Project Deliverable

Entrepreneurial skills for young social innovators in an open digital world

DELIVERABLE 2.5

REPORT ON ISSUES TO REACH SPECIAL REQUIREMENTS FOR SPECIAL TARGET GROUPS AND SETTINGS

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“DOIT – Entrepreneurial skills for young social innovators in an open digital world”
A HORIZON 2020 INNOVATION ACTION

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Description of the Deliverable

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Summary

Within our DOIT activities, we encountered several different target groups. In order to address them properly, we did an intensive literature research and questioned internal and external experts for their experiences and learned lessons. This work is a combination of these well grounded experiences from different sources and provides an overview of special requirements for the target groups. Our target groups include: young children, older children, within school settings, children from less privileged backgrounds, children with special needs, girls, children in rural areas, advanced young makers and social entrepreneurs. For every target group we identified specific needs, building upon on literature and project research, and give concrete recommendations on how to reach and work with these children. These recommendation includes existing one, building upon other projects and research similar to DOIT as well DOIT experiences from the pilot activities (mainly from phase 1). The recommendations can be helpful for all who addresses social innovation activities within makerspaces, but could be helpful maker education in general as well. Parts of this deliverable are or will be published, e.g. as practical advice within the DOIT toolbox.

Content

1. Introduction

DOIT is developing activities for social innovation in makerspaces with and for children from 6 to 16 years of age in various European countries. Within the group of children in this age group there are different needs. Within the framework of DOIT, we have set ourselves the goal of addressing the following special target groups in particular, involving them in our activities and gaining specific experience in the process.

These special target groups are:

- Children within (and outside) of school settings, whereas we see the school settings as the special variation
- Children with less privileged backgrounds
- Children with disabilities
- Girls
- Children in rural areas
- Advanced young makers and social entrepreneurs

We additionally see differences concerning the age of the children, so we added as well two chapters for our main age groups:

- Younger Children (6-10 years) - with a focus on the younger ones, 6 to 8 years
- Older Children (11-16 years) - with a focus on the older ones, 14 to 16 years

Within this deliverable, we want to present collected existing experiences with these target groups, as well as impressions and experiences we got from the DOIT pilots. We decided to focus on a presentation of these insides as recommendations for others, who plan to work in DOIT related activities within these target groups. This way of formulating and giving recommendation seems to be the most effective way to condense experiences for future practice.

2. Materials and Methods

To collect and present the needs of the target groups and recommendation to work with them on social innovation in makerspace settings, we did the following

- A literature and project research on the target group and their needs and potential recommendations.
- We asked experts from other projects as well as our own DOIT experts for their input and did several interviews and written request for statements as contributions for this report.
- An iterative approach to collect, aggregate, select the sources as well as the recommendations.
- We asked all our DOIT practice partner to review the deliverable, and discuss the given recommendation or add recommendations building their own experiences within the DOIT activities.

As DOIT aims as well to disseminate results through diverse channels, parts or variations of this deliverable are already or will get published as scientific and practice publications and added in the DOIT toolbox.

3. Special requirements for younger children (6-8 years)

“Rather than pushing children to think like adults, we might do better to remember that they are great learners and to try harder to be more like them.”
Seymour Papert, MIT Media Lab (Papert, 1993, p. 155).

3.1 Introduction and approach

Children in primary school, from about 6 to 8 years, are seldom involved in entrepreneurship education in Europe. But they need to develop "21st Century skills" to thrive in an ever-changing world. Looking at their needs, pedagogy will involve concrete activity, creating, working with others, analysing, presenting and sharing both the learning experience and the learned knowledge or wisdom. It is relevant to include sharing with peers, and using mentors as well as teachers. Especially the experiences and publications shared by the H2020 MakEY project were good sources for existing experiences (see https://makeyproject.eu/).

3.2. Needs of the target group and requirements

Especially the following needs of this younger target group were addressed and highlighted in the discussions:

Playful approaches and child-friendly narratives - Younger children are great learners, as in Papert’s citation at the beginning of this chapter. Of course this is not directly related to a school learning competence, but to their natural, playful approach to exploring the world (cf. Papert, 1993, Marsh et al. 2017)

Limitation in reading and writing - Not every child knows how to read and write at a very young age. If they can read, they are considered to be more independent from others and can better express themselves. This influences the usage of possible tools and materials, and strongly limits the handling of apps or programming with text.

Need to see and hear - It is difficult to teach younger children by simply talking about the steps that need to be taken as their vocabulary as well as their abstract thinking abilities may be limited (cf. Fleer 2000, p. 45).

Supporting teamwork skills development - Children in primary school are typically not very experienced in social competences and teamwork skills, although they love to explore the world together (cf. Marsh et al. 2017).

Foster creative chaos and uncontrollability - In the formal education system, children are often restricted in drawing their own creative and spontaneous resources and generating further knowledge from this (e.g. strongly controlled learning also in the field of arts education, limitations due to a strong focus on spelling and correctness in expression).

Support in time management and task management - Younger children have no control over their time or an understanding of how long each task will take),

3.3 Recommendations from existing literature and practice

There are several suggestions and recommendations to find in literature.

Provide playful instruction - A fitting approach is to show younger children examples of how to do things and then let them work themselves (Blackley et al. 2018). Children need a challenging and rich environment where they are motivated. They are naturally active and therefore are perfectly prepared for a makerspace setting.Tutors should motivate the children to go on with their work and give help when asked for it. Play and learning should not be treated separately, but as interconnected (Samuelsson & Carlsson 2008, 637f., cf. Marsh et al. 2017).

Support collaboration and team work - Especially younger children are not always experienced very well in collaboration and teamwork. Within an Italian project, "La Tata Robotica", this is directly supported by a limitation of the material (see box below), as Enrica Amplo described in her presentation in a workshop on learning in makerspaces organised by the EC in May 2019 (see box below).

The art of sharing

Sharing is not easy, both for adults and children, but so important at the same time, because it reminds us that we are part of a community. And we can live in a more sustainable and responsible way.

Sometimes there are not enough tools for children, but the material can be limited on purpose to train what I call the "art of sharing": children will be lead in asking "please" and replying "thank you". They will learn to wait and be patient.

Be prepared! You could probably meet disappointed parents, teachers and children. Gently explain to all of them that most importantly, we have TIME. So we can share tools and materials, we can wait and we can be kind.

Remember! You (tutor/teacher/facilitator) are a role model for them. Be patient, be kind, do the same you are asking the children to do, with them and with your colleagues and adults as well.

Besides the advantages in training soft-skills, sharing the materials is also a way to raise awareness. Seeing that materials and tools are limited will make them think about the importance of understanding how to manage them. They will learn to take only the amount of material they really need, without wasting it.

Figure: Photo of Enrica Amplo, STEAM education specialist and consultant, mechatronic engineer and Kids and Toy designer, founder of La Tata Robotica (latatarobotica.it). Enrica combines her different passions to engage in a creative and aware way, both kids and teachers in STEM. Her motto? "Think with your hands, do with your mind".

Photo/Figure Source: E-Mail to authors

Choose the right digital tools and methods - Jammer & Narr (2018) published a handbook for making with kindergarten children. The authors suggest to start early with the introduction to topics such as electricity or programming. They argue that the ability to understand is more important than knowledge itself, but that it is being neglected. Therefore, children can gain useful insights from constructing and deconstructing devices themselves. In

order to practice said activities, the authors provide the readers with step-by-step instructions on experiments with Makey-Makey and electricity. The experiments with basic materials are fit for beginners and kids aged 4 and above. Group activities enable collective learning and testing of electrical conductivity (cf. Marsh et al. 2017).

Wiggle bots by 5 and 6 years olds?

In a study 291, kids from the ages 5-6 and 10-12 in Indonesia made wiggle bots in a workshop at a makerspace. Previously to the workshop they were taught about electrical circuits in school. Then the children were shown a functioning wiggle bot. Afterwards they had the opportunity to make their own one, but did not get instructions. This open setting was experimental as the facilitators wanted to test how well the students could use their limited knowledge and make a working wiggle bot without further direction. By trial and error the kids tested the materials and made their bots work, which was a success. Almost all children perceived the activity as positive, 98% liked it and 99% understood that they used scientific knowledge to build the wiggle bot. They also felt more confident with science and making their own products in a makerspace. During the process, they learned from each other and answered that they now understand science better. The study showed that small children are able to use basic materials to construct their own working electrical circuit. It seems that the open approach with learning from trial and error was an effective strategy to involve every child in a meaningful way.

Source: Blackley et al. 2018, p. 27ff, p. 30ff.

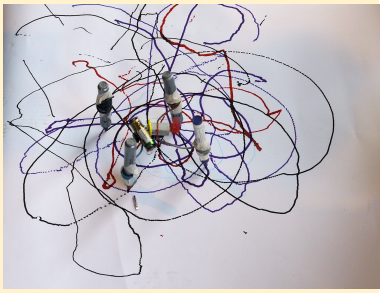


Figure: An elaborated wiggle bot drawing with its feet (“Bibberich”), Source: Schön, Ebner & Narr (2016)

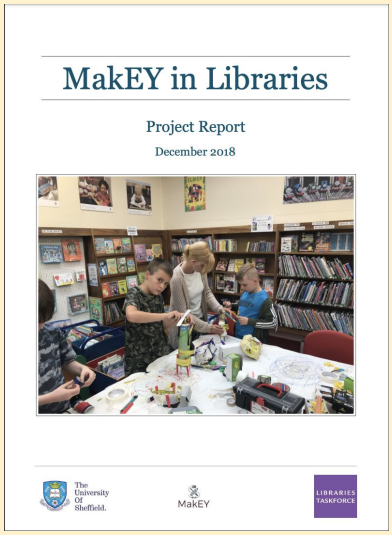
Explain the connection between sketches and objects - In the idea creation process, it can be helpful to draw sketches first and/or build cardboard prototypes . However young children have difficulties to understand the relationship between a sketch and the physical product. This is because teachers often do not teach the use of drawings for expression, but merely for art (Fleer 2000, p. 46). If sketches are used, the teachers should explain the connection between a sketch and an object and demonstrate it once. Then the children may build a 3D object out of paper to get used to the principle. After understanding the principal, children can be taught about the steps in a design process, for example starting with a drawing for the prototype. (Fleer 2000).

Rise attention with interesting topics - The tutors sometimes need to remind the children of the focus of a certain work, because they easily get distracted (Samuelsson & Carlsson 2008, p. 626ff.). For children to learn something, it is crucial that the topic has personal meaning for them (Samuelsson & Carlsson 2008, p. 635f). When working with young children, it is important to understand, what topics interest them and what their reality looks like.

MakEY Insights: Main findings in making with young children in libraries

- Let children explore new materials through play
- Encourage children to continue working even if something does not work
- Have enough staff (volunteers or professionals) and train them well for the interaction
- Kids want to take their products home, but that is not always possible, because the materials are needed for the next workshop or it is a joint work of a team
- Libraries are a good place to provide makerspace education for young children (public, safe...)

Source: Chesworth, Marsh & Nutbrown 2018, Figure (right): cover of the report



3.4 Recommendations based on DOIT activities and experiences

Already in the first practice partner meeting im Billund (February 2018), some partners collected ideas for maker tools that fit well to the youngest group of participants.

Use tools where the kids do not need to read - There are several maker ideas and tools available, where the need to read or write is not given - or very small. Within the first practice partner meeting in Billund, February 2018, the partners collected some activities which meet these requirements, it includes:

- Producing short videos, especially stop motion apps, to show and explain ideas and prototypes
- Drawing paper sketches or as well online sketches for cookie caster as first experience with 3D modelling and 3D printing (cookiecaster.com).
- Making sketches of "dream places" such as the "perfect playground" or "my classroom" on special paper that allows to get a digital 360 degree image (panoform.com)
- First tinkering with LED and electronic circuits using copper band as well as LEDs.
- Last, but not least: cardboard prototypes with hot glue, crepe tape or normal glue and the help of a lot of clothespins

Provide more facilitators, if the children are younger - Within our practice partner days, partner shared the experiences, that younger children need a lot more support by facilitators as their manual skills and experiences in crafting and tinkering are sometimes low. In order to avoid situations in which individual children could experience a high degree of frustration, because they (still) find it difficult to work manually, greater support is necessary, especially for younger children. Younger children need more support in project management - when do you do this, when do you start with that... A care ratio of up to 1:3 for children from 6 to 8 years, when using scissors or glue and colours, seems appropriate.

