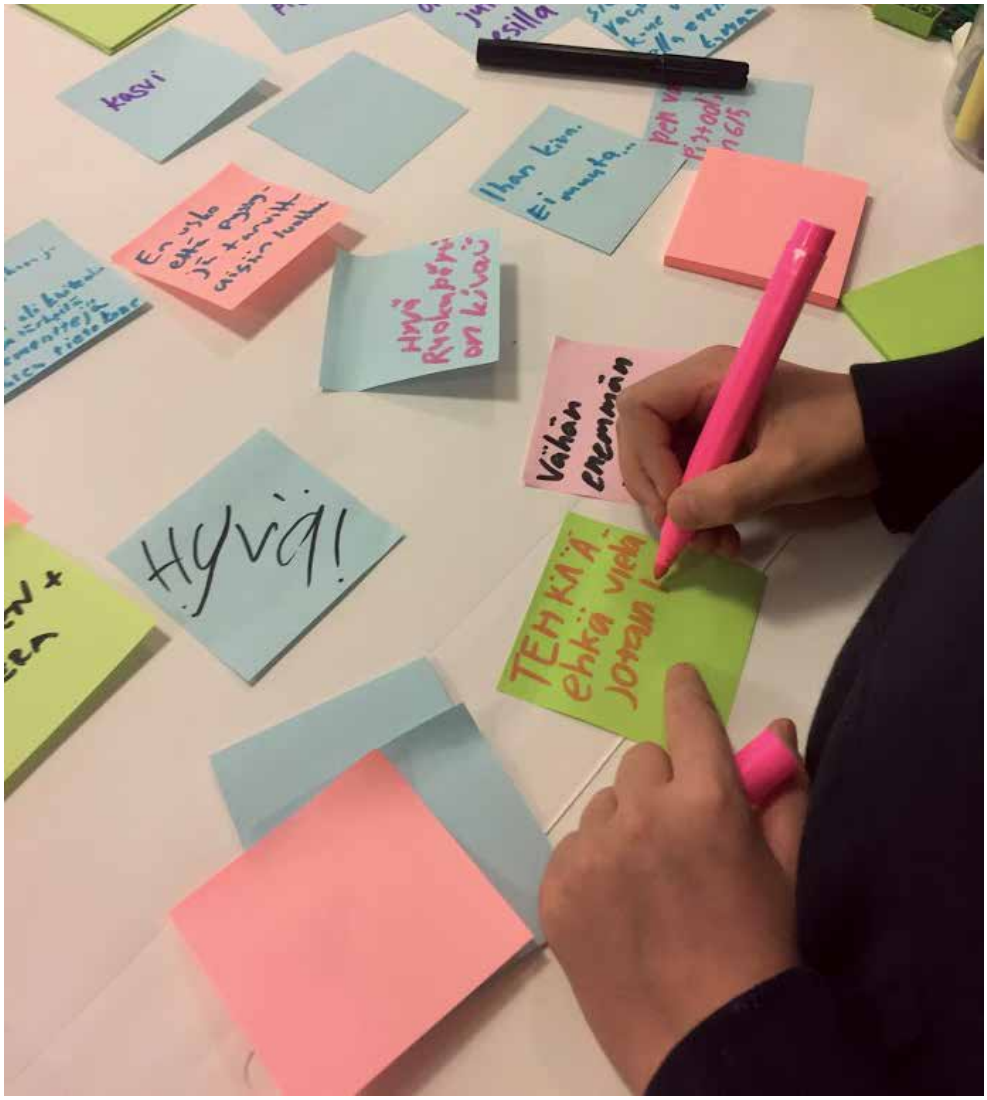
When the whole tour has been done and everyone has given feedback to all plans, they should return to their group's desks to review the feedback they have received.

During the second round, the students should only focus on difficulties and complications. What could be difficult if this plan is implemented? This feedback will be written on pink Post Its. A different person will remain behind to present the plan this round. After the round, everyone will return to their desk to review the feedback they have received. At this stage, they can start solving the challenges demonstrated. Students should also be encouraged to argue for why they believe something does not work when they are giving feedback.

Ideas for giving feedback:
I wonder how this part would work, because...
Could there be some other solution for this part, since...
I'd recommend you to think about this more closely, because...
What if you changed this section, because I think...

During the third round, the students solve the challenges listed on pink Post Its and answer the question: How will the difficult thing be solved? The purpose is that the green Post It notes will be used for ideas on how to solve the challenges written on the red notes, or parts of them. The green Post It will then be attached next to the red Post It so that it is easy to see which challenge it is linked to. After the round, everyone will return to their desk to review the solutions they have received.

On the last round, the students have the chance to give further ideas and answer the question: What else would you like to include in the space? These ideas are written on the yellow Post Its.



The fifth lesson: Adjusting the plans based on the feedback received

Duration: 45 minuuttia | Slides: 24–25

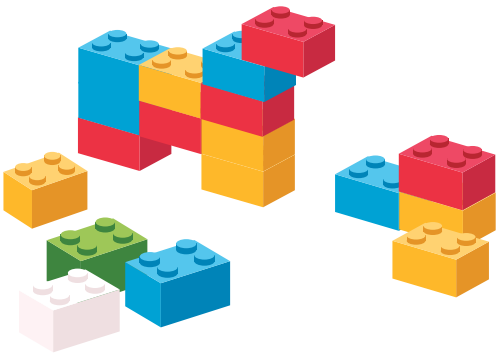
Objective:
Making concrete changes to the plan by adding something, removing something and designing something differently. Understanding the significance of the feedback received from the perspective of the user: how should the plan be changed so that it can better meet the user's needs? At the same time, it will be understood that better results can be achieved through teamwork than alone or in small groups. At the end of the class, each design group will present the changes they have made to the whole group.

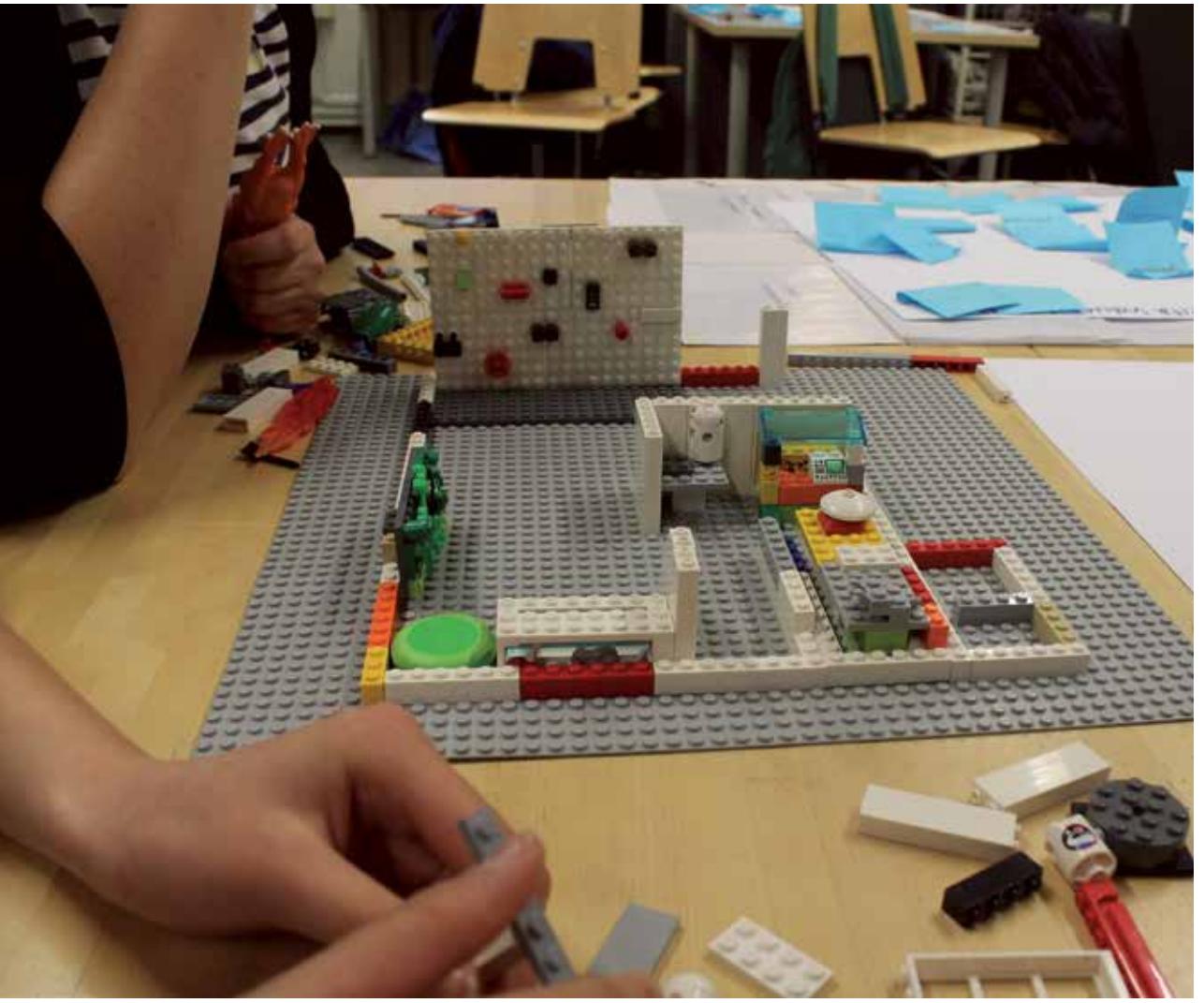
Equipment:
Lego, coloured pencils, iPads with AR interior design software for making changes.

