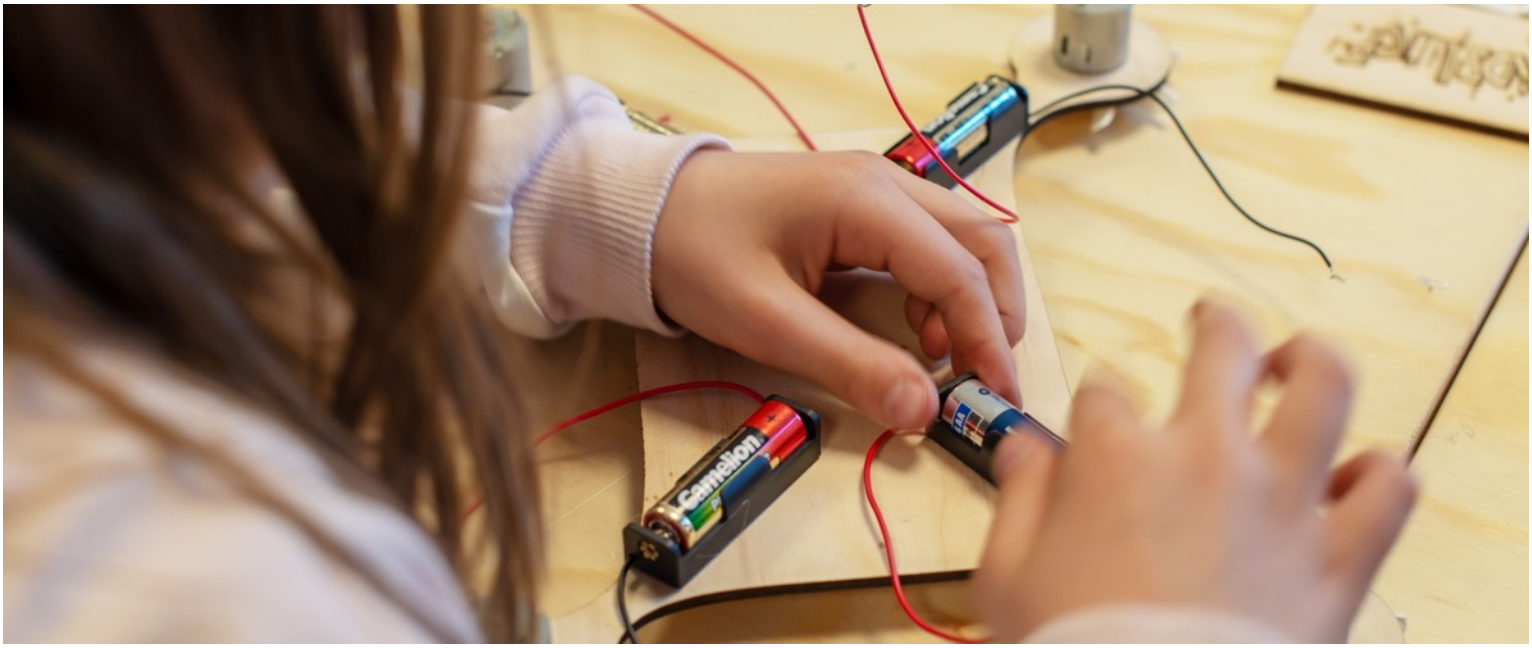
Entrepreneurial skills
for young social innovators
in an open digital world



Tool

FACILITATION GUIDE

prototyping with digital fabrication and electronics for 8 – 12 year olds

waag
technology & society

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Facilitation guide

prototyping with digital fabrication and electronics for 8 – 12 year olds

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Tested and developed during three iterations the program in Maakplaats 021, Amsterdam

This guide covers how to use prototyping in a design thinking context using digital fabrication and electronics for the age group 8 to 12 year olds. First step is an ideation phase in which divergent thinking is stimulated. Children explore a societal problem and come up with different directions of solving problems. After the exploration of different solutions, there is a convergent phase. Children will need to choose a solution and start prototyping, which means the children will have to narrow down and become more precise and concrete in their ideas.

There are two routes to take in this guide, route one is for children who find making desicsions and believing in their own choices during the prototyping phase difficult. This route will focus on coaching the children in these steps. The second route is for children who find the prototyping phase easier and have no problem in decision making, in this route the focus lies on deepening the concept and making design choices very consciously based on prioritization of the functionalities.