Plan physical exercises and fun activities - Especially for the younger children, physical exercises or activities should be carefully planned. A competition on how far a new product can fly, drive, a wake-up dance in the morning and a ball game in between can bring in such activities.

Co-design your code of conduct - Within DOIT we see it helpful to develop and agree upon a certain way to work together with the children of all ages - this includes, although such approaches are not very spread - the early age group as well. Plan a certain time or activity to discuss and modify your rules for your common work. You will see, the children know how to work best and in a joyful way together.

Take and share photos of results - Especially the younger age group want to show their parents and families what they did. If the products cannot be taken home - because it is a joint work - then we recommend to take and share or as well print photos. This can include some written text about what was done, so that the parents are able to understand what was the issue, especially if new technologies were used, where the parents eventually are not aware of (e.g. production of a stop motion video, 3D printing).

Topic needs to be connected to the children’s life - Provide a challenge which is very practical and connected to the children’s life. Your activity should not be abstract or only vaguely related to the current situation. It should not be about how to have cleaner parks in general, but to have a clean schoolyard. It is not about producing healthy food, but to develop a healthy product for the own youth club. This avoids frustration.

3.5 Summary

To sum up, the following illustration lists the identified needs of the target groups of young children from 6 to 10 years within activities on social innovation in makerspaces, as well as all recommendations, including the ones which we have found in the literature or derived from it, and on the experience of DOIT practice partners.

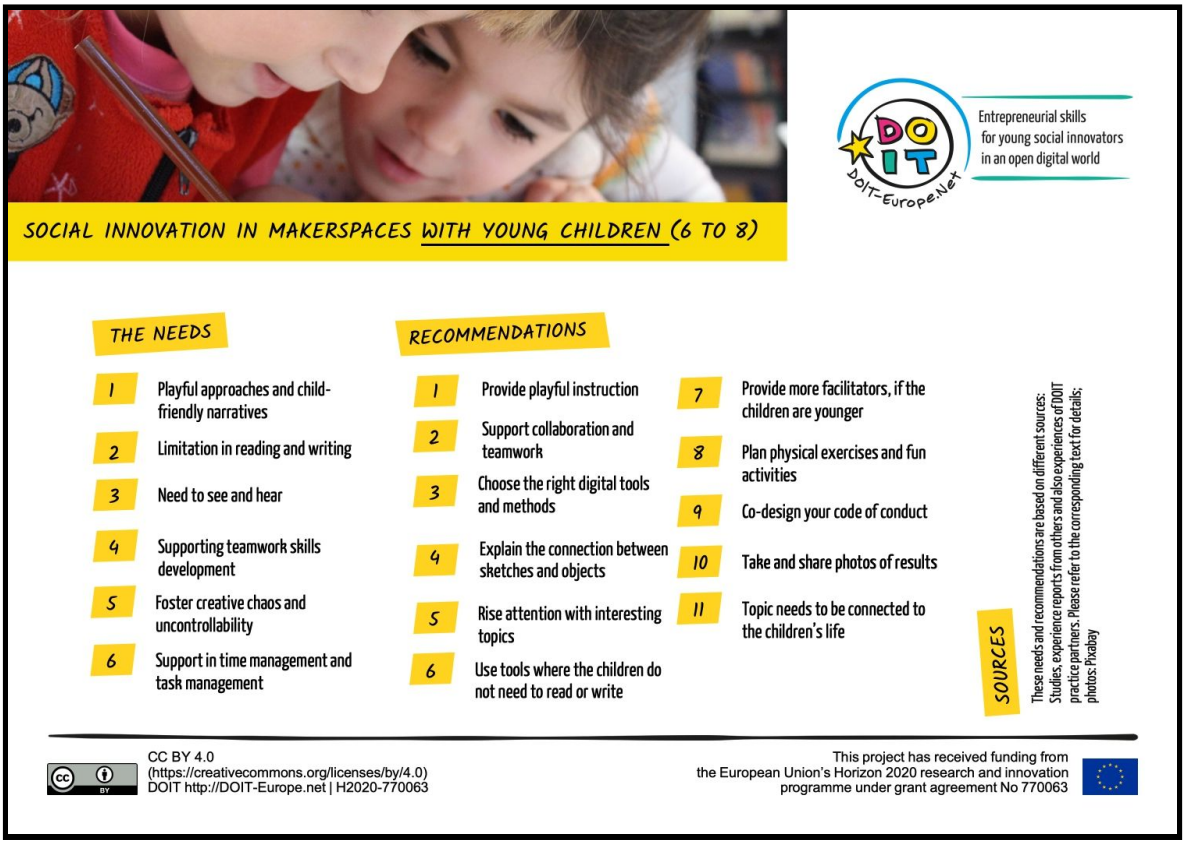


Figure: Overview of needs of young children (6 to 8 years) and recommendations for social innovation in makerspaces

3.6 Literature

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4. Special requirements for youth (13-16 years)

“Young people today have lots of experience ... interacting with new technologies,
but a lot less so of creating [or] expressing themselves with new technologies.
It's almost as if they can read but not write.”
Mitchel Resnick, MIT Lifelong Kindergarten (Resnick 2012, minute 4:14)

4.1 Introduction and approach

Older children are experiencing severe changes both physical and mental. With the change from childhood to adulthood, different wishes arise. Therefore, we need to address them differently than younger children, taking their daily life into account.

4.2 Needs of the target group and requirements

What do teenagers especially need? In the following we have selected key needs.

Adolescence as a time of changes - There are some challenges in the transition from child to adult. Adolescents have a variety of specific needs: although the following needs were always there, adolescents now needs to get acceptance as adults, and as well to self-expression. For some, these years as well is the ”beginning of a downward spiral in school-related behaviors and motivation that often lead to academic failure and school dropout” (see Eccles et al., 1991, p. 521). (CF. Roth & Brooks-Gunn 2000, p. 4).

Need to belong, need to master, need to be independent and need to be generous - These are the needs listes by IOWA State University (2018) for adolescents.

Different needs depending on culture and neighbourhood - depending on their culture and peer groups, young people may have a variety of different needs. In some communities it is of great value to show physical force while in others, mental abilities may be the key factor (UNFPA 2007, p. 14)

4.3 Recommendations from existing literature and practice

Build alliances with youth networks - Reach youth through youth networks, as you may notice that adolescents are already engaged in meaningful activities. These networks may have good access to youth and already have rich experience in working with them. Learn from each others' experiences to enhance the work (UNFPA 2007, p. 39).

Educate youth to teach other youth and provide team work - When youth teach each other, they better understand the topics and concepts that are and feel acknowledged by others. This promotes self organisation and strengthens the possibility to learn by teaching, which includes acknowledgement of own competencies (cf. UNFPA 2007, p. 14)

Be culturally and socially sensitive - young people are exposed to partially contradicting values and belief systems, understand what their internalized values are and support them to use the positive aspects of their culture in their advancement. Prepare for different needs and adapt the programme accordingly. Youth are diverse in their

needs because of their neighbourhoods, families and backgrounds. Special target groups could be out-of-school and unemployed adolescents, which could be a topic in future research (UNFPA 2007, p. 15).

Establish a welcoming and encouraging learning environment - Adolescents have a variety of different needs which can’t all be addressed in a makerspace setting. For example sexuality is often difficult to include. Thus the institutions set a specific focus on a topic of their choice. For example Murray & Rosanbalm focus specifically on self-regulation as one of the main goals when working with adolescents. They argue that self-regulation is an important factor for wellbeing in life and needs to be developed early on (Murray & Rosanbalm 2017). Others focus on establishment of rules of good conduct and to generate a respectful environment through leading by being a role model (Roth & Brooks-Gunn 2000). Opportunities for peer work in general supports the establishment of trustful relationships, among peers and facilitators. Besides the family, peers are becoming more important during adolescence and can deeply influence the behaviours of youth. Young adults do not trust blindly, it is therefore important to spend time with them and prove that they can rely on the facilitators (Roth & Brooks-Gunn 2000, p. 5), which shows the importance of closeness, communication and engagement.

The ideal adolescent workplace

would offer youth the chance to

- WIDEN their horizons, particularly in terms of future careers, develop
- ORGANIZATIONAL skills, learn about
- RESPONSIBILITY, and gain valuable
- KNOWLEDGE.

Source: Roth & Brooks-Gunn 2000

4.4 Recommendations based on DOIT activities and experiences

Within the DOIT activities, we have seen certain challenges and possibilities to reach and work with adolescents in a friendly and effective way.

Co-design activities concerning their interest. A meaning for them is a must for active contribution. As freedom at work could lead to absence periods and lack of activity, a public presentation of the results could motivate to stay and contribute in an appropriate way as well.

Plan activities with schools to reach older adolescents without prior interest - Concerning our experience, it is typically not possible to reach a teenager for a makerspace or DOIT event on a voluntary basis, if it is not an existing interest of them. Therefore a school setting, where a complete class is involved, is a possible solution.

Use the chance for school underachiever - a DOIT and maker activity is a great opportunity to show potential of some school underachievers.

DOIT experiences

DOIT facilitators from DOIT pilot activities shared similar stories concerning surprised teachers who got to know some of their students from a new angle. Students who were otherwise rather bad, presented themselves in makerspace as good inventors or organizers.

4.5 Summary

To sum up, the following illustration lists the identified needs of the target group of youth from 11 to 16 years within activities on social innovation in makerspaces, as well as all recommendations, including the ones which we have found in the literature or derived from it, and on the experience of DOIT practice partners.

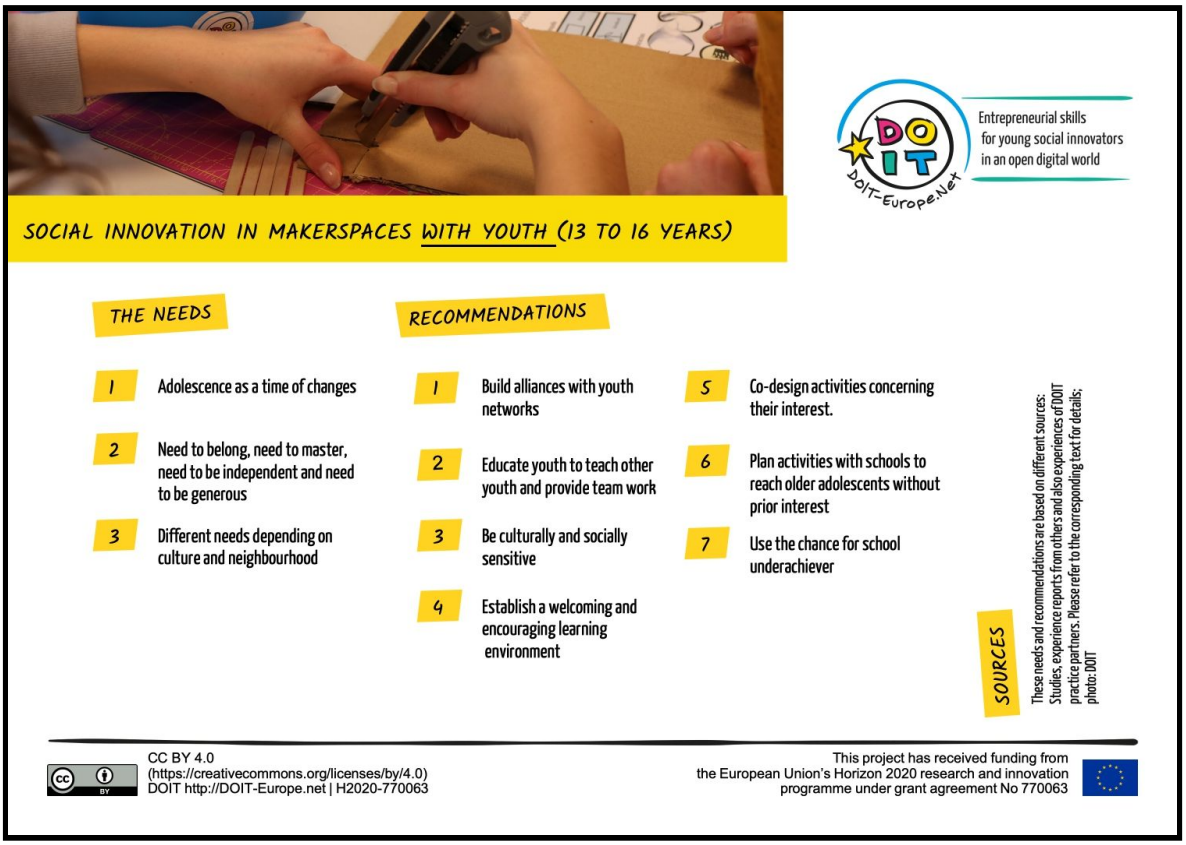

Figure: Overview of needs of youth (13 to 16 years) and recommendations for social innovation in makerspaces

4.6 Literature

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5. Special requirements for children within school settings

“To run a makerspace in a school, you have to ‘un-teach’ parents and teachers”
Marc Teusch, BEEcreative (Luxembourg) at an EC workshop on makerspaces for learning, May 2019

5.1 Introduction and approach

Children in schools are typically easy to access, if the schools allow cooperation. Nevertheless, children within the school system could show a different behaviour as they would do outside the school. For this chapter, we discussed our lessons learned at our practice partner day in Vienna (February 2019). The DOIT pilots in schools shared the impression that it is really a challenge to build a real makerspaces setting and situation, especially and more challenging in traditional, teacher-focused classrooms. We did additional research on existing experiences from others, especially concerning the makerspaces in schools.