Course of the lesson:
The students will make the changes to their plan based on the feedback they have received. (25 min)

At the end, each design group will present the changes they have made to the whole group. (20 min) The finished works will be photographed and saved in a format that enables their easy presentation to different operators for further development.

The learning evaluation is done using a self-assessment form, which the students can fill in online. The teacher could also alternatively print the forms out. (5 min)





Sources:

Keune Anna, Leinonen Teemu, Toikkanen Tarmo (2014) Edukata - osallistava muotoilumalli. Ohjaajan opas oppimisaktiviteettien kehittämiseen. Aalto University School of Arts, Design and Architecture Department of Media - Media Lab Helsinki.

Keune Anna, Leinonen Teemu, Toikkanen Tarmo (2015) Designing Edukata, a Participatory Design Model for Creating Learning Activities. Teoksessa Van Assche F., Anido L., Griffiths D., Lewin C., McNicol S. (2015) Re-engineering the uptake of ICT in schools. Springer open, 41-58.

Leinonen, Tiina (2014) Muotoilukasvatus. MUTKU – muotoilukasvatusta peruskouluun - opetuskokonaisuuden opetussuunnitelman laatiminen. Aalto yliopisto, Muotoilun laitos, Taideteollinen muotoilu.

National Core Curricula for comprehensive education (2014), Finnish National Board of Education

Sitra (2017) Megatrendikortit. https://www.sitra.fi/aiheet/megatrendit/#megatrendit-2017

Edukata facilitators: Katri Lehtovaara katri@schooldaydesigner.com

Virve Vakiala virve.vakiala@gmail.com | koulutukset@edukata.fi

2.

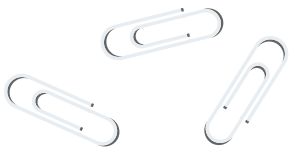
From plans and scenarios to concrete spaces
- Makerspace Helsinki concept

Inkeri Halla-aho, Interior Architect,
Master of Arts (Spatial Design), Main interiors Oy
Leenu Juurola, Project Planner, Master of Arts (Education)
Antto Wirman, Project Instructor, Master of Arts (Education)

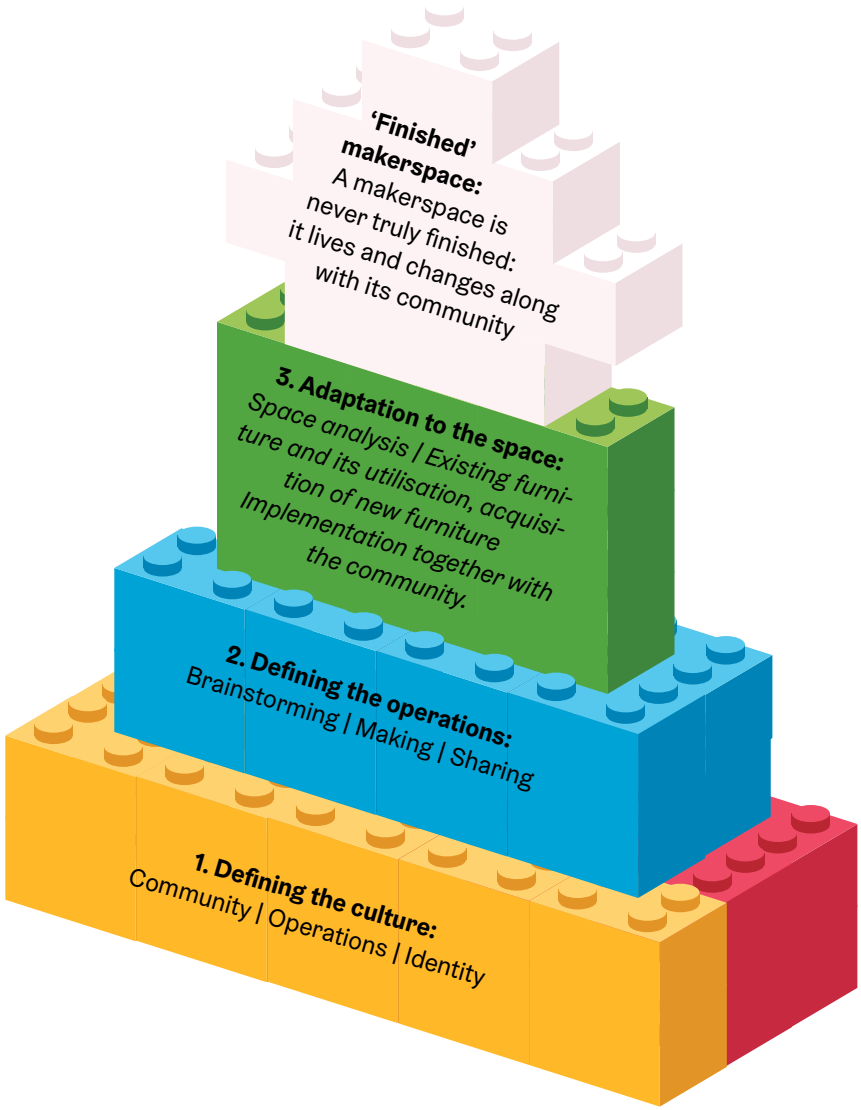
When designing a makerspace, a joint design process is key. The pupils' scenarios, the teachers' wishes and the opportunities and limitations of the space provided by the school will be taken into account during the concepting stage, which results in a finished and ready-to-use makerspace. It is important that the pupils are also shown at this stage of the process how the ideas and plans they produced have been taken into account. This will strengthen the community's feeling that the school's makerspace is a space just for them, that it is important to keep it in good condition and that developing it together is fun. A comfortable space that meets the pupils' wishes and needs supports learning. It is motivating to see that the space and its equipment enable the tinkering in which the pupil has expressed interest.

Makerspace Helsinki concept was produced by Main interiors Oy. The concept utilised both interviews with the teachers and the scenarios pupils had produced in the Design workshops about a makerspace of their dreams and its functions. The schools introduced the concept gradually according to their schedules and resources. The interior design plan should be revisited, for example when buying new furniture in order to keep in mind what kinds of wishes the users had and that perhaps could not be met yet. When the interior design plans were utilised at schools, the pupils' hopes regarding maker activities were also taken into account: in some schools the activities requested by the pupils were tested even before the makerspace was ready for use. The experience of how tinkering can be done in a regular classroom supports the design process of the actual makerspace.

The experience of how tinkering can be done in a regular classroom supports the design process of the actual makerspace.



The Makerspace Helsinki concept will be applied in accordance with a process progressing in stages:



Stage 1: Defining the culture

Community: Before establishing the makerspace, it is important to review what the school's maker community is like and who will use the space.

- the users' age
- size of the groups
- external users?
- special notes, e.g. the needs of special education?
- the teachers' role in the operations?

Operation: The operations need to also be carefully specified before establishing a makerspace. What will be done in the makerspace and what does it require?