Before the prototyping phase, there should be a phase in which to explore a theme or a societal issue (e.g. sustainability). This exploration phase can be done by using the tool 'mapping of the problem' on the DOIT toolbox. During the exploration phase, different aspects of a problem or theme should be identified and broken down into smaller, clearly defined problems. When you have a problem definition, you can continue using this tool to ideate and prototype solutions.

Step 1: exploring different routes

This step is based on *Vakjesvel van Ontwerpen in de Klas*:
https://www.ontwerpenindeklas.nl/losseles/vakjesvel/

Let children ideate different solutions for a concretely defined problem. Formulate a 'how to question' for the problem. Give the children a large piece of paper with an empty grid with 12 fields. Children will sit in a group of 3 – 4 around a

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piece of paper. Each kid will draw (or write) at least one solution for the problem. After five minutes, give the paper to the next one. Children will get inspired by other ideas and generate ideas in different directions.

Step 2: pick a solution

Let each group of children decide what solution they would like to work out in a prototype. Let them decide which it will be. To help them choose, ask them questions on which might help them decide: What would be the best solution? What is the craziest idea? What is the most realistic idea?

Step 3: prototype a solution in cardboard

After they have decided on a solution to prototype, make very clear that the first prototype is an exploration and not the final prototype. By using crafting materials make a prototype. Provide a limited amount of material children can use. Children are free to choose their construction techniques and can use their imagination to add functionalities. This a phase in aims to come up with creative solutions and generate enthusiasm. In the next step children will narrow down, and are asked to prioritize functionalities, but in this step it is important be very affirmative and encouraging as a facilitator.

Children might ask for help to make their prototype. Try to let children do everything themselves, by explaining, demonstrating and let them repeat: If they don't know how to make a hole in a piece of cardboard, don't make it for them, but explain how it is done, demonstrate how to do it and let them repeat it in another piece of cardboard.

Materials that can be used are cardboard, paper, rope, plastic cups/trays and clay. Tools that will be needed are glue and a knife/cutter. It matters what kind of materials you provide. When you are designing for sustainability, use recycled materials. When you want children to focus on concept or functionality, rather than looks, it helps to use plain materials.

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Decide as a facilitator what route to take

Sometimes this step is already challenging enough. Children need decide **what** they are going to make as well as **how** they are going to make it. It might be the first time that they are in such a process and sometimes it is needed to slow down in this step and focus on decision making skills and encouraging to believe in their own ideas. On the other hand, if children find it easy, you can give them an extra challenge

→ Route 1

If children find the prototyping challenging, because of the decisions that need to be made and they look for confirmation that their choices are 'correct' instead of believing in the value of their own ideas follow route 1. Giving the children complete ownership of the process will take time and therefore we will not add extra steps, but stretch this step and focus on coaching the children in making choices and believing in themselves.

→ Route 2

If the children find the prototyping easy, they can make choices independently and are not afraid of making the wrong decision even though they might not know the outcome you can follow route 2. This will give the children an extra challenge in deepening the concept and they will start their prototype from scratch fully digitally designed.

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Route 1

In this route we will continue working on the first prototype and focus on enabling children to make choices in uncertain conditions. We will give the children the opportunity to add electronics, digitally fabricated technological parts and decorations to their prototype. They will have to decide themselves what they think is needed. The order of step 4, 5 and 6 could be swapped. It will be combined in the assembles prototype.

Step 4 - Route 1 – demonstrate and repeat electronics

When they have a frame or base for the prototype, you can invite them to add electronics to their prototype. As a facilitator, you demonstrate how to assemble the electronics. After that you take apart the assembly and let the children themselves repeat the technique. Now they have seen how it works and know they can do it themselves. Demonstrate, take apart and let children repeat the following techniques:

- How to connect a motor: ***https://www.youtube.com/watch?v=fG9RPoOJ5Gw***
- How to connect a LED light: ***https://www.youtube.com/watch?v=CGbdTv_fY4A***
- How to connect a switch: ***https://www.youtube.com/watch?v=zKqa363lSew***
- How to make a set of wheels: ***https://www.youtube.com/watch?v=hnhUKZVaAJE&***

Do not tell the children where to add the electronics in their prototypes. Now they know how the techniques work, they have to decide themselves if and how they want to use the electronics.