Please note that we address requirements for children outside school settings within chapter 7 for children with less privileged backgrounds. In outside school settings, children might be participating because of their parents’ support (primary level) or friends/peers (secondary level) which can influence the activity.

5.2 Needs of the target group and requirements

Traditional schools do not fit to Maker Education and needs to be prepared and adjusted - Schools all over Europe have diverse teaching issues and structures, especially concerning ICT (European Commission, 2019), where ICT usage in the classrooms is only common in Northern Europe nations. Very general within most of the national systems and schools, the following characteristics can be found:

- The day is structured by schedules for whole groups of children (classes).
- The prescribed learning material is distributed among school subjects and school materials (curricula).
- Teachers are experts in the field they teach.
- Tests, grades and assessments are routine.

Against this background, a makerspace setting as proposed in DOIT is a challenge for most of the schools as well the pupils as they are not familiar with the characteristics of maker education. These are, e.g. failing forward, self-organised learning, teacher as co-designers, peer learning etc. (see Schön et al., 2015).

Pupils are typically new to makerspace setting and need to be introduced to it - From the perspective of the children, this requires especially the need to clearly introduce the new setting, its rules and practices. Beside the pupils, it is important that all relevant stakeholders - especially the teachers as well as parents are aware of this different learning setting (cf. Schuldt & Mumenthaler 2017).

5.3 Recommendations from existing literature and practice

The existing literature on makerspaces and making in schools very often focus on the spaces, the needed materials, the funding, and other practical issues which are not directly related to the children’s needs. For the following suggestions and practical needs, we used the following studies and literature: A Swedish large-scale study on making in schools, where 1.350 individuals and 100 schools were involved (Eriksson et al., 2018), a study about the effects of documentation on students progress (Schroeder-Yu, 2008), a literature review by the MakEY project (Marsh et al. 2017), as well as other publications on makerspaces in schools (Egerton Center & MIT 2019; Martinez & Stager 2013, New York Hall of Science 2013, MakerMedia 2013).

Develop a concept for your makerspace - Recommendation for the implementation of a makerspace in a school can be found, amongst others, in a publication by New York Hall of Science (2013). These considerations help to develop a first draft of a concept.

- What is your target audience? (boys, girls, age group, skill level...)
- Financial model? E.g. Sponsorships or funding from the government
- Finding a place (unused building in close proximity to the school, the basement),
- Finding a format for the makerspace (open, closed, workshoplike, after-school, regular meetings, special events, summer camp, different classes taking place there (in-school),
- Content: decide if you want to address different areas or just one theme
- Get mentors/volunteers
- Celebrate student achievement and evaluate success (children can teach others, make online portfolios where each kid documents their progress)
- Constantly adapt the place and the programme to the target audience (and with them) (Take surveys and feedback at the end to enhance the programme)

There are different possible functions as well as usage of a makerspace in schools.. Edgerton Center & MIT (2019) named the following function in a school, which should be clarified in a concept as well:

- Academic class support: Serves as a resource for enriching, engaging activities that serves many students and teachers
- Student projects (for classes, clubs, teams, personal, etc.): Opportunity for students to work together in a space on projects that they likely could not do outside of school.
- Competitions: Allows students, teachers, and parents and community members to work together in a shared space
- Camps: Can bring in funds and make use of the space at times other than regular programming
- Gathering place: Provides a safe, inspiring space for students to be during free periods or before/after school
- Community space for various gatherings: Provides a valuable space for community gatherings of all types, increases visibility of the space, can bring in sponsors and ideas for more community events

A concept as well can define different educational settings as defined by Martinez & Stager (2013, p. 65):

- Specific concept (gears, friction or multiplication of fractions)
- Thematic project (build something that actually exists,
- Curricular theme (find a problem and build a prototype for the solution)

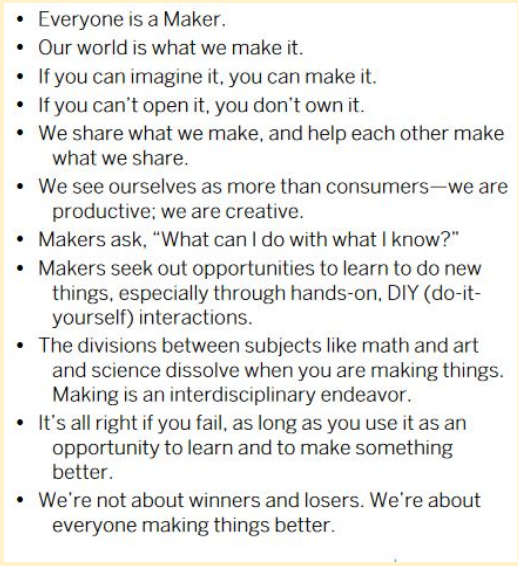
- Freestyle

Organise and prepare the infrastructure - MakerMedia (2013) are one of the sources which describes how to plan and organise a makerspace in a school. The recommendation includes for example:

- Location: unused rooms can be used for the makerspace, also art rooms may easily be transformed into makerspaces
- Creative environment: plan for group work and individual work, with open areas with large tables and small secluded areas for single children, include common areas for relaxing and informal conversations
- Offer different tools and materials and make them easily available
- Have space for showcasing of products and progress
- Have enough shelves, cleaning tools and rules of conduct to keep the place in order
- Safety signs and access to fire alarm and fire extinguishers should be easily accessible as well as first-aid kits
- Have wireless internet accessible for all participants,as they may want to look something up on the internet and it may be needed for some tools
- Have several electricity points available through out your makerspace as students may want to bring their laptops or charge machines
- Furniture can partly be self made (such as workbenches, shelves...)
- Tools: It is not necessary to buy a lot of materials, think instead about what kind of work you want to do in the room and what kind of tools are required for it, is it possible to make the tools yourself? Can they be made out of recycled materials? Calculate the budget with one time expenses (cost of machine) and ongoing expenses (electricity, expensive parts, maintenance). Get general equipment before considering the purchase of a very expensive machine. Some tools can also be rented from private people or other makerspaces. Consider buying used tools or find a sponsor. Every tool should be labeled with its name and proper use. (just in time purchase, beg and borrow, secondhand, buy in bulk, open source)

Foster the right learning spirit - Beside the infrastructure, the right mind-set and usage of the makerspace must be introduced, e.g. with challenges and trainings or the development of an own maker manifesto. Regular feedback session could be implemented as well (MakerMedia, 2013). Be patient, listen, treat kids respectfully, be reliable, discover and innovate together (MakerMedia 2013, p. 59).

Maker Manifesto



- Everyone is a Maker.
- Our world is what we make it.
- If you can imagine it, you can make it.
- If you can't open it, you don't own it.
- We share what we make, and help each other make what we share.
- We see ourselves as more than consumers—we are productive; we are creative.
- Makers ask, “What can I do with what I know?”
- Makers seek out opportunities to learn to do new things, especially through hands-on, DIY (do-it-yourself) interactions.
- The divisions between subjects like math and art and science dissolve when you are making things. Making is an interdisciplinary endeavor.
- It's all right if you fail, as long as you use it as an opportunity to learn and to make something better.
- We're not about winners and losers. We're about everyone making things better.

The maker manifesto at the left side could be used as a first step in the development of own rules of conduct.

Source: MakerMedia (2013)

Implement teacher training on maker education and your makerspace. There is a big need to educate and train the teachers, especially for their new role (see Eriksson et al., 2018). Schroeder-Yu (2008) suggests that teachers who want collect experiences should take photos of the steps and works of the student (p. 133f).

A practical advice: Teachers should take photos!

Teachers can learn to see the process of their students by documenting their steps, e.g. via pictures, text or observation. This also shows respect for the children's work. Schroeder-Yu suggests documentation of process for several reasons:

- the progress can be shared and can help others
- the participant is valued and respected
- teachers learn to see how their students work
- Teachers can point out “teachable moments” to their students
- the findings can be evaluated and can contribute to the scientific field

Source: Schroeder-Yu 2008, p. 133f.

Adapt the school concept and/or curricula - Very often, the concept and ideas of making and maker education does not really fit to the practice in schools, because it is project-based, not directly related to a curricula topics and interdisciplinary. Maker Education must be integrated into the curricula as well to the school concept so that it can actually be used in everyday school life. (see e.g. Erikson et al., 2018)

5.4 Recommendations based on DOIT activities and experiences

Within DOIT, we did not focus a lot on the makerspaces as a space, but more on the new setting. We see the need that children within school settings see, feel and experience the makerspace situation. This is especially important, when maker education settings such as project work, self-organised learning or peer tutoring is not a daily issue within the classes and schools.

Within a DOIT practice partner meeting, and as well in a DOIT online interview with two of our experts, Kristijan Tkalec from BioTehna in Ljubljana (ZAK, SI) and Roberto Vdovic from the University of Zagreb (UZAF, HR) highlighted their lessons learned and recommendations on how to introduce the maker concept wisely.

Re-conceptualize the classroom as a makerspace. If possible, choose a room that is closest to the ideal makerspace (a workshop room or an art room, if available). If you use a regular classroom, completely change the structure. This includes the following:

- The tables and chairs should be taken away or should be set up in a completely different way; in the best case, for example, the chairs should not be used at all.
- The facilitators should not use the blackboard to show something, but should introduce themselves from a non-typical direction a teacher would not use (e.g. the back of the class)
- Kristijan Tkalec, for instance, just took away all the tables and chairs and sat down on the floor with the kids - demonstratively showing that he is on the same level and the setting is very different to what the children are used to.
- Within an online interview, both DOIT experts state that the main aim of the facilitator is to build a space for creativity. It is this makerspace setting that encourages ideas and makes coworking possible, which is more valuable than expensive machines.

DOIT Insight: Turning the familiar upside down

Kristijan and his team experimented with different approaches to change the classroom environment into a makerspace setting. What worked best was a rearrangement of the furniture in the room: At the beginning, they pushed all desks and chairs to the side and made room in the middle. There they all sat down, children and facilitators alike. This physical change resulted in an environment, where children and facilitators can interact on the same level. This different structure irritated the kids at first, but brought them out of the classical school setting, where one teacher stands in front of a class.