- A supervised or unsupervised space?
- Rules (for, e.g. using the equipment, storing and cleaning it).
- What kinds of activities can be done in the space and what tools are needed?
- How interdisciplinary is the space or does it focus more on certain topic or action?

Identity: What is the makerspace of this school like? What makes this community special?

- What kinds of special competences do the community members have?
- A space that looks like its users and that has been made together
- Utilising the school's focuses and strengths in design

The users of the makerspace, i.e. the community, is a key factor in designing the makerspace. The users' age range affects the furniture solutions and their adaptability. If external users may also use the space, it must be considered how different equipment is stored and how its use is supervised. If the pupils are allowed to use the space unsupervised, taking user safety into account is crucial.

The decision as to what kind of activities will be offered in the makerspace has a large effect on the space's design. Making sewing patterns and cutting clothes require a large desk surface, whereas making videos and recording music require a quiet acoustic space. Often, compromises have to be made in planning and a decision must be made as to what kind of activities take the priority. Usually this prioritising happens naturally by thinking which activities could be more easily arranged in some other space. For example, schools often have workshops that are better for woodworking machinery, for example. It would be ideal if makerspaces could be located near to premises that will also be used for maker projects.

In order to reinforce the space's communality and uniqueness, it should be considered what makes this maker community special. For example,

the community may include very skilful and enthusiastic 3D modelers or knitters. The identity may also be seen in the makes of the makerspace users or the furniture upcycled together. The presence of these in the space demonstrates that 'this space belongs to us'. The school's focus areas or topical, interesting phenomena could also be showcased in the space: for example, small nurseries for plants could be built in a makerspace focusing on natural science, and these plants could be directly utilised in experiments or researched under a microscope.

The decision as to what kind of activities will be offered in the makerspace has a large effect on the space's design.

Stage 2: Defining the operations

The maker operations affect how the space is designed: adaptability enables the different purposes of use. The space must enable brainstorming, making and implementation as well as showcasing the results.

The maker operations require

- The premises and tools for brainstorming: inspiration sources (e.g. a small library), brainstorming corners, drafting platforms, etc.
- The premises and tools for making and implementation:
  - storing the equipment, ease of use, safety,
  - adaptability of furniture: grouping the desks, movable seats
  - technology and the required premises (e.g. green screen, sound recording, 3D printing).
  - Options for sharing and presenting: Presenting results and sharing them with others: e.g. an exhibition room, stage and seats for an audience, showcases, etc..

BRAINSTORMING:

Starting a new project begins with brainstorming, and inspiration can be found from electronic sources or literature, for example. The makerspace should have a small library or the option to use a laptop or a tablet device. Sharing ideas with other is also a central part of maker culture. Therefore it is important that the space also features comfortable areas for group working, such as beanbag chairs, sofas, armchairs or footrests.

Example, finished makerspace – brainstorming

Photo and design: Inkeri Halla-aho, Main interiors Oy

When the ideas start to become clearer, there should be space to write and draw at hand. This makes it easy to share thoughts with an instructor or friends. A movable drawing board doubles as a room divider that helps create peaceful nooks if refining an idea takes a little longer.

MAKE AND EXPERIMENT:

When the brainstorming phase proceeds to concrete implementation, it is important to have easy access to the necessary tools. Tools and equipment can be stored in a movable storage unit with transparent lockers that have been clearly named, for example. The movable storage units also make the space easier to clean and more adaptable. The necessary equipment can also be hung on walls on open shelves, a net, or a perforated sheet using S-shaped hooks or other solutions. However, it is important that the supervised and more valuable equipment can be stored in lockable cupboards.

Sharing one's own results and presenting them to others is a social event that reinforces the ties of a maker community.

The work is carried out at a desk, alone or in groups. It needs to be possible to group the desks together into units of different sizes. The seats should also be flexible and easy to move.

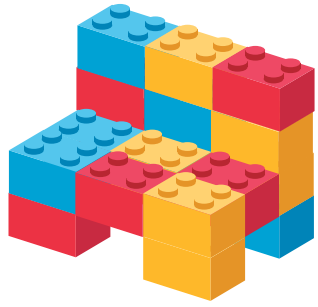
Workstations reserved for specific actions requiring technology (such as sewing, 3D printing, green screen working and sound recording) should be placed on the edge of the space, so that the sockets and other amenities required by these technologies are easily available. It is also good to place workstations that are hard to move, such as heavy woodworking benches, next to a wall so that they are not in the way of other activities.

SHARE AND PRESENT:

An essential part of maker culture is presenting one's creations and sharing them with others. At this work stage, drawing and writing surfaces, screens and tablet devices could be utilised. In some cases (such as robotic projects), the floor must be cleared of all furniture in order to view the results, which is another reason for easy-to-move furniture.

Sharing one's own results and presenting them to others is a social event that reinforces the ties of a maker community. Therefore it is important that the makerspace is a comfortable place to spend time when no one is working in the room. Some of the space can be allocated for exhibitions and the community's 'front' to visitors.

The maker operations affect how the space is designed: adaptability enables the different purposes of use. The space must enable brainstorming, making and implementation as well as showcasing the results.



Stage 3: Adaptation to the space

Typically, makerspaces at schools are designed in premises that have been used for other purposes, such as classrooms or open breaktime space. In such cases, it should be taken into account in the plan that changing permanent fixtures, such as a water faucet, may prove difficult. Often, the space will also partly remain in its previous use, such as an art classroom or media space, and this often requires some compromises in terms of the interior design. On the other hand, the different purposes may also make the makerspace unique (e.g. with changing art exhibitions) or provide it with more versatile tinkering tools or techniques.

The space will be adapted based on user experiences, which will also strengthen the feeling that the space looks like its users.

The strengths and weaknesses of the future makerspace should be reviewed carefully at this stage. Often, solutions to the space's challenges can be found in true maker spirit by tinkering together: if the space is too bright, curtains could be sewn for it together, and if the surfaces of cupboards and desks show some wear, they could be renewed by painting or taping them. Utilising old furniture could take one far when implementing a makerspace. However, it should be considered whether the recycled furniture is safe and what its history is. It is not even purposeful to finish the makerspace at once. The space will be adapted based on user experiences, which will also strengthen the feeling that the space looks like its users.

Maker activities are versatile and, at best, there will be several ongoing projects at the premises at the same time. Due to this, it is important that all equipment is easily accessible and cleaning is effortless. Transparent storage units and boxes and clearly visible basic tools make independent use of the space easier. However, it is important to take the users into account and consider carefully what kind of tools can safely be kept visible. Often, the pupils would like the space be decorated with rugs, for example, to make it more comfortable. However, rugs or soft furniture may make cleaning more difficult or become a fire safety risk.

Case
Puistopolku

Community

- max. group size 20 pupils
- users are pupils of a lower stage comprehensive school
- no external users
- space used under supervision
- requires a reservation