Step 5 - Route 1 – technical parts with digital fabrication

Some parts might be easy to make by hand, but simple to make with the laser cutter or 3D printer. For examples, wheels that are perfectly round and have the right diameter of the hole for the axle are difficult to make by hand, but easy to make with the laser cutter. If they are familiar with design software like InkScape or Tinkdercad they can make their own digital design.

If children don't know digital design software yet, and you want to focus on letting the children make decisions instead of learning software, let them draw it out on paper with specified dimensions and let them give you instructions on how to draw it. The facilitator will only follow the instructions of the children. If the instructions are not clear, ask for more precise instructions. Do not correct them if you know it will not work, but laser cut the 'wrong' part, so they can

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figure out themselves what should be different and give them the opportunity to correct themselves and cut out another part.

Step 6 - Route 1 – decorations with digital fabrication

Children might want to add decorations to the prototype. Of course, they can do this with materials like feathers, pipe cleaners, paint, etc. Offer them the opportunity to decorate by using digital fabrication. This can easily be done with the laser cutter for parts in wood or acrylic or use the vinyl cutter to make stickers. Let them make their own designs on paper by using a black marker. Do not let them download an image and cut it out, but let them make their own designs. They might be insecure about their drawing skills. Encourage them and give them some hints in they are stuck, but let them make the design themselves. The facilitator will scan the drawing and trace the outlines in the design software and cut out the part. Involve the children in the steps the facilitator takes, so they get a sense of how the machines work.

Step 7 - Route 1 – assemble the prototype

When the children have all the parts of step 4, 5 and 6, all that is left is assembly. This is the part where they might find out that things do not fit together or won't work. Give them time to figure out themselves what is the problem and if give them the tools to adjust. If a hole is missing in a laser cut part, you can adjust the design and cut is out again, or use the drill to make a hole. If they are stuck, try to identify the problem together by asking the child questions that will lead them in the right direction.
When the prototype is not finished before the end of the workshop, tell them that this is not a failure. Make them realize all of the things they have learned and let them present it as a work in process.

Step 8: Presentation

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Route 2

The next step after the initial prototype is to start over with a new, better version of the prototype which new materials and an improvement of the concept. It is recommended to keep the first prototype phase short and prepare the children to the fact that this will not be their final prototype, so they do not get to attached to this prototype, but see it as a step to the final prototype. The approach for the second prototype is to focus on functionality the design principle is form follows function. To know that the form will be, you have to know the function. That is why before starting to make the prototype, the children will first go back to their concept and define the functions. To do this we will use some design thinking tools.

Step 4 - Route 2 – personas

The first step after the initial prototype is to redefine the solution, but letting the children define who they are designing it for. Children in the age of 8 to 12 usually follow their own interests and want to make something for themselves. By letting them make a persona, they can make a solution that for someone else.

There are various persona tools available, we used this one in Dutch which has a canvas you can print out: ***https://www.ontwerpenindeklas.nl/losseles/persona/***

Step 5: Route 2 – requirements and wishes

The prototype for the solutions they have come up with will have multiple functionalities, in this step the children will prioritize the functionalities. First discuss with the children the difference between requirements and wishes. With a requirement you decide what solutions will solve the problem: the prototype must ... For example: the prototype must wheigh less then 3 kg. By defining wishes you can distinguish a more preferable solution over the other: the prototype may ... For example: it is desirable that the prototype is as light as possible.

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Source: *https://www.ontwerpenindeklas.nl/losseles/eisen-en-wensen/*

Step 6 - Route 2 – making 3D model of the solution

The next step is to make a 3D model of the solution in Tinkercad. They will take the shape of the first prototype as a starting point and in Tinkercad they will adjust the shape based on the specifications they have made during the personas and requirements and wishes. Now the cardboard boxes will take shape in the digital environment, and the children are not limited in shape by the materials that where available, but can decide on the best shape based on the functionalities they defined.

Step 7 - Route 2 – digital Fabrication, Electronics and assembly

Follow step 4, 5 and 7 from route 1. We skip step 6, there will be no decorations added, since we have followed the form follows function principle.

Step 8 – Route 2- Presentation

During the presentation, make sure also to exhibit the first prototype and not only the end result. By showing all the steps and make them visible in the space, the children can also explain the process and not only the final product.

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