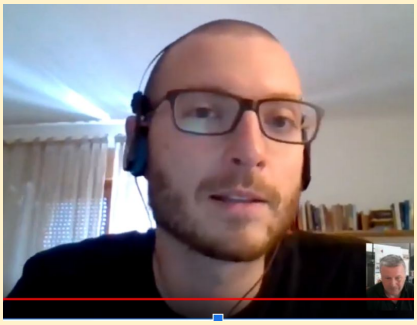


Figure: Kristijan Tkalec from BioTehna in Ljubljana (ZAK, SI) sharing his lessons learned in a DOIT online talk (July 2019)

Introduce the (new) practices in a makerspace to children - Make the new agreements clear. The children can decide for themselves, have a say and in the best case have not been forced to participate, but can also go for alternative activities. This, as well, needs the inclusion of the children in the planning of the workshop. If it was not possible to include the kids directly, Kristijan's advice is that facilitators should step into the children's shoes. It is

important that the workshop fits to the children's point of view, for example to have fun elements also. The facilitators also need to constantly develop new material and work on their attitude of openness.

Not directly concerning the target groups of pupils in schools, the DOIT pilots clearly shown the following.

Be aware that the makerspace can be a chance to show unseen potential of pupils - Last but not least, underachievers can be great makers, and maker education and DOIT brought such unseen talents on the table in several of the pilots.

Prepare the teachers and parents - As the new setting in a regular classroom or school is new for the teachers and parents as well, information and eventually a short training is helpful to prepare everyone for the challenge of starting to work and learn in a makerspace. A rule which originally was shared as practice in the German “Jugend hackt” facilitator trainings is to “Never touch a children’s thing without asking”. Especially with younger children, adults tend to just take over and help - but forget about the children autonomy as a maker and co-designer. Therefore, the Salzburg pilot as well shared this rule within a short facilitator training in preparation of the first pilot. What is important to understand is: (a) Teachers are no experts, but co-designers, (b) Failing forward - failing is okay and possible, (c) Use Internet for help - it’s allowed! (d) Adults should be role models for self-organised and peer learning and being curious, unsure, etc. DOIT experts shared experiences that some teachers are sceptical and at first lack trust in their students. The new open situation may seem unstructured and chaotic, but at the end everyone is surprised at what the kids have accomplished. In DOIT, it turns out that children are more capable than some adults expect them to be. The open setting helps the young participants to establish and follow their ideas instead of being pushed into a certain direction. That way, they can grow and work together to build something, which has great value for them and their environment.

Build and establish cooperation with makerspaces and makers - This recommendation is practically one of the biggest barriers for schools, which did not have teachers who are curious and interested in making or do not have a fitting equipment. DOIT partners and its network seen these cooperations to crucial, that this was addressed within DOIT’s first EC policy brief.

5.5 Summary

To sum up, the following illustration lists the identified needs of the children in school settings within activities on social innovation in makerspaces, as well as all recommendations, including the ones which we have found in the literature or derived from it, and on the experience of DOIT practice partners.

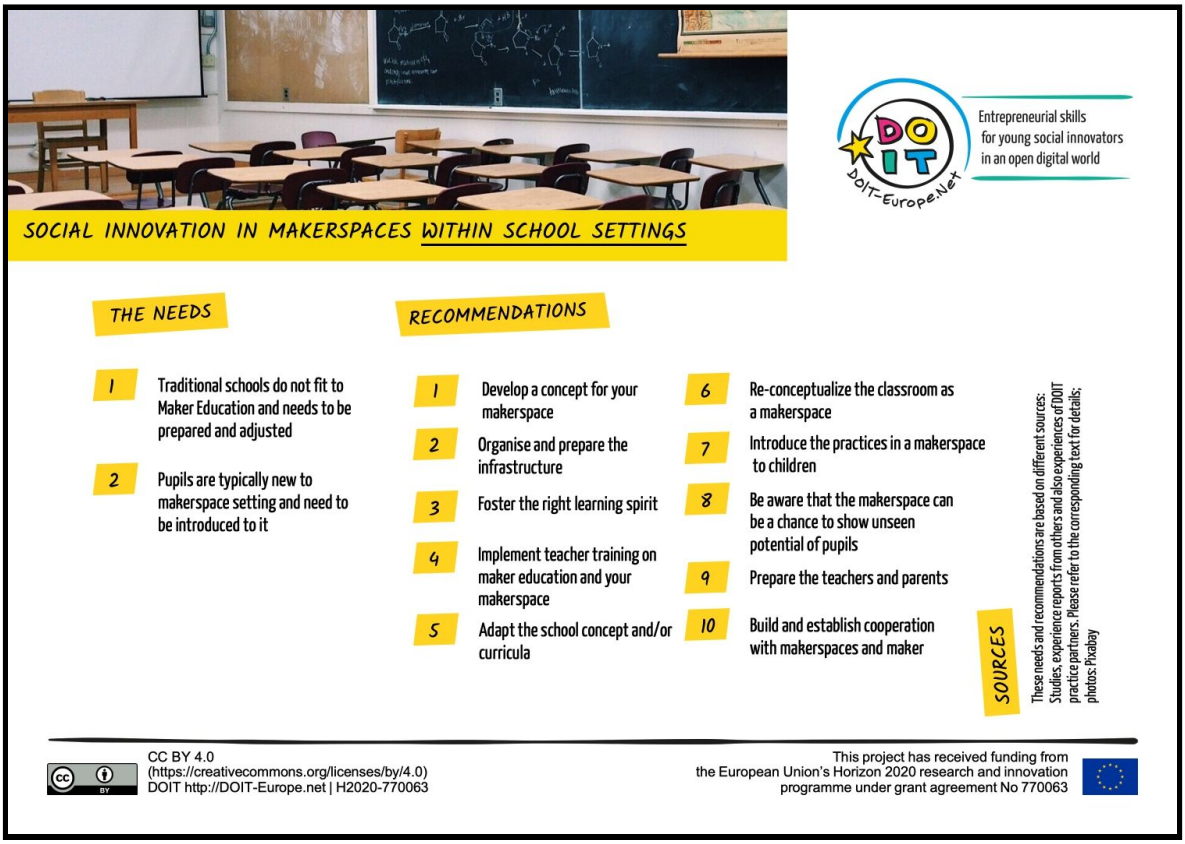


Figure: Overview of needs of children in school settings and recommendations for social innovation in makerspaces

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6. Special requirements for children with less privileged backgrounds

“If life was a Formula 1 race, my children would unfortunately start from the last positions.”
Luca Bellana, fellow at Teach First UK. (Teach for Austria 2018).

6.1 Introduction and approach

Children from less privileged backgrounds are less likely to be found in the maker community. For our DOIT approach we also want to address less privileged children as they have a greater need for the activities, since they do not learn the abilities at home and are thus hard to reach. In this episode the needs of our target group are discussed in order to evaluate the possible interventions. Our insights are meant to enable others to effectively include children from less privileged backgrounds.

6.2. Needs of the target group and requirements

There a several needs of the target group of less privileged children - from very obvious needs, as the need of affordable (free) offers to more complex such as less scientific capital in the children’s family. Within the following, we address especially missing privileges from the socioeconomic perspective, knowing that not all rich children needs to be privileged in all perspectives.

The underrepresentation of the target group happens frequently, but is difficult to see and is hardly taken into account - Although there are only a few data and figures available, as e.g. the participants’ data reported by a “Jugend hackt” evaluation (see box below, Glaser, 2015), the underrepresentation of less-privileged children is mentioned by several projects from the field of making (e.g. Gerlinde Heil statement in APA-Science 2019). As it is not possible to directly ask if a participant has a less-privileged background, how much his or her parents earn etc. it is hard to measure this criteria and really assess the reach of this special target group without potentially deter or discriminate someone.

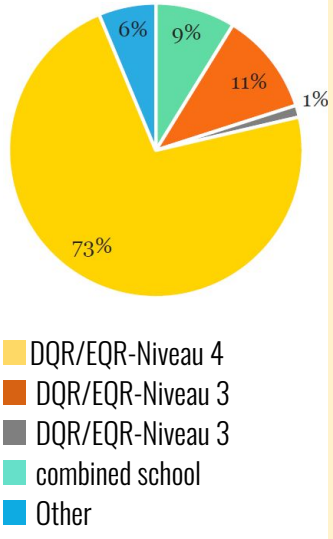
Survey Insights: "Jugend hackt" demographics

Since 2013, the project is organised by the Open Knowledge Foundation and Mediale-pfade.org. With the help of voluntary mentors, young people are working on their ideas for a better world under the motto Improve the world with code. Jugend hackt uses the hackathon format. Hackathons are characterized by their clear formatting and product orientation: Interdisciplinary teams work on specific products within a fixed period of time. The goal at the end of the hackathon is to present an executable software and/or hardware hack or at least a prototype that deals with a social problem (Hollauf & Schön 2019).

In a survey from "Jugend hackt" 2015, the participants were asked to fill in an evaluation questionnaire. From 120 participants, 80 questionnaires were suitable for the analysis. The participants generally come from higher social classes with good education and academic parents. There are no children with only basic school level (lowest secondary level).

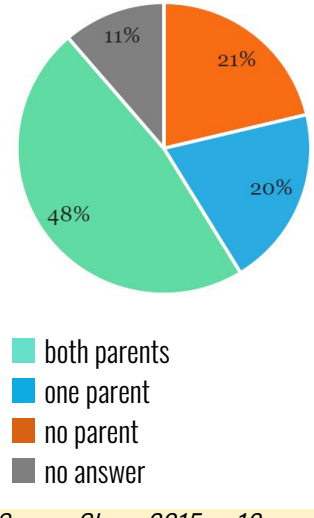
Most of the questioned children strongly identify themselves with programming and consider a job in that field.

Level of schooling[1]



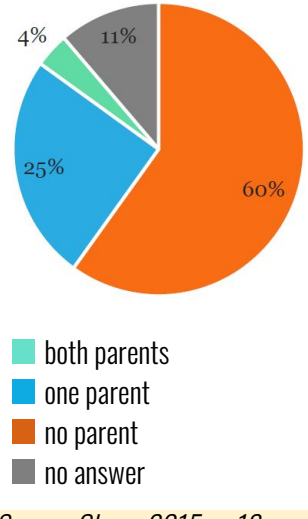
Source: Glaser 2015, p. 17.

Parents with academic occupation



Source: Glaser 2015, p. 18.

Parents working in STEM related fields



Source: Glaser 2015, p. 18

Low threshold activities with no costs: Many offers cost money and thus are only being bought by privileged people. Since money is one of the factors which limits the engagement of low-income children, the need for cheap or free education rises. While rich parents can afford to send their kids to special summer camps and buy them expensive toys, poor parents cannot afford these things. It is hard to reach less privileged children, because the workshops are often expensive (see Gerlinde Heil statement in APA-Science 2019).

[1] According to the European Qualification System 2019

Only few potential role models in makerspaces: People who work in makerspaces typically not tend not to share background with less-privileged children. As it as an be shown, within the survey insights in the box below, maker typically came not from less-privileged backgrounds (MakerZine, 2012, see box below).

Survey Insights: Maker Demographics

In a survey from MakeZine (2012, p. 24), a sample consisting of 789 respondents randomly chosen from Maker Faire exhibitors and subscribers of MAKE were questioned on maker topics, such as demographic factors.