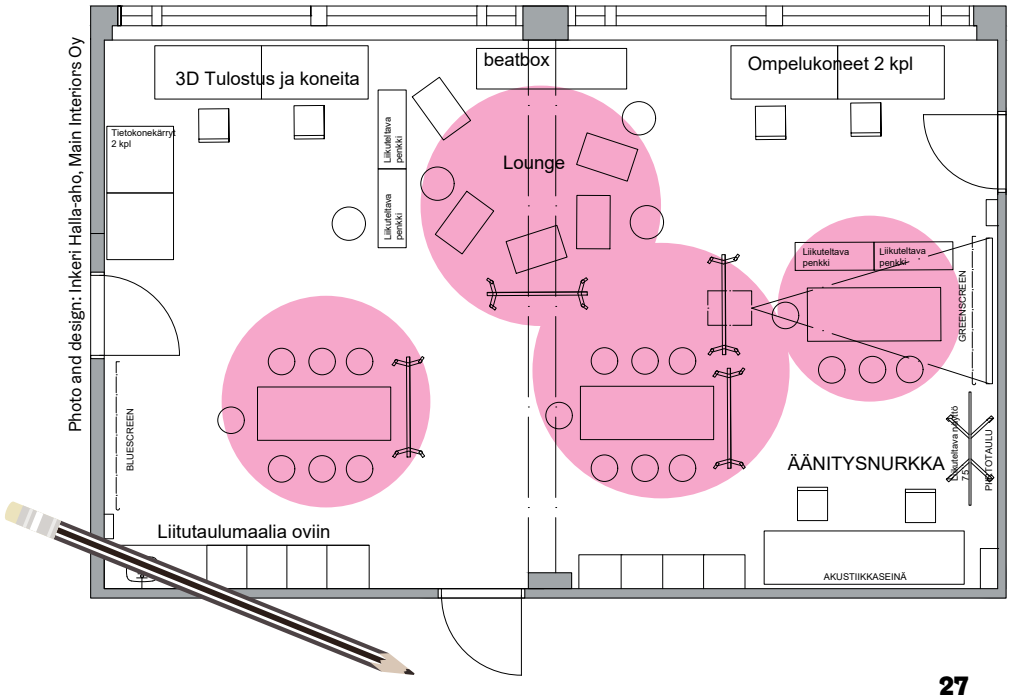
Operations

- space that is allocated for video recording and sound work
- sustainable, versatile, agile furniture
- laptops and their storage
- storage boxes for Lego, also cupboard space
- both lessons and club and breaktime activities, also in the use of expressive arts
- wishes: 3D printing, robotics, VR technology, mobile games, a sewing machine, basic tinkering and woodworking tools