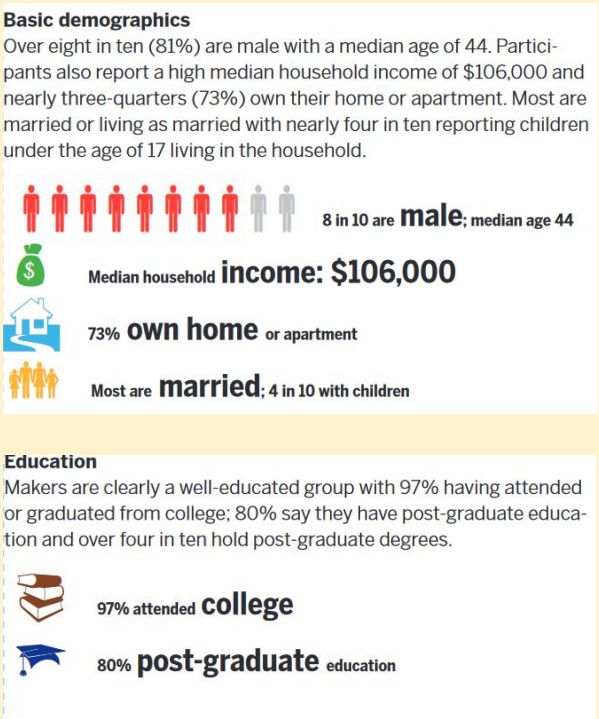


Figure: MakeZine (2012, p. 24)

Need for so-called "scientific capital" - Children are easy to reach when they are in an institutional context such as school. Within our project we made the experience that the participating children often came from a privileged background with academic parents. There seem to exist barriers which hold less privileged children back from the experiences that are offered. Archer et al. (2015) introduced the term "scientific capital": Capital is defined as a legitimate, valuable and exchangeable resource which leads to social advantages. Children from academic families tend to be better educated in science and thus do better in scientific tasks than their peers with a less academic background (Archer et al. 2015). This "scientific capital" is acquired by growing up within a science friendly environment e.g. watching science shows, discussing scientific findings in daily life or experimenting with scientific equipment. Scientific capital is not only consisting of a measurable form of knowledge, but also ways of thinking and acting such as critical thinking and self confidence in their own skills. The habitual practices and thought patterns are the intangible structure of this form of capital. (Archer et al. 2015) Privileged children actively search for opportunities to enhance their abilities and with the help of their parents are able to do so. They for example know what is important and strengthen their skills with tools. That way they are better prepared for the challenges of the time than their less privileged peers (Gee 2004, S. 96). That is why the influence of academic parents is so crucial for an education of scientifically equipped children. If these scientific knowledge and skills are not taught at home, it is very hard for children to gain equal chances in science (Archer et al. 2015).

Risk of reinforcing the impact of less privileged through participation gap and negative Matthew effect - Due to the conditions outlined, children participate less in programmes - and the differences to the privileged children increase. Jenkins et al. (2006) call this circumstance “The Participation Gap” (Jenkins et al. 2016, S. 3). It means that children, who already have access and skills to deal with new technologies, will enhance their abilities through the offered events and workshops. When in fact, they do not need these occasions. While for less privileged children these offers could be the only chance to learn such skills. The participation in social media for example is already limited through the technical devices and proper skills which are necessary for the access. Not every child learns how to work with a computer and the internet (Jenkins et al. 2006, S. 14). The “Matthew effect” refers to the experiences, that privileged children - with better starting conditions - profit more from educational intervention, which widens the gap.

6.3 Recommendations from existing literature and practice

The great change in maker education lies within the possibility of the democratization of knowledge (Bevan 2017, p. 76) which should make it potentially easier for less privileged children to participate. In the following paragraph recommendations to reach less privileged children from existing literature and practices are presented.

Free education and less-thresholds - Providing free workshops and courses is one step to lower the barrier for children from socio-economically less privileged backgrounds. Another one is to work without any need for registration as well (Schön, Ebner & Reip 2016).

Go to the less-privileged children - and do not wait for them to come - In order to reach children from less privileged background you should cooperate with organisations that have a direct access to the target group, e.g. youth clubs, schools, institutions for leisure activities, provider of living communities for children, mentoring programmes. It is important to understand the reality of the children's daily life: How do they spend their free time? Where do they go? With what kind of organisations/institutions do they have contact? What kind of schools do they go to? - This advice comes from “Teach for Austria”. The initiative aims to give children from less privileged families the opportunity to get equal education. Therefore teachers work with these children in kindergarten and school to motivate them and encourage their learning (see direct e-mail from COO Elizabeth Witzani 04.07.2019).

Select your participants and use quota - “Jugend hackt” aims to select the participants according to quota for girls and boys as well as different types of schools and regional backgrounds in order to have a heterogeneous and diverse group of participants (Jugend Hackt 2019).

Use role models from less-privileged backgrounds - Apart from the financial and material issues role models also have great influence on children.

Practical advice from Luca Bellana (Teach First UK)

Luca Bellana, a Fellow of Teach First UK (quoted at the beginning of this chapter) gives advice on how to work with children from less privileged families:

“We start from simple but essential things, such as **having high expectations** from all of them, **challenging** them with high level thinking questions, reading to them frequently. We want all children to develop a **growth mindset**, get used to challenge themselves and be passionate about reading and learning. The goal, for which I am responsible, is to make a difference for these children and help them achieve their goals and dreams, whatever

they may look like: going to university or getting a diploma, having a decent job that makes them economically independent, travelling, etc. How? Being a high-quality trained pedagogue, a professional who believes in these children’s potential and is determined to lead them towards educational success, despite the difficulties that surround them. [...] I teach all subjects with a **dialogic approach**, which means that children are involved through questioning and explorative tasks. Classroom conversation is highly valued, as is collaboration among children.”

Source: Teach for Austria, 2018

6.4 Recommendations based on DOIT activities and experiences

Within DOIT, we have a wide variety of European regions with different school systems involved, as well as big cities or rural areas. Therefore different approaches were applied.

Work with school and a whole class - Especially in a comprehensive school systems it is best to work with such a school and a whole class, as there is typically no separation process of children from less or better privileged backgrounds. Amongst DOIT regions, such a region is Finland.

Provide your actions in existing open areas in districts of families with less privileged background - Practically, it does not only seem to be a part of the city where families with less privileged backgrounds live, but as well an existing location with low thresholds, e.g. not a university or tech centre, but a public library.

Provide a higher ratio of facilitators and tutors and or different focus of activity - Sharing opportunities on pilots with children from different backgrounds, we see a potential need to provide more tutors and see a shift of focus. For instance, this target group seems to need more support for presentation as some tend to have less self esteem (and experiences) for presentation.

Be prepared for metal detectors at schools in less privileged neighborhoods - This is a very practical advice. DOIT partners in Berlin (Germany) and Belgrade (Serbia) were in schools with metal detectors at the entry and it needs time and understanding because you are usually having a lot of metals with you for the makerspace.

6.5 Summary

To sum up, the following illustration lists the identified needs of the target group of children with less privileged backgrounds within activities on social innovation in makerspaces, as well as all recommendations, including the ones which we have found in the literature or derived from it, and on the experience of DOIT practice partners.

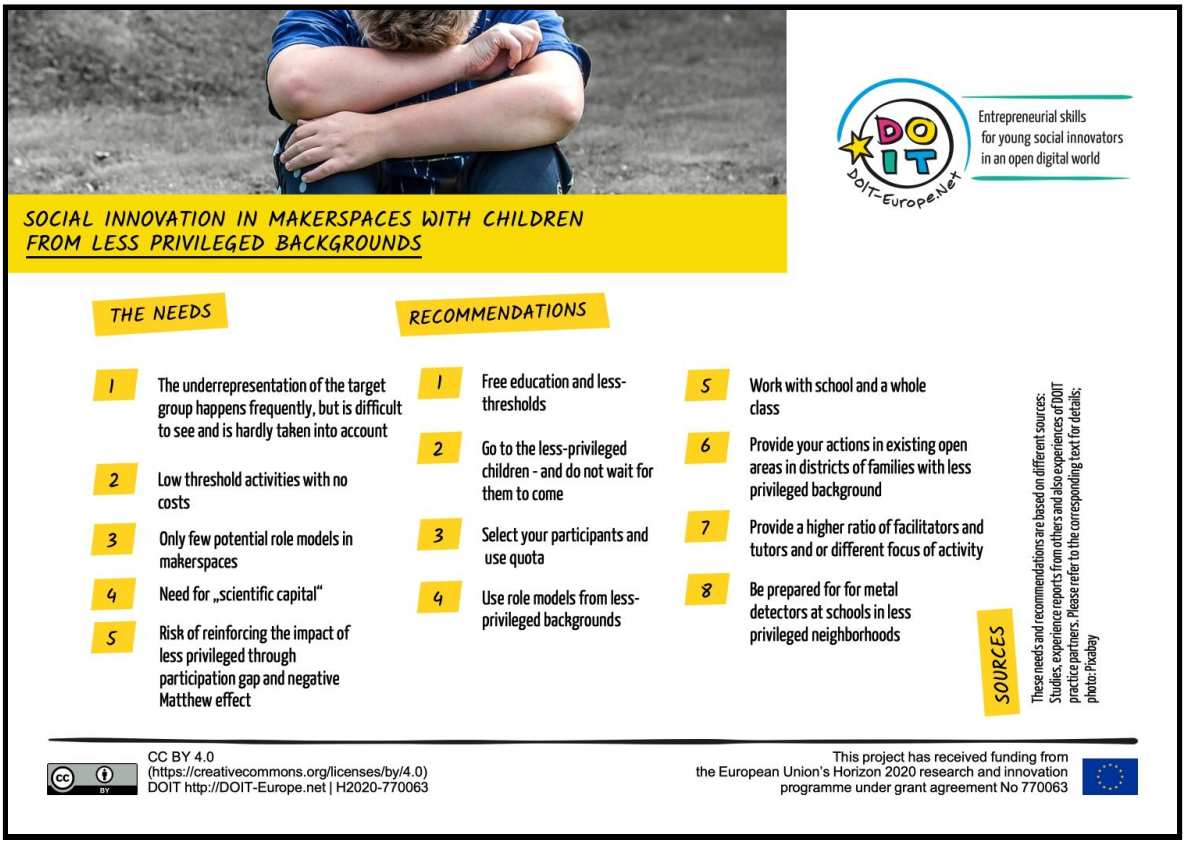


Figure: Overview of needs of children from less privileged backgrounds and recommendations for social innovation in makerspaces

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7. Special requirements for children with special needs

"I believe in a passion for inclusion"
Lady Gaga, songwriter and singer (Dart 2017)

7.1 Introduction and approach

The Do-it-yourself (DIY) community and Makerspaces share the ethos of openness and sharing. This community manifests within makerspaces, hackerspaces, as well as online platforms. This is also a part of the democratization of technology. But often, people with disabilities are excluded from participating. Although there are guidelines for barrier-free concepts and some of these are implemented, there is not much information available about how many people with disabilities actually use the makerspaces (Mangan 2017, p. 1).

Including people with special needs is a difficult topic. Because the policies and architectures are made mostly by people without disabilities, the basic requirements for participation are often missed and people are left out, for example not every makerspace allows guide dogs. The needs of people are not addressed, because they are usually not included in the planning process in the first place (Mangan 2017, p. 2).

In the following chapter we will provide general and helpful information from existing literature and our DOIT pilots.

7.2 Needs of the target group and requirements

The needs of the target group of children with special needs are mainly the following four:

- **Accessibility in makerspaces -** Some makerspaces have never thought of the needs of people with certain disabilities (Mangan 2017, p. 16ff.). The general problem behind this is the exclusiveness of the maker community. While it is theoretically open for everyone, it is also self-selective and outsiders face entrance barriers.
- **No patronization by others -** Children with disabilities sometimes experience situations where they are patronized by others. This stops them from living out their full potential and often is not only caused by their physical or mental disabilities, but by the social constructed disability (Peppler & Warschauer 2012, p. 17f.).
- **Faith in one's abilities -** people with special needs may feel like they are not capable of participating in a makerspace, which restricts their motivation and their engagement in the activities (Mangan 2017).
- **Please note: The children's disabilities are very diverse -** Children with disabilities may have, depending on their disabilities, a wide range of specific needs from learning disabilities to wheelchair use, from blindness to missing fingers. These include very specific and personal needs, usage of assistive technology or communication tools (DO-IT & UW, 2015a).

7.3 Recommendations from existing literature and practice

In the following, we will combine recommendations from studies by the University College London (Mangan 2017) and by the University of Washington (DO-IT & UW 2015a, b). Both give details about how to make a makerspace accessible for different disabilities. In the study of Mangan (2017) 22 people from makerspaces as well as 5 sight impaired adults participated in the workshop. The five participants and the facilitators were questioned about their experiences and took part in a workshop in the makerspace where they talked about their daily challenges and built prototypes of helpful tools (Mangan 2017, p. 12). Even more tips for inclusive makerspaces are available in DO-IT & UW (2019b).