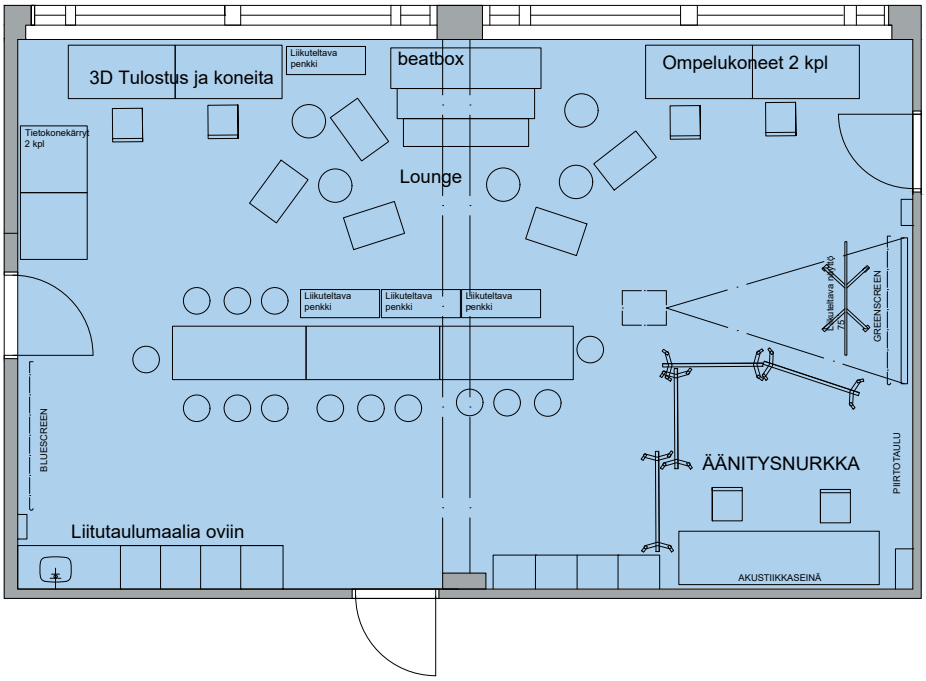
Identity

- the users are especially interested in boardgames and computer games

Brainstorming

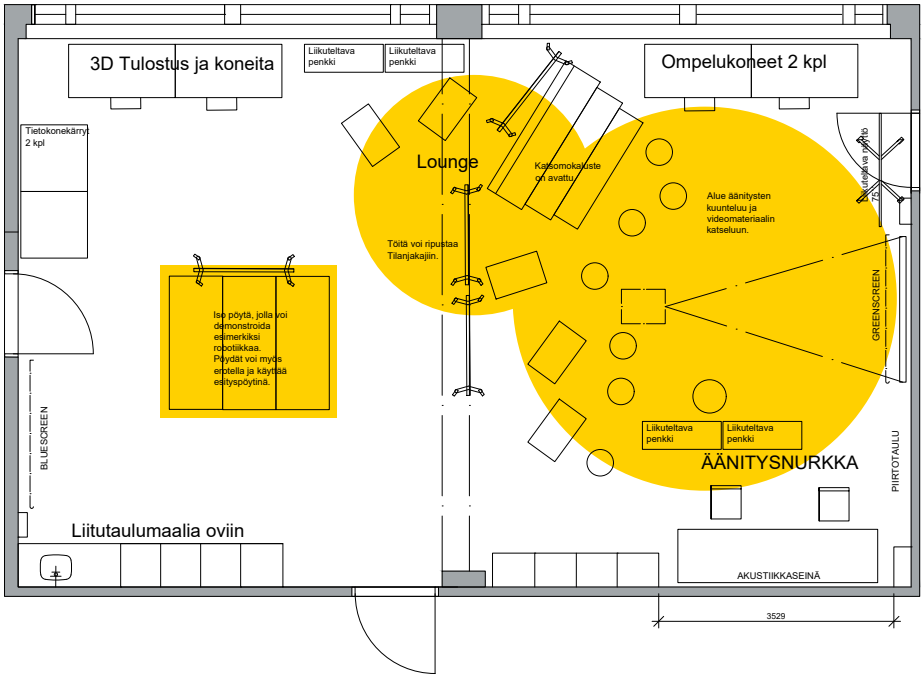


Make and experiment



Kuva ja suunnitelma: Inkeri Halla-aho, Main interiors Oy

Share and present

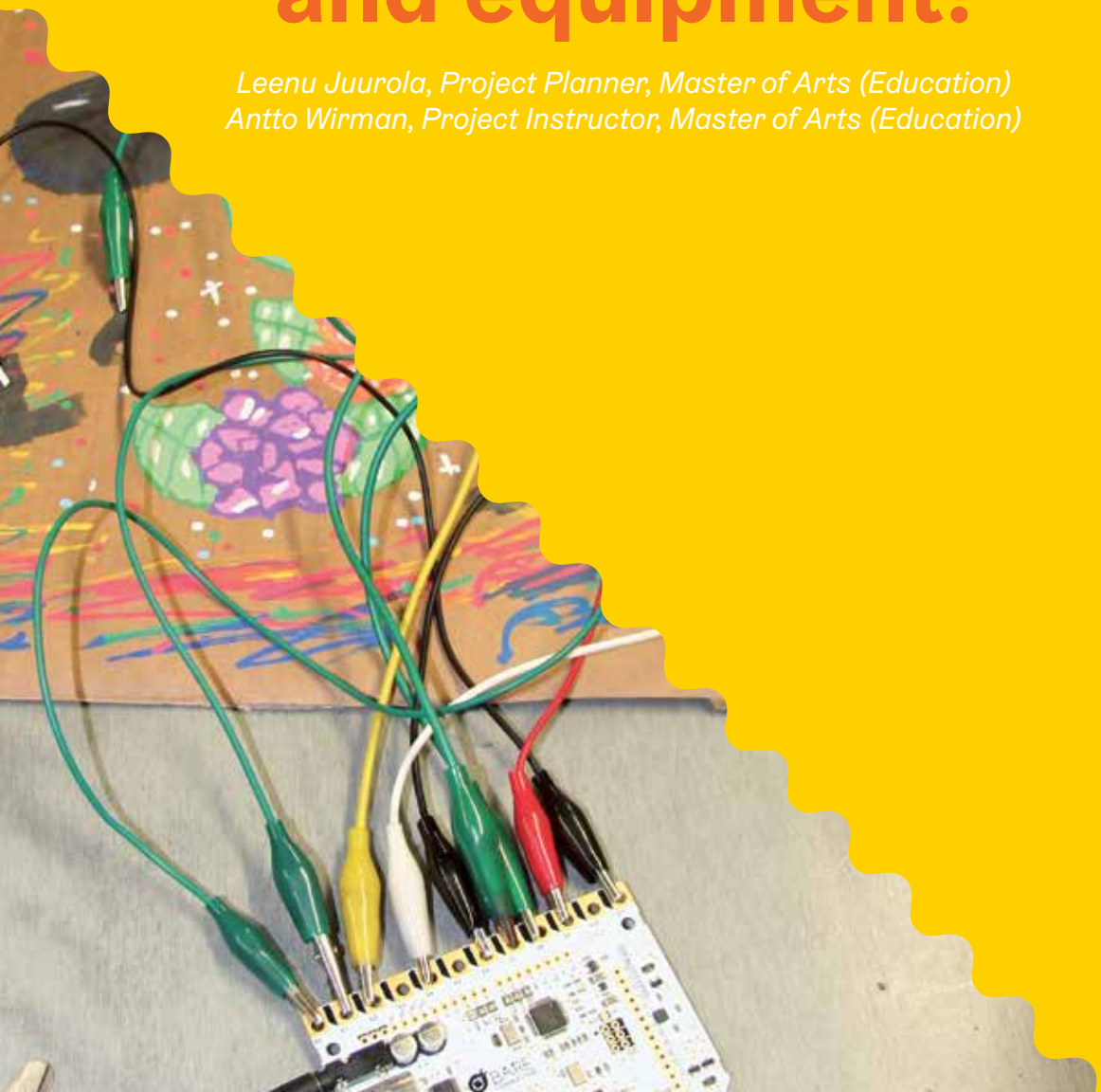


Kuva ja suunnitelma: Inkeri Halla-aho, Main interiors Oy

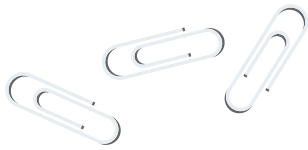
3.

Using the space and equipment!

Leenu Juurola, Project Planner, Master of Arts (Education)
Antto Wirman, Project Instructor, Master of Arts (Education)



Maker operations – what are they?



The culture of handmade is on the rise: social media enables sharing ideas, finding low-threshold DIY projects and training techniques while new technologies offer new, inspiring ways of implementing one's own creative projects. The costs of new technologies and components are also rapidly decreasing, and the tools that were once only in professional use are now also available to hobbyists. Many pieces of 3D design software, for example, are free-of-charge, and printing out one's own designs is very affordable, for example at libraries. The democratisation of maker culture is, in fact, a central part of the maker culture: open makerspaces and their equipment allow everyone to realise their own projects.

Maker culture is built on community and sharing one's own projects, ideas and the techniques and applications used on them. Maker working often highlights the possibilities offered by digital tools, such as coding, robotics and 3D design, but, above all, maker culture is a way of thinking and an attitude. The maker has an idea or a challenge, which they attempt to solve by experimenting and making. When one is familiar with the working techniques and tools, they can be creatively applied to personal projects. The maker culture frees a person to design unique, 'customised' solutions. At its best, tinkering changes a person's attitude towards everyday issues: they can design and implement a better game controller or a door stopper by themselves.

Maker pedagogics help pupils practise many kinds of skills, such as problem-solving, creativity, the innovation process, project work, cooperation skills and various working techniques. Reinforcing the change of attitudes is also important: tinkering can transform a pupil from a passive consumer of technology into its active producer and designer. Pupils may easily think that school assignments are mandatory and they are free to do things that interest them only at home. However, tinkering, at its best, enables challenges and working method that interest the pupils, allowing them to do interesting things at school.

Maker culture is built on community and sharing one's own projects, ideas and the techniques and applications used on them.

The makerspace at school can have many purposes of use. Typically, the activities are more formal than in a library, for example; maker working and new techniques are practised in a similar way to regular lessons: phase by phase and under a teacher's guidance, and school is an excellent environment for practising new techniques. However, the important thing is that the school's maker operations emphasise active making and experimenting done by the pupils and cre-

Pupils are also good peer instructors, and a makerspace is a great way of practising how to share one's knowledge.

ative application of the techniques. At its best, maker operations facilitate long-term projects. These help refine skills and allow the pupils to practise determined working, as building prototypes and developing them demands commitment to the project. Through maker activities, children will experience success but also failures, which are important to both new innovations and the pupil's own growth: will I give up, or will I use what I have learned to find a new solution? Pupils are also good peer instructors, and a makerspace is a great way of practising how to share one's knowledge.

The makerspaces of schools are also used for break or club activities that are less formal than regular lessons. The challenge of breaktime activities is the shortness of even so-called long breaks: half an hour can easily go by when looking for the necessary tools, starting a machine and trying to remember where the project was left off. However, the schools involved in this project had demand for breaktime activities. In the lower grades, especially, there was an even number of boys and girls who proved to be enthusiastic tinkerers. In breaktime activities of lower grades, in particular, short and quickly realised projects proved to be popular. When a pupil's maker skills develop and the methods become more familiar, committing to longer projects will become easier.

Some schools taking part in the project also offered maker club activities, which resemble the operational method of makerspaces outside schools. Implementing longer projects becomes easier when there is more time available. In a school environment, pupils are used to having the teacher's support when needed. However, a teacher should, through their own actions, attempt to reinforce the thought that the teacher's role in a makerspace is more that of an coach, and the pupils can also ask for advice from one another and solve problems together, by examining and experimenting. However, the makerspace often features tools that can only be used under the supervision of an instructor or a teacher. In club activities, it is crucial that the rules and principles of the makerspace are familiar to all the members of the maker community.

However, a teacher should, through their own actions, attempt to reinforce the thought that the teacher's role in a makerspace is more that of an coach, and the pupils can also ask for advice from one another and solve problems together, by examining and experimenting.

What are maker projects like and how are they guided?

At a school, a maker project can be launched based on a theme or a phenomenon, in which case the maker methods are used as a part of a larger project. The end result of project with an environmental theme, for example, could be a waste bin created by the pupils that inspires users to sort waste and utilises micro controllers. Often, a starting point for a maker project is a new working technique or a technology pupils want to practise and that will be used as a part of the project. For example, the green screen and animation techniques could be utilised in a story project for a language class or the pupils could build a story-telling player device, utilising micro controllers.

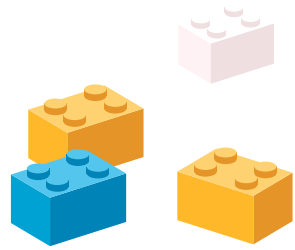
In maker workshops, the teacher is a coach and a facilitator, and any technical problems can often be solved by studying the issue together with the pupils. However, the teachers taking part in the project have brought up that when taking new technology or materials into use, the teacher should possess the necessary basic skills. This facilitates the solving of problem situations and helps find other solutions without unnecessary waiting that could easily rob the pupils of their interests. However, it should be remembered that the teacher does not need to know how to code in the C programming language or build fantastic electronic projects when they start the maker activities. Both the teachers and the pupils build up their tinkering knowledge and skills gradually. Basic skills will take one far, and in more challenging projects help is also available on the online pages of the equipment manufacturers and through video tutorials. Often, enthusiastic and motivated pupils look for information and projects themselves without being prompted, for example on the Internet.

Pupils need to practise the use of different techniques so that they can creatively apply them to their own projects. In the 'Tinkering to take on the world' project, a project trainer instructed both teachers and pupils primarily on how to use the various maker techniques. Due to this, the workshops often followed a certain pattern:

1. Presenting the use of a work method or technique and going through the key functionalities under the teacher's instruction.

2. Practising the work method or technique with the help of examples.

3. Applying the work method or technique in one's own or the group's project.

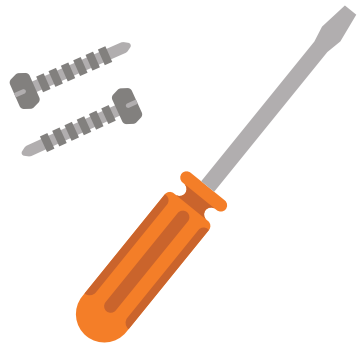


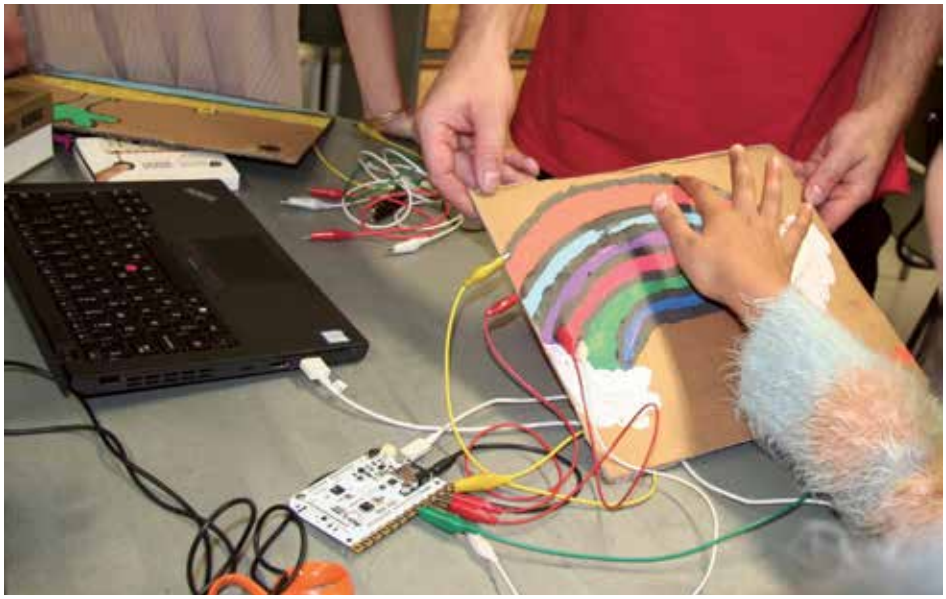
Maker equipment and its use

The starting point for planning maker activities is the pupils' own interests. If tinkering is a new thing at the school, examples of maker thinking need to be given to the pupils. Tinkering is not about the gadgets, but instead the innovation process is at the core of the operations; a pupil can start developing solutions for various challenges by examining, experimenting and building prototypes. However, new technologies do enable new types of solutions and by utilising them a pupil can learn skills of the future, such as programming and 3D design. In a school environment, new types of tools also motivate pupils. A very typical comment from pupils when learning about maker tools is 'cool!'

The needs of the maker community will guide the equipment acquisitions. Establishing a makerspace can be started small and new equipment can be acquired gradually, according to needs and resources. It is not important to have the newest devices; what is done with them is more important, as is the question what kind of product development processes they should enable. It should also be taken into account who uses these equipment: if microcontrollers are this maker community's 'thing', it should be considered what kind of tools are suitable for younger pupils and what activities are challenging enough for experienced makers in the upper stage comprehensive school. Maker technique should be considered in units: For example, what kind of unit do we wish to build for producing videos and films? The unit includes both the requirements related to the space's size and acoustics as well as the entire production process, programmes and tools for sound and video recording, editing and performances. A typical mistake during the procurement stage is to forget one part of the unit. It is recommended that you review what kind of demands the planned activities set for the equipment. For example, functional virtual reality demands a great deal of the hardware's performance and some woodworking machines require efficient dust removal.

The starting point for planning maker activities is the pupils' own interests.





Instructions for tinkerers and instructors of makerspaces:

Working in the facility:

- Be prepared to learn new things. If you fail, try again.
- Work together with others.
- Be polite. Ask for and give help. Don't belittle the achievements or skills of others.
- Do your work as well as possible. Work well done is a prize in itself.
- Be enthusiastic and use your time for working.
- Allow others to work in peace.
- Move calmly around the space.
- If you want to play, go elsewhere; do not cause any hazardous situations with your actions.
- If an accident happens, always report it to a teacher.

Using tools and materials:

- Makerspace equipment and tools are part of the premises. If you take any tools or devices out of the space, report this, and bring them back after use.
- Report any device malfunctions to a teacher.
- Practise how to use the tools. Ask someone to help you with the tools when necessary.
- Only use the tools for their correct purposes; a torch is not a hammer.
- Follow all the instructions. Some machines cannot be used without a teacher's supervision.
- Notify a teacher or makerspace attendant if materials run out.
- Do not waste materials. Make sure materials are recycled properly.

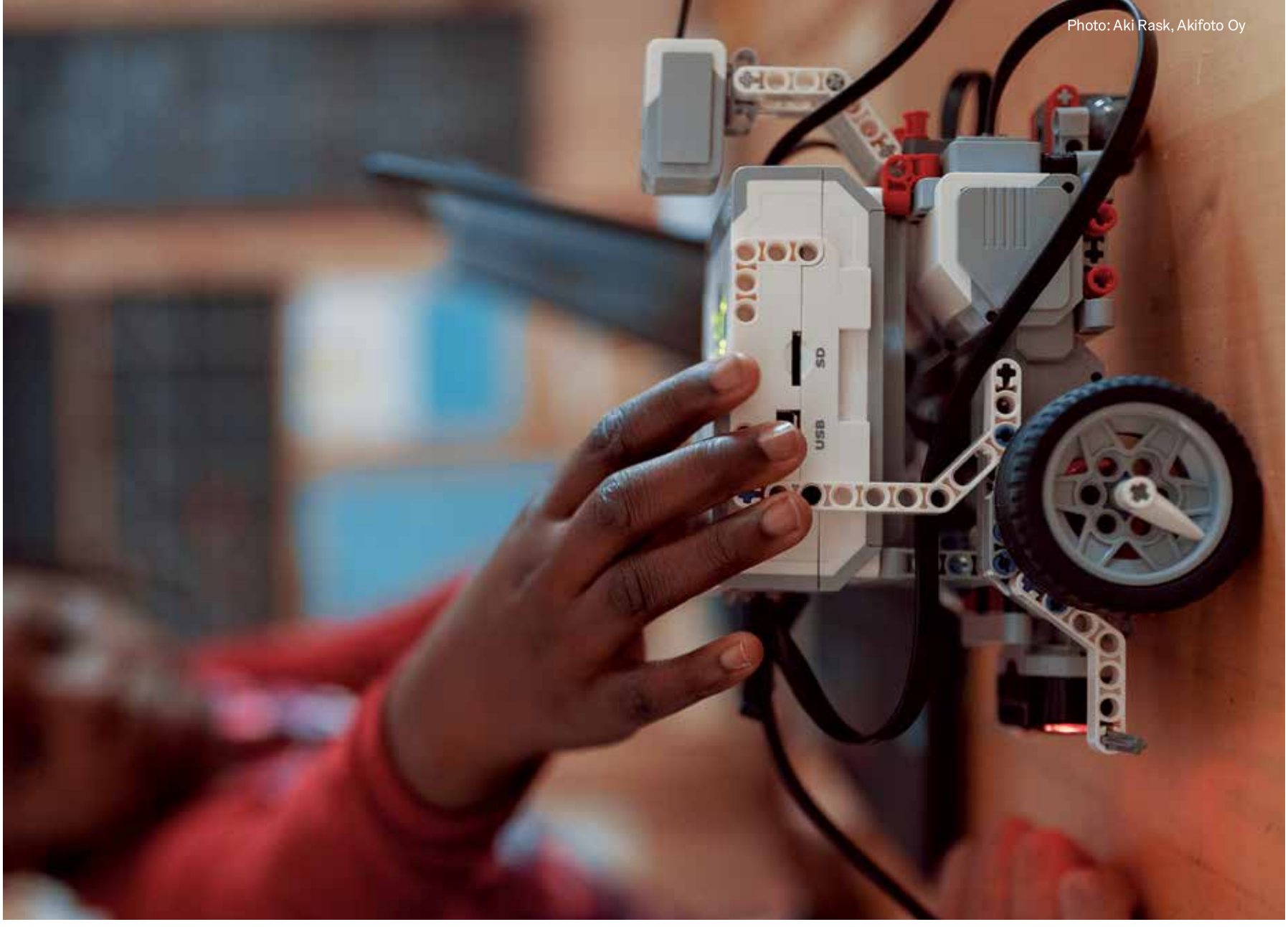


Photo: Aki Rask, Akifoto Oy

When you start on a new project:

- Think about what materials you will need.
- Which tools will you need for your work?
- Which skills will you need to execute your project?
- Whose help will you need? Who will help you, if needed?
- How much time will you have to finish the project?

Completed projects:

- Enjoy your success and the things you have learned.
- Go through the process with someone else.
- Explain to them where you succeeded and what you could have done better.
- Consider what you will do with your finished work.
- Think about what you could make next.
- Share your enthusiasm and success.
- Present your work to others or exhibit it. Finished works can help others come up with ideas.
- Respect the achievements of others. Do not touch the works of others without the maker's permission.