Inspiring role model for a maker kid with disabilities: Jordan Reeves

One example for the integration of children with disabilities is Jordan Reeves. The 14 year old girl developed an unicorn-glitter pistol which fits perfectly to her arm (Ceceri 2019). Her mother and Jordan initiated a foundation, which is called "born just right", that should support activities to enable other children with disabilities to accept and work with their disability to create something new and helpful. In a five day workshop the kids created their own prosthesis and built in some special features (Born just right, 2019).

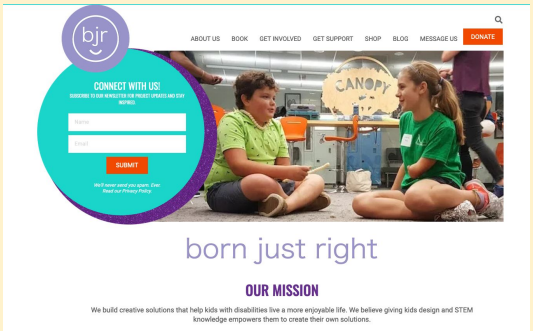

Figure: Screenshot from "born just right", July 2019, URL: https://www.bornjustright.org/

What facilitators need to do or not to do when working with children with disabilities:

Do ask and listen to needs but do not assume they want or need your help - children with special needs know very well what they need. Be open and ask them about their needs and assist. It is important to challenge the kids and let them work independently, while the tutors keep in the background. Children with special needs should not be separated from kids without such needs. Give each participant enough time to finish at their own pace.

Do strengthen kids faith in themselves - The participating children should also get a feeling of self-efficacy. This may be achieved by letting them present their work in front of a rewarding public (Peppler & Warschauer 2012, S. 38f).

Do implement accessibility in the makerspace - Accessibility of the physical makerspaces is particularly important as are accessible websites and learning materials. Wheelchairs for example need a broader space between tables and hallways to be moved around easily. Existing settings show that not all buildings and rooms can be reached by a wheelchair. Since approximately 1.85% of the world population need a wheelchair (Wheelchairfoundation 2019), it is thus a topic that needs to be considered before implementing an inclusive project. Persons with learning disabilities often need an environment, where they can learn at their own pace without time pressure. People with hearing or seeing restrictions need special devices or tools to learn and communicate (Mangan 2017, p. 14). It is useful to prepare for participants with low physical effort by providing automatic doors and machines which can be used easily (DO-IT & UW 2019d, Resnick and Silverman 2005, S. 1). The desks should allow for example wheelchair

use. It might as well be helpful, to provide visual as well as tactile maps of the space (see next box) and lettering on the bottom for better orientation through the space. Half-transparent doors enable people to see if someone is behind it, preventing bumping into someone. Reflecting areas such as pictures, tables or mirrors help deaf people to know if someone is approaching them (Vox 2016).

Example for a tactile map

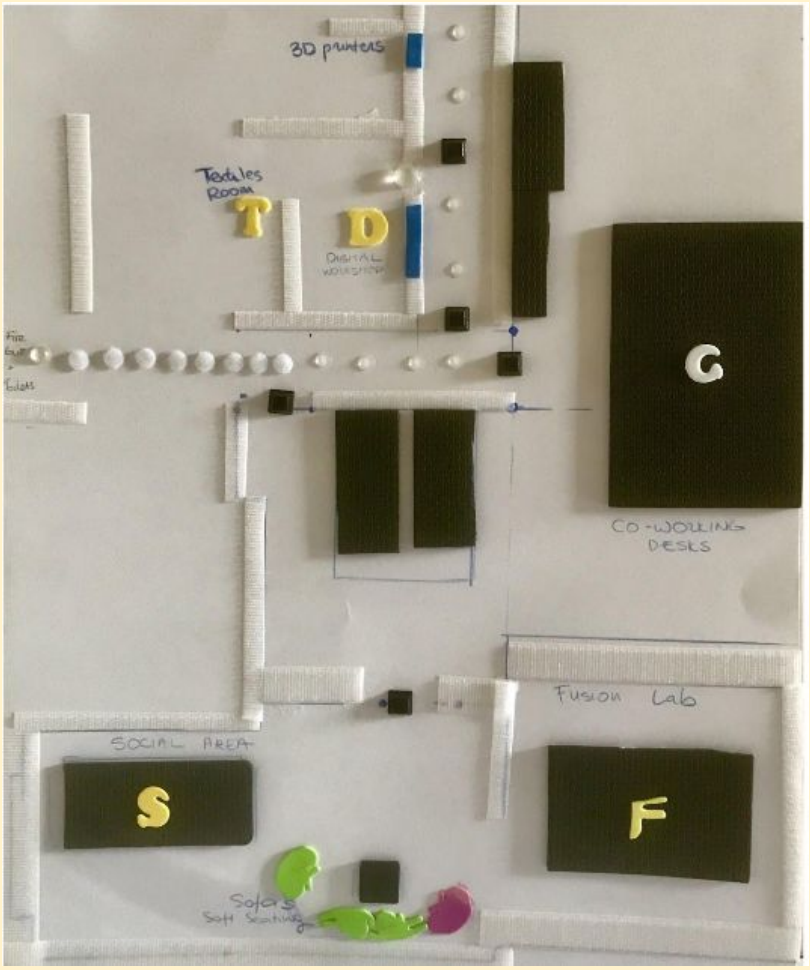

Figure: A tactile Map of a Makerspace, Source: Mangan 2017, p. 21.

Do implement clear safety rules and safe tools - Safety rules should be written in large letters with good contrast, for people with visual difficulties, these safety signs should be provided in braille or audio explanations. Think about how participants can be insured while working in your makerspace. Fire alarms and extinguishers should be in reach from a sitting position. All the signs in the room should be big and clear with high contrast, e.g. signs for exit, bathrooms, working area. Clearly mark dangerous zones with signs and safety barriers.

Sharp and hot tools must have shells or other safety barriers to prevent accidents. Every tool needs to be labeled with a distinct texture to be easily recognized by blind people as well as good visible sign. Each material should have a clear description on how to use it properly. All tools should be reached from a sitting position and also for left and right handed people. Assisting tools like magnifying glasses and desk lamps should be available. Measuring tools that have different outputs such as audio or text are useful as well. Sharp tools need a shell. There should be tactile tools for prototyping e.g. clay.

Do support practical experience - Invite people with special needs to workshops and introduce them to the place and the tools. Let them gather their own experiences and strengthen their faith in themselves (Mangan 2017, p. 4).

Do provide access to learning materials - Every learning material needs to be accessible digital. Instructions can be read by screen readers with slower audio output or magnified visuals, which helps people with special needs to learn at their own pace and in their own environment. Learning videos with description of visuals and with subtitles are also a great possibility for deeper learning. Devices and work assignments need to be clearly (step-by-step) labeled, so that everyone can understand it easily. All the materials should be simple and intuitive to use in order to enable everyone to use it. People may be physically restricted and thus need additional tools for their daily work (DO-IT & UW 2015b). Besides these and similar "DO's", DO-IT & UW (2015a, b) lists as well recommendation concerning the special group of blind adults in a makerspace (see box below).

Special recommendations for work with blind people in makerspaces

- Do not assume they want to use a lift, ask them. As someone said, "There's nothing wrong with our legs, we can walk. Let us choose"
- Do not grab them, let them hold on to your elbow. Walk slightly ahead of them so that they can feel the directions, for example if you are slowing down.
- Do warn them of kerbs, steps, doors and aboards. Plus tell them if steps are going to be up or down.
- If you are pointing or referring to something, describe where it is from them as explicitly as you can (e.g., left, right).
- Do not say things like 'go straight' (close your eyes and go straight, you will see why)

Source: DO-IT & UW (2015)

7.4 Recommendations based on DOIT activities and experiences

Within DOIT, we collected and shared our experiences within practice partner rounds. Especially our partner in Croatia, Roberto Vdovic (UZAF), got a lot of insights and has a wide range of experiences with maker education events with children as well as adults with special needs. He was interviewed in an online DOIT interview (July 2019) about his experiences and recommendations and shared his experiences as well at the practice partner meeting in Vienna (February 2019).

Plan and co-design the workshop and its structures with the participants - The main challenge for working with children with special needs is the need to take more care and be sensible for their needs. By including the kids in the process of the planning of the workshop, the design per se gets tailored to fit their needs, because they typically are very aware of what they need, e.g. to follow an instruction.

Do not underestimate the children's abilities - At the beginning of his DOIT pilot, Roberto explains, the children's mentors argued that the participants are not able to concentrate as long as thirty minutes and work with certain tools. These teachers had little faith in the abilities and self-directed working of the children. In the process however, it turned out that these children indeed possess the capabilities to achieve their goals. This was achieved through a structured process with intensive design thinking before the actual hands on prototyping. This guidance made the children aware of challenges and helped them to finalize their ideas.

Encourage the children - Roberto Vdovic as well shared the experiences that children with disabilities might need more encouragement than others. He therefore suggest to show interest, for example to ask questions on their work, to describe what they are doing and to appreciate their work and progress.

Mix groups and work in teams for integration - Roberto Vdovic also made the experience that kids with special needs can achieve the same things as kids without disabilities when mixed in a group where everyone is included. While some kids have a hard time following the traditional teaching in a classroom, the workshop setting usually enables more children to actively participate and change the situation and thus is a better solution for the teaching of certain topics. The inclusion of all children without a separation also brought fresh insights into the group.

DOIT Insights

Roberto Vdovic made the experience, that children with disabilities can formulate very clearly what special requirements they have - because they regularly have to explain this to strangers. Therefore, it is also best to simply ask them how to communicate with them. Hearing impaired people have told Roberto to look in their direction when he explains something - and if he doesn't, they remind him by knocking on the table. The children also know quite well which activities are possible for them and which are not - so you should simply ask them during the planning phase and avoid false shyness.

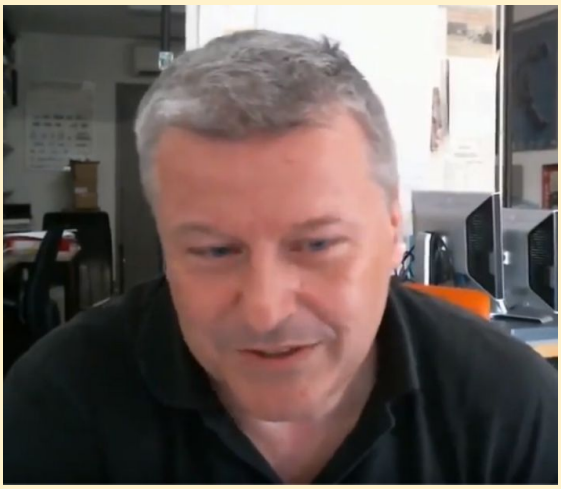

Figure: Roberto Vdovic, responsible for DOIT pilot activities in Croatia, sharing his lessons learned in a DOIT online talk (July 2019)

7.5 Summary

To sum up, the following illustration lists the identified needs of the target group of children with special needs within activities on social innovation in makerspaces, as well as all recommendations, including the ones which we have found in the literature or derived from it, and on the experience of DOIT practice partners.

Figure: Overview of needs of children with special needs and recommendations for social innovation in makerspaces

8.6 Literature

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8. Special requirements for girls and gender mainstreaming

"In many countries, they do not even keep track of how girls are doing in school, or if they are there at all. If we say, 'Girls count,' then we must count girls, so we can see if we are really making progress in educating every girl."
Malala Yousafzai, Activist and Nobel Prize Winner (Yousafzai 2014)

Introductory remarks

The following text (9.1-9.3) was a collaborative work of DOIT key partners as well as two external persons from the Graz University of Technology. Shorter versions of the text were or will be published within 3 different modes; as short paper in the proceedings of the EduRobotics Conference 2018 in Rome (Schön et al., 2019) and presented as a poster at the EduRobotics Conference 2018 in Rome (Schön et al., 2018a, see 9.3.8). The poster was additionally translated for the German speaking Weblog for media education (Schön et al., 2018b) and were presented in an online webinar (Schön, 2018), see the following details:

- Schön, Sandra; Rosenova, Margarethe; Ebner, Martin & Grandl Maria (2019). How to support girls' participation at projects in makerspace settings. Overview on current recommendations. Short paper within the EduRobotics 2018 (will be published in approv. 2019, Springer)
- Schön, Sandra; Rosenova, Margarethe; Ebner, Martin & Grandl Maria (2018a). How to support girls' participation at projects in makerspace settings. Overview on current recommendations. Poster presented at the EduRobotics Conference in Rome, 12. October 2018, URL: https://www.researchgate.net/publication/328175572
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8.1 Introduction and approach

Several biases challenge the work with girls, e.g.: teachers have perceptions that boys are more interested in technology (Legewie and DiPrete, 2014) or that makerspaces are not safe for girls (Wittemyer et al., 2014). Studies, e.g. of 1,920 Catalonian girls and boys from 11 to 13 years shows that the girls show more anxiety when using a computer and lower self-confidence, whereas boys reach higher self-efficacy for doing tasks with computers (Cussó-Calabuig, Carrera & Bosch-Capblanch, 2017). Already in the age of kindergarten children, 4 to 7 years old are "already beginning to decide which technology and engineering activities and materials are better suited to boys or girls" (Sullivan and Bers 2016). These biases - and other framework conditions - result in the fact that girls are typically underrepresented in activities from the field of educational robotics, makerspaces and coding and that women are underrepresented amongst engineers, scientists, IT experts and related domain. There are a wide variety of approaches to influence this and to gain a higher share of females, this is amongst others one of the sustainable development goals of the UNESCO (UNESCO, 2018).

Children and youth between 6 to 16 years are the addressed target group of the Horizon 2020 project "DOIT-Entrepreneurial skills for young social innovators in an open digital world" (2017-2020) (DOIT) co-financed by the European Union. It builds upon the consideration that social innovations in makerspace settings allow authentic learning experiences fostering future entrepreneurial spirit and ambition to co-create a (better) world. The DOIT initiative refers and builds upon the experiences of social entrepreneurship and innovation education (SEI) for young learners (Schön, Jagrikova & Voigt 2018). Amongst DOIT's measures to deal with challenges concerning gender issues already in the phase of the project proposal were the following:

- The project consortium and involved persons starting with a well-balanced team concerning gender issues.
- DOIT measures should reach at least 40 percent girls, all partners are aware of the importance not to exclude girls with their DOIT events and activities.
- 50% of intergenerational advisory board committee will be female.
- Addressing girls and such biases will be part of the DOIT facilitator training.
- Specific needs or success of girls have to be collected and topics included in analysis (Warren 2009).
- DOIT's final policy recommendations will also address sex and gender issues.
- DOIT pilots will include female as well as male adults as peer-tutors and role models, with a particular effort to work with female entrepreneurship ambassadors and female teachers.
- Success stories will be developed about girls and boys (50/50).
- DOIT will use a gender-sensitive language, as gender-sensitive texts are known as important to girls (Blumberg 2008, Good, Woodzicka & Wingfield 2010).

Graz University of Technology as well takes socio-political aims seriously and therefore highlights and facilitates diversity, promoting equal opportunities for women and men, encouraging girls and women to develop a passion for technology and the natural sciences, focusing on the compatibility of partnerships, family, career and studying. Furthermore, there are several actions every year to encourage especially girls to use technology or even study on a long run a technology-related field. This can be seen at the corresponding homepage of the Office for Gender Equality and Equal Opportunity (TU Graz, 2018).

For our future activities we looked for relevant literature that give us advice on how we reach (more) girls within our activities within makerspaces as they are currently underrepresented.

This includes answers on the following sub-questions: What do others to reach girls? What do they recommend?

To give an adequate answer on the question, we did the following:

- A description of experiences from a model project called Maker Days for Kids for 10 to 14 years old with a reach of 44 percent girls.
- Research for scientific literature on girls and maker education, girls in makerspaces, girls and robotics from the last 5 years (e.g. in the ERIC database)
- Research for project descriptions and statements about girls in makerspaces and more general, in STEM education

Building upon this, we will give recommendations on how to deploy the suggestions into future activities.

8.2 Needs of the target group and requirements: Participation of girls in maker education, educational robotics, coding and STEM

For a start, we want to provide some data about girls' participation for the age group from 6 to 16 years. We therefore looked for research literature and project descriptions as well as guidelines concerning girls' participation within the following fields from the last 5 years:

- Maker education, e.g. fablabs, this should include digital technologies such as 3D printers and computers (Schön, Ebner & Kumar 2014);
- Educational robotics;
- Coding activities (e.g. programming apps or games);
- As well as STEM activities (Science, Technology, Engineering, and Mathematics) in general.

8.2.1 Exemplary data on girl's participation in voluntary IT projects in Germany

What looks trivial at first glance has turned out to be complicated: We wanted to collect participation rates of girls at STEM-related events where participation was voluntary. The following overview gives such exemplary insights into the diversity of girls' participation over different projects in Germany within the last 5 years, where the participation in the activity was voluntary, e.g. in a youth club or afternoon event.

*Table 1. Exemplary rates of girls' participation in voluntary educational robotics, makerspace and coding projects. Remarks: * They selected the children, therefore we guess they had a female quota. ** Note: Jugend hackt reserves places to girls, if they apply (as well as to other minorities)*

Name of the project/initiative (Country)	**Short description (activity and age of target group)**	**Number of Children**	**Percentage of Girls**	**Source**
Bamberger Informatik Tag 2015 (Germany)	Children and teenagers should get insights in the field of computer science and the offers of the University of Bamberg (age 7-15 years)	41	21	https://nachwuchs.wiai.uni-bamberg.de/fileadmin/daten/11_freak-it/pdf/BIT15_Eva.pdf
Bamberger Informatik Tag 2018 (Germany)	Children and teenagers should get insights in the field of computer science and the offers of the University of Bamberg (age 5-19 years)	89	33	https://nachwuchs.wiai.uni-bamberg.de/fileadmin/daten/11_freak-it/pdf/Evaluation_BIT_2018.pdf
Do-Camp-Ing 2015 (Germany)	Children and teenagers are camping for one week on the campus of TU Dortmund and are working on projects together with students, professors and professional engineers (age unknown)	34	36	https://www.tu-dortmund.de/uni/de/Einstieg/docamping/de/do-camp-ing/das_projekt/index.html
Erfinderlabor 2017/2018 (Germany)	Teenagers can apply for a one-week workshop that is part of the ZFC-Initiative "School 3.0 - future teaching technologies" (age 16-19 years). *	48	50	http://www.z-f-c.de/Projekte/erfinderlabor-oberstufe

Jugend hackt Hello World 2017 (Germany)	A workshop for children who have no or less experience at coding but who are interested in it (10-18 years).	21	33	https://jugendhackt.org/

Please note that we are not able to assess if preferring girls eventually actively influence these rates, as this is not always open mentioned.

8.2.2 Experiences with special programs for girls

There are organizers in the maker movement, who are directly focusing on engaging girls and women to motivate them to take part in such projects.

- One example is the organization Techbridge, a makerspace in Oakland. They started in 2009 with the idea to inspire girls in the fields of science, engineering and technology and serve about 500 girls annually in grades 5 through 12 in underserved communities. After the Techbridge's after school program in 2012/13, "81 percent of the girls said that they could see themselves eventually working in technology, science or engineering" (Martin 2014). Also 96 percent of the students believed in 2013/14 that engineering is a good career for women and 85 percent felt more confident using technology because of Techbridge (Techbridge Girls 2015).
- Another maker program for girls from 5th grade to high school graduation in California is called DIY Girls, where in afterschool and summer programs the girls work together with mentors to create wearable electronic projects, video games and toys, supporting a technical career (Martin 2014). By providing hands-on STEM experiences 89 percent of girls say that they are enjoying their science class more and 97 percent want to continue in participating in STEM activities (DIY girls. Students results 2018).

Other projects are as well described within scientific literature (see e.g. Sullivan, Keith & Wilson 2016, Sheffield et al. 2017, Olge et al. 2017, Brady 2017). Although several authors recommend single-sex programs for girls (e.g. Jethwani et al. 2017, Chau 2015), we will now focus on both gender settings within this contribution as co-educational approaches are typical for our organisation and projects.

8.2.3 Good Practice: Maker Days for Kids – an open makerspace for 10 to 14 years olds

Some of the authors of this contribution were involved in four days long open makerspace event where it was one of the ambitions to reach about 50 percent girls. For this contribution, we will focus on the measures that were explicitly part of the plan and implementation of the event as well as present results from an intense evaluation (Schön, Ebner & Reip 2016, Gappmaier 2018).

The "Maker Days for Kids" was a creative digital workshop that was open for four days in April 2015 for children aged 10 to 14. A total of 69 children took part in the preparation or in the open workshop, modelling dream houses and printing them out on the 3D printer, programming games or mounting LED lamps in acrylic paintings. The model project has won the German Jürgen Baacke award, a recognized award for media education projects in 2016. Through a detailed documentation of planning and development as well as recording of attendance, participation in various activities and the use of the infrastructure, it is also possible to take a closer look at the special features of pupils from different types of schools and of boys and girls.

Didactic objectives and measures concerning girl’s participation

Six didactic objectives were decisive for the design of the workshop. With the aim of facilitating and promoting creative (digital) design, the main focus of the Maker Days was on a (a) open, low-threshold offer, (b) the participation of the participants, (c) the promotion of their idea (and innovation) development, (d) an (also self-directed) expansion of media and IT (STEM) competence, (e) a gender-sensitive design and (later) accessibility of the tools for the participants.

Building upon e) as well as a) and b) the following measures were considered as relevant and developed:

- The offers were selected with gender sensitivity, i.e. girls and boys should feel addressed by all offers. This included as that there have been no stereotypical "pink princess workshops" or "shooting boys workshops".
- Already in the run-up to the Maker Days, young people (from about 12 years of age) were called upon to participate in the preparation (planning, conception, design, PR and Co.) and to be trained as peer tutors (together with the adult supervisors). 4 of 6 peer tutors were female.
- In order to reach disadvantaged children and young people in particular, the project was designed to be as open and low-threshold as possible. The House of Youth with the majority of visitors from the lower secondary school required a simple language application for the event - on posters and flyers there were only pictures and the word "digital" as a reference to the digital tools. The targeted PR in the Hauptschule (a secondary school in Germany, offering lower secondary education) was a corresponding measure. There were no fees and no registration was necessary (or possible).

Participation of children

A total of 61 children took part in the Maker Days. Since girls seem to be more difficult to reach for technical subjects, the girls' quota of 44 percent seems good, and the target group was also well reached in terms of age (8 to 16 years, on average almost 13 years). Looking at the course over the days, the start was at a high level (28); on the 2nd and 3rd day, with 39 participants each, the upper limit of 40 participants was just missed. On the 4th day the number of participants decreased again to 28. On the one hand, it is important that many children were already there before or during the opening of the workshop or still came in the morning and, on the other hand, stayed for the most part until the workshop was closed. The evaluation also revealed high numbers of participants who came repeatedly. On the second day 24 participants out of 28 who were already there on the first day asked for admission, i.e. 86 percent of the children came back on the second day.

Differences between girls and boys

In the following we would like to take a closer look and examine to what extent there were differences between the participants. To this end, it was examined to what extent girls differed from boys. On average, girls are barely younger with 10.8 years than boys at 11.0 years in average. 23 percent of boys attend high school and 21 percent of girls. There are therefore no substantial differences between the two groups with regard to these two criteria. As far as participation is concerned, there is first of all a clear difference between the sexes in the way the children learned about the workshop (see Table 2). The role of friends is significantly higher in girls than in boys (44 vs. 24%), but this result is not significant ($p < 0.10$).

Table 2. How participants became aware of the “Maker Days for Kids” (in percent)

Learned about the project through…	**Sum (N=61)**	**Girls in percent (n=27)**	**Boys in percent**

			(n=34)
Parents/grandparents	23	19	26
Friends	33	44	24
Poster/Flyer/School	23	22	24
TV	2	0	3
Internet	3	0	6
Journal	5	7	3
Not specified	11	7	15

Looking at the activities of the participants by gender, there are clear differences, especially with regard to the creation of 3D models (and thus also with regard to 3D printing) (see Table 3): Only 21 percent of girls, but 53 percent of boys have developed a 3D model (this difference is highly significant, $p < 0.01$). Only the girls borrowed a 3D Doodler (this difference is significant, $p < 0.05$). All other differences are not significant.