Cleaning the space:

- Tinkering leads to mess. Cleaning up is an essential part of any communal activity.
- Clean up after yourself after finishing work and maintain the space's general cleanliness.
- Take the extra materials and tools back to their own places.
- Help others with cleaning when necessary.

The teacher's role:

- A teacher is an instructor, a coach and a facilitator in a makerspace. Support the pupils' own ideas and help them realise them through discussions.
- Familiarise yourself with new techniques and project ideas through training and networks and online. Ask a friend, share your own competence.
- Teach new techniques.
- Start with small projects and techniques that you already know.
- If a pupil wants to take on a project for which they are not yet ready, guide them in the right direction. Assess the pupil's skills in relation to the skills required by the project. Assess the available time in relation to the time needed for the project.
- Share information, borrow devices, guide the pupils towards information sources: books, the Internet, other pupils...
- Inspire the pupils to speak about their own project.
- Demonstrate the meaningfulness of the pupils' work by encouraging, inspiring and coaching them.

Tinkering always results in something: laughter, friendships, memories, joy, failures, success and inspiration.

Ideas for tinkering

A boardgame

All pupils have experiences of playing boardgames and, when designing a game, the pupils can creatively utilise their own experiences and skills. A boardgame project can easily include practising handcrafts, a product development process, teamwork and problem-solving. Technology can also be incorporated into the game by, for example, building a die using micro controllers or designing the game tokens and printing them with a 3D printer.

How is it done?
Discuss different boardgame experiences together: What boardgame did you play last? What is your favourite boardgame, why? Who do you like to play with the most? What makes playing boardgames fun? Has someone played a lousy game? What was it like? What kind of boardgame would you like to play?

1. Topic of the game
Before starting the design process, discuss and decide on the topic of the boardgame. In some games, the story is important (e.g. Cluedo), while others have functional objectives (such as Jenga).

Design a topic, theme and story for the game. The game can be, for example, a space adventure, a treasure hunt or a fighting game.

2. The idea and goal of the game:
There are many ways to find the winner in boardgames: The winner can be the one who collects the most points, reaches the goal first or is the last one playing. In cooperative games, all players can play together to beat the game. Together, consider: What will the players try to do or achieve in the game? How is the game won or completed? How do you make moves in the game?

3. The game board
The game board may be visible during the entire game or it could be built during the game. Some games do not need a game board at all. Together, consider what your game board will be like: Foldable or in one part? Compact or perhaps three-dimensional? Does your game have a game board? (Only needs cards, dice, etc.) Draft the game board on paper first.

4. Implementation
What equipment is needed for your game? The amount of tokens and other parts vary in different boardgames depending on how moves are made and the game's goal achieved. Together, think about what parts your boardgame will need (cards, a die, money, game tokens, etc.) and design and create the parts and the game board together.

Materials: paper, 3D prints, cardboard, magazines, drawings, toys, natural materials, etc. The boardgame should have its own storage box.

5. Game rules
The rules will be developed and agreed together. When writing down the rules, keep in mind that they will change when the game is developed further. It has to be possible to play the game in accordance with the rules you have compiled. Consider what kinds of rules the other player will find easy to understand.

6. Testing the boardgame
In the testing phase, the game is presented to others and played together while thinking how it could be developed. When playing the game, it is often easy to spot problems in the game, for example with regard to the rules.

7. Final touches
After testing, the boardgame rules, the game board and the other parts will be finalised. A box will be designed for the game, and the recommended age of players, the number of players and the duration of one game should be written on the box, as well as the names of the game designers.

Green screen

Green screen technology is used in many movies to create various kinds of environments and backgrounds. It allows us to go places that are not otherwise normally accessible or do things that we would not be able to do, such as diving to the bottom of an ocean, going back in time, travelling into space, flying or transforming into a giant.

This technique is based on the monochrome background, which will be removed and replaced with the desired photograph or video. The background colour should not be one that is often seen in skin tones, clothes or other things in the video. Green or blue are often used as background colours, but white, black and brown should be avoided.

How is it done?
When working with a green screen, keep layers in mind. In a way, photographs and videos are layered upon each other. For the base layer, select the desired background image or video, on which the videos recorded in front of the green screen will be layered. The green colour of the screen will be faded out of these videos, and the resulting video and its background video will be linked as one film.

There are various programmes available for green screen work.

! Project ideas:

Space
1. Find an interesting fact about space in a book or online.
2. Select a space-themed background image for the green screen.
3. Film a video in which you read the information you have learned in front of the green screen, as if you were in space.

News
1. Draw or find online an image to use as the background image of your news studio.
2. Write or look for a piece of news that you can present on film.
3. Prepare the news studio for filming by finding a table and chairs.
4. Film your class news in your own news studio.

A living painting
1. Draw the frames for the painting and place them in the top layer.
2. Use the mask tool to make a hole in the middle of the frame.
3. Choose a background image and place it in the bottom layer.
4. Record the Living painting video for the middle layer against the green screen: the person to be filmed must first stay still for a moment, then move slightly and say something and, finally, become still again.

3D printing

3D printing has become more commonplace as the printers have been developed further and they have been bought for schools and libraries. Designing and printing 3D models is fairly simple and enables the user to design and customise their own, unique items. At the moment, industrial 3D printing works with many different kinds of materials, such as textiles, ceramics, various plastics, metal, glass and even replacement parts for a human body.

How is it done?
The pupils are asked questions about the topic: When have you made an item by yourself? If you could make any item you would like, what would it be? Have you been able to try 3D printing?

The teacher will present the stages of 3D printing: first a virtual model is created with a computer and then printed out as a physical object using the 3D printer. the 3Dprinter's nozzle will melt down the material and spray it onto the printing base, building the model on it as thin layers on top of each other.

The phases of 3D printing: modelling, slicing and printing
1. There are several free-of-charge programmes available for making 3D models. The modelling programme is used to create the desired model, which will be saved in the STL file format.
2. The models (STL files) produced with the modelling software will be opened in the slicing software which will transform the 3D model into layers for printing. There are several slicer programmes for 3D models available, most of them free. Settings will be determined for the software, according to which the item will be printed. For example, the following must be determined for the slicer programme:

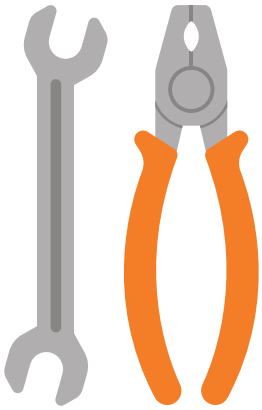
- Which printer is used? (print setup)
- Printing material
- Height of the printed layer
- Print speed
- Infill
- Any support structure (support) or attachment to the printing base (adhesion)

3. When the work has been determined, it will be saved on a SD card in GCODE file format for the 3D printer.
4. The file will be transferred to the printer on the SD card, and the work to be printed will be selected from the printer, which will then print it out automatically.

Tips for printing:

- Take into account the maximum size of the device's printing base. A large model can be divided into parts for printing with 3D design software and the parts can then be attached together after printing the model out.

- If the printer is poorly calibrated, the print quality may be poor. Practice makes perfect, even with calibration!
- Be prepared to spend a lot of time on printing.
- The different filaments have different properties, which affects factors such as the hardness and flexibility of the prints.
- Place the printer on a stable base somewhere calm. If the device shakes, it will affect the print quality.
- Spread some glue from a glue stick on the printing base to stop the work from moving. This will also make detaching the finished work easier.
- Support material is needed under layers that would otherwise be printed over thin air.
- Take into account the different printing temperatures of different filaments. If the temperature is too high or too low, the printing quality will be uneven.
- The printing base and the printer need to be cleaned after use. From time to time, the device should be maintained thoroughly. Cleaning and maintenance affect the device's service life and printing quality.



! Project ideas:

printed buttons for crafting, a piece of jewellery you've designed yourself, a logo or a text for a hat or a cap, fairytale figurines from your own story, a scale model or a key chain.

Projection mapping

Projection mapping is a technique that allows users to project animations, images and videos onto surfaces of different sizes and shapes using a data projector. With the help of an application, the parts onto which the image or video will be projected will be selected from the image area to be projected. The projected image can be edited to the desired shape and size. This technology is often used for making video art, decorating the facades of public buildings or creating video sculptures and illusions.

How is it done?

To use this technique, you will need a data projector, a tablet device, projection mapping software and a cable and adapter between the tablet and the projector.

The projection mapping technique can be utilised for decorating the school halls during celebrations, staging of plays, exhibiting art or crafts or making teaching livelier, for example.

! Project ideas:

Projecting onto balls

1. Coat a balloon by pasting strips of newspaper on it.

2. Allow the ball to dry and remove the balloon.

3. Paint the ball white.

4. Record a video of your friend's face.

5. Place the white ball in a place of your choosing.

6. Connect the tablet device to the data projector and start the projector.

7. Open the projection mapping programme, delimit the projected image area to the white ball.

8. Bring the recorded video into the marked delimited image area.

You can implement the project using several balls and projecting something such as planets onto their surface.

Design your own character, such as an animal or robot, and divide it into sections (e.g. head, torso, limbs) Implement the character using cardboard boxes of different sizes and use the projection mapping technique to project the different body sections.

Tinkering challenges

A challenge competition is a playful, voluntary and participatory competition where the pupils will be able to utilise their own competence and present their makes to others. The theme selected for the challenges guides the making, and solutions to it can be discovered alone, in pairs or as a group. The focus is on working together, learning and increasing the visibility of the pupils' competence.

Tinkering challenges should be held regularly, for example once a month or once during a term. This way, the pupils know how to better orientate themselves towards the work and the tinkering challenges become a natural part of school operations.

How is it done?

1. Present the tinkering challenge's idea to the pupils: What is tinkering and DIY culture and what kind of projects can be implemented?

2. The teacher will share the topic for the challenge, present the materials used for the implementation and explain the project schedule. At this stage, the teacher may share more details about which characteristics will be assessed in the challenge.

3. The pupils will plan a project that suits the theme and implement it. The project stages should be documented in an electronic portfolio, for example. It is important to share one's learning process with others: What did I learn? What was the best thing, what was challenging?

4. The finished works will be presented, evaluated and awarded. Celebrate the great results together! The works should be presented at the school's makerspace to inspire future projects, The results can also be presented on social media, during morning assembly, at the school's maker event or at the principal's invention reception.

! Challenge ideas:

- Completely cardboard
- Lego contruction
- Candy construction
- Toy upcycling
- Christmas card
- Microcontroller project
- Dream house
- Musical instrument
- Moving, dancing or cleaning robot

Appendix 1
Megatrend cards

(Photos: https://pixabay.com/fi/, https://unsplash.com/)

Inequality will increase

Virtual reality will be more common

Renewable energy will become cheaper

Climate change

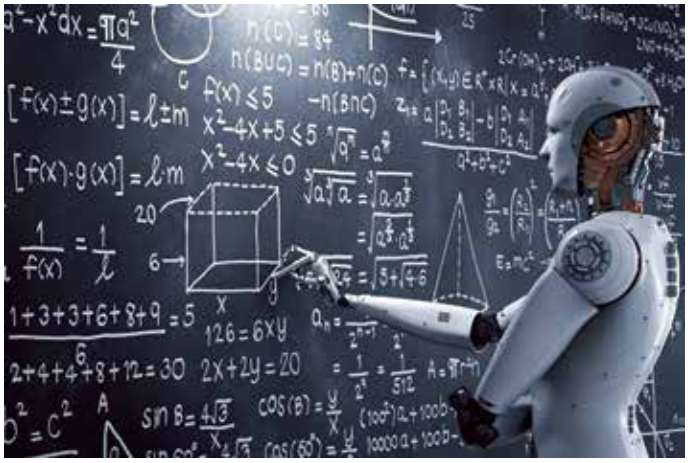
The number of refugees will grow and migration will increase

Robotisation

Smart goods will become more common

Sense of community and charity

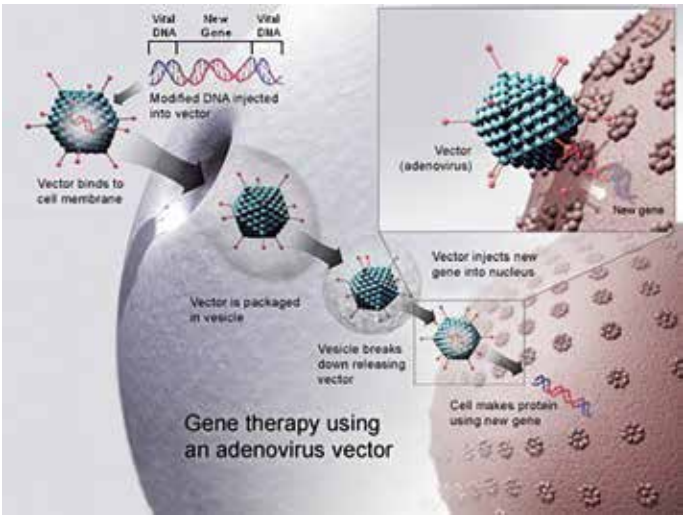
Culture of experimentation



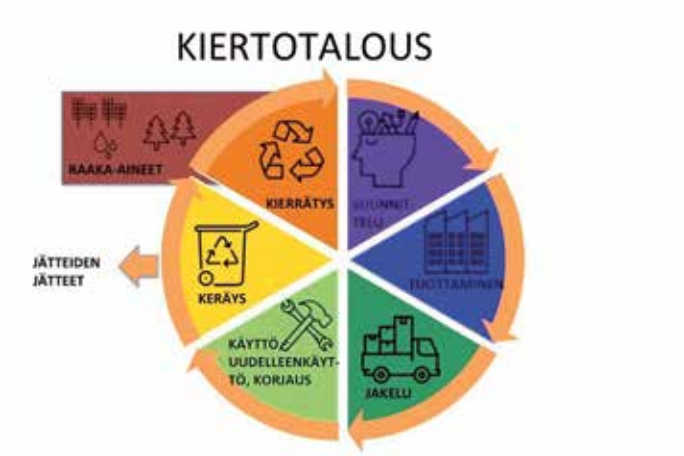
The use of artificial intelligence will spread

Global citizenship will be more common

Increasing life expectancy



Evolving gene technology



The significance of the circular economy will increase

Emphasis on health and well-being

Environmental degradation

Urbanisation will continue

Increasing importance of interpersonal skills

Appendix 2
Self evaluation

What new concepts/ideas did you learn about design?

What did your group accomplish today?

What could your group have improved on?

What changes did your group implement after receiving their feedback?

How would you rate the following aspects of the design workshop
(5: Strongly agree 4: Somewhat agree 3: Neither agree nor disagree 2: Somewhat disagree 1: Strongly disagree)

a) I worked diligently throughout the day	1	2	3	4	5
b) I got to share my opinions	1	2	3	4	5
c) I had the opportunity to put forward new ideas	1	2	3	4	5
d) I gave constructive feedback to others	1	2	3	4	5
e) I helped others to solve problems	1	2	3	4	5
f) I received feedback	1	2	3	4	5
g) I collaborated with others	1	2	3	4	5

Photos by:

Photo s.36: Akifoto Oy, Aki Rask

Photos s. 19, 24, 27, 28: Inkeri Halla-aho, Main interiors Oy

Photos s. 1, 5, 9, 13,15, 17, 29, 31, 35, 45: Jaana Brinck, Tuomas Hakkarainen, Virve Vakiala, Antto Wirman

Photos s. 46-49: https://pixabay.com/fi/, https://unsplash.com/

Sources:

https://www.instructables.com/class/Easy-3D-Printing/

https://www.instructables.com/contest/

http://www.doink.com/support

https://www.kasityokoulurobotti.fi/2018/12/videoveistos-projection-mapping/

https://makezine.com/ http://www.makerspaceman.com/ https://www.innokas.fi/

http://www.koodikoulu.fi/

https://www.wikihow.com/Make-Your-Own-Board-Game https://growingmind.fi/

Kiviniemi, Juha (toim.). 2019. *Maker-toiminta nuorisotyössä*. Helsinki, Verke.

Lang, David 2017. *Zero to Maker: A Beginner's Guide to the Skills, Tools, and Ideas of the Maker Movement* 2nd Edition. Maker Media Inc. San Francisco.