Table 3. Participants' activities at the Maker Days (excluding peer tutorials) proportionately

	Sum (N=61)	Girls in percent (n=27)	Boys in percent (n=34)
Number of days	2,2	2,3	2,1
Number of workshops attended (average)	5,3	4,9	5,6
Proportion of children attending the workshop	9	86	94
Proportion of children who designed models for the 3D printer	39	21	53
Proportion of children who used films for the vinyl cutter	43	39	44
Proportion of children who have borrowed the 3D doodler	7	14	0
Proportion of children who picked up lenses for 3D glasses	11	14	9

Some additional general, but gender-related figures about the event: At the Maker Days, five women and five men, as well as four female and one male peer tutor, were deployed in different compositions, but continuously. Together they accompanied the participants and in some cases also looked after parents (e.g. through guided tours for parents). A total of 121 "mini workshops" were offered on the four days during the opening hours of the Maker Days (10:30 a.m. to 4:30 p.m.), 92 were actually held. 110 of the workshops offered, i.e. a large majority, were offered by adults. However, the peer tutors were also covered with special tasks and did not have much scope for further offers: One girl was almost continuously in charge of the cutting plotter and ironing press, and the peer tutors also took over the guided tours for participants and parents. After all, they were also informally very active, one girl tried so hard in the instructions of the participants while sewing in the studio, two girls prepared the final public presentation on the last day.

Lessons learned concerning girls' participation

In sum, the organisers as well as the funding foundation were happy with the results of the model project, including the relatively high reach of girls (see as well Table 1). There was especially one interesting finding, concerning the workshops in the DevLab (Digital Fabrication, Physical Computing, Programming). In summary 49% of all boys did workshops in this area and in comparison 39% of all girls. Due to the fact that three workshop were done by male teachers and one by a female, we are only interested in who participated in the female ones'. The analysis points out that 9% of all the girls did a workshop there and only 8% of the boys (Gappmaier 2018). This is remarkable that this

means that the female teachers educated more girls than boys. Finally, it can be concluded that a role model (workshop teachers & peer tutors) seems to a strong supporter to help girls to get in touch with technology.

8.3 Recommendations from existing literature and practice

8.3.1 Approach and overview

Within the following, we collected recommendations from several reports and guidelines how to support girls in STEM with a focus on how to reach a high percentage of girls' participation.

The following materials are used for the condensed recommendations:

- Recommendations building upon research (e.g. Hyun 2014, Sullivan, Keith & Wilson 2016, Jethwani et al. 2017, Kekelis, Ryoo & McLeod 2017);
- The "Gender Action Guidelines" of the EU project Phalabs 4.0 which aims to "create gender-sensitive material for the "Photonics Workshops" and "Photonics Challenger Projects" that they gain the interest of girls and have a lasting impact on their personal relation to science, technology and Fab Labs" (from the project's homepage (Macdonald 2018));
- And lessons learned from the above mentioned good practice model project.

Figure 1 gives an overview of stages within the project / activity development that need a special awareness concerning gender, if it is seen as crucial to reach a special or equal rate of girls: Already within the preparation of the activity it is needed to care about gender-sensitive language and illustration and to find potential role models, e.g. voluntary mentors. To reach a minimum of proportion of girls it might be needed to select participants concerning their sex before the start. Within the activities within the maker education, robotics or coding assignments it is needed to develop collaborative, typically non-competitive assignments and to support collaboration. Of course gender-sensitive language and role models are also suggested for the activities itself.

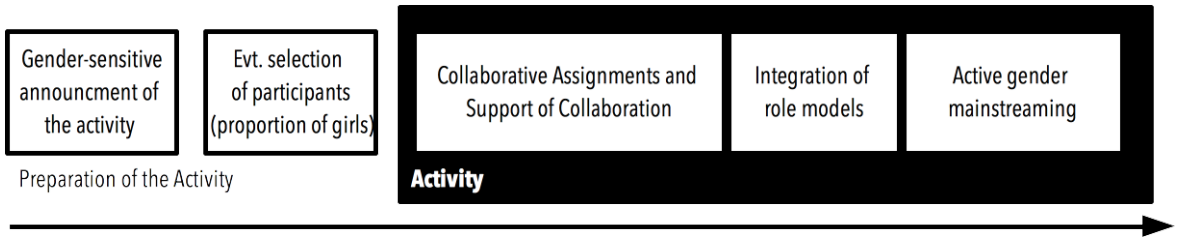

Figure 1. Overview about necessary strategic measures within the development and execution of an activity

As a remark, we would like to point out that there is of course a minority of girls who feel addressed even without such a feminine adaptation of the activities of STEM, Robotics etc. Moreover, such a combination always carries the risk that such a juxtaposition of more feminine and masculine approaches to gender stereotypes is consolidated.

9.3.2 Marketing the event: So-what motto, gender-sensitive language and illustrations

Girls tend to get (more) motivated if the title of the event or activity includes not only what something is, e.g. "Robotics with kids" but to get a sense of value of the activity, e.g. "Robotics for gardeners" or "Robotics within the book sector". Macdonald's (2018) formulate the advice as follows: "Ensure the title is evocative of the value of the activity (the 'so what') and not just a utilitarian title that says what it is – try to think why should a teenager bother to do this other than the act of doing."(p. 8) Additionally, it is helpful if the "story behind the activity to give it a context where the activity can be seen to have a positive impact on others in the real world" (Macdonald 2018, p. 8.). When

marketing a measure, it is also helpful to ensure that it is not advertised to (future) engineers, scientists, and mathematicians. There is evidence to suggest that such professional identities are less common among girls (Tan et al. 2013), especially, if they are from minorities, and can therefore be less appealing.

Gender-sensitive language and gender-sensitive illustration is in general known as important for girls, therefore Macdonald recommends (Macdonald 2018, p. 8):

- "Check that the language in any materials is sufficiently feminine (this doesn't disadvantage the males so there's no risk)."
- "Show females in all images – but DON'T show the males 'doing' and the females 'observing' or taking notes. All female groups are a positive image for females – look in any female magazine for evidence of how females like to see females portrayed."

The following Figure 2 shows exemplary for announcements of robotics/IT activity that should be a little bit more attractive for girls (left side) respectively less attractive (right side) building upon these assumptions.

Figure 2. A good practice example of the announcement of a maker activity concerning potential girls' participation and a less accomplished example. Sources: Techknowledge Education (left), RWTH Aachen via URL https://start-coding.de/ (2018-07-15) (right)

8.3.3 Deal with females' quotes and low thresholds

If it is planned that children have to be registered for an event, the proportion of girls may be smaller - at least the participation of boys in technology-related offers is rather supported by (grandparents), as experience at the Maker Days has shown. On the other hand, an enrolment procedure and confirmation of enrolment also allows a quota to be set for girls. Macdonald (2018, p. 8) gives the advice to always insist on the 50:50 schools, if mixed school are partnering.

8.3.4 Developing collaborative prompts and assignments

Hyun (2014) show "STEM-based classroom environments that are more collaborative and cooperative, increasing the chances that girls will stay interested in STEM-related fields" (p. 124). Interestingly, e.g. robotics classrooms are described as more collaboratively than math and science class because of the collaborative and communicative (Hyun 2014, p. 111). Also Macdonald (2018), within the "Gender Action Guidelines" of the EU project Phalabs 4.0 explains that females will prefer activities that are collaborative, which means that they have a positive outcome for all that

are involved - and are not a competition. To illustrate how assignments and prompt could be attractive to girls, the following Table 4 gives examples.

Table 4. Activities that work for females respectively males. Source: Selection of at table provided in Macdonald, (2018, p. 5)

Females	**Males**
Design a house to keep it safe as possible in an earthquake	Build a house to test the destruction on an earthquake table. The group with the house that falls down last wins.
Add light/music to a soft toy so that an elderly person with dementia is helped to remember their childhood	Add coloured lights to a toy to make it brighter - the group with the brightest toy wins.
Design a marble-run to link to all the other marble runs to see how far the marble will go before it falls off.	Design a marble run - the marble that gets to the end fastest win.

Building upon a study focusing on peripheral learners, who were not highly involved in the discussion within a robotics workshop for girls, key activities for supporting collaborative group learning are: "Teaching students how to engage in meaningful discussion while working collaboratively, teaching students how to manage and share the tasks at hand, teaching students how to make room for other's ideas" [Sullivan, Keith & Wilson 2016, p. 2824]. As well it is recommended by Macdonald (2018) to "emphasise the collaborative aspect of the activity – explain why the ability to work with others is a real asset in photonics" (p. 8).

8.3.5 Female tutors, role models and female-oriented interaction in maker education

Female tutors and role models are important for girls – as evaluation of the above mentioned Maker Days already showed (Schön, Ebner & Reip 2016, Gappmaier 2018). Role models are great, especially if they can as well tell stories how they failed or other personal stories (Macdonald 2018). Women speakers and tutors are seen as "'powerful' and 'inspiring' and that they 'were really relatable'" (Jethwani et al. 2017, p. 15).

The following "promising practices to support mentors in making programs" builds upon the research-practice partnership focused on the afterschool "Making" program for high school girls "Techbridge Girls" were volunteer mentors are involved (Keklis, Ryoo & McLeod 2017, p. 14f):

- "Set Mentors Up for Success: [...] Trainings in inquiry-based Making contexts should show mentors how to facilitate project work as advisers or helpers rather than doers. [...]
- Make Time for Ongoing Constructive Feedback [for the volunteer mentors: [...] We have found that prompts like "What can we do more of or less of to support you?" and "What did you find surprising or challenging today?" help to start conversations about areas for improvement. [...]
- Help Mentors Make Personal Connections: [...] Personal stories of their own experiences and passions can help set the stage for real connections with youth. [...]
- Embrace Mentors with Diverse Knowledge and Skills: [...] We have learned to help mentors become co-learners with youth [...]
- Seek Both Diversity and Shared Values: [...] We understand how important it is for youth to see women, people of color, individuals with disabilities, immigrants, and people from other underrepresented groups working in STEM fields.

- Show Appreciation: […] Thank-you’s not only validate mentors for volunteering their time, but also acknowledge the impact they have on students.”

8.3.6 Gender mainstreaming in project activities

Practically, teachers or tutors can contribute to gender disparities in makerspace settings as well (Legewie & DiPrete 2014). Active gender mainstreaming in maker activities could therefore include gender mainstreaming along the whole activity: “If supervising a school group, ensure you spend as much time talking to the females as talking to the males. Males often demand more of the teacher's attention (often by doing silly things) while females get on with the task in hand. Females then perceive that they are of less value in STEM as teacher didn’t talk to them very much or ask how they were getting on” (Macdonald 2018). Gender mainstreaming in project activities includes e.g. considerations such as give girls the same attention as boys, girls should be similarly participating e.g. at presentations of group work. It should be noted here that such a conscious - but not compulsive - proposal does not necessarily meet with public approval (Kuhar & Zobex 2017).

8.3.7 Additional recommendations if vocational interest in IT, STEM and future career decisions should be actively supported

From the perspective of STEM promotion, it should be added that it is not only a question of promoting girls' interest in STEM. Gomoll et al. (2016) points this out: "we must not lose sight of the importance of providing an environment that not only sparks interest, but that supports its development over time" (p. 913). Measures should therefore be developed to ensure that interest in STEM activities also leads to a more or less systematic development of relevant competences.

If also targeted professional aspirations are to be awakened, Macdonald (2018) recommends some extended measures (p. 8), e.g. the linkage of activities to a potential career in the sector, including the talk about salaries, and e.g. a take-home flyer “to show Mum/Grandma/sister about what photonics does and what the daughter can do if she keeps studying” the addressed STEM topic. She also suggests: “Insist on ‘floating voters’ – ask schools to select students (male and female) who aren’t convinced science is for them but have the ability. They should not bring those who have already made their minds up to study science.”

8.3.8 Overview in a poster

The following poster, accepted for and presented at the EduRobotics conference 2018 in Rome, summarizes our findings from literature and project descriptions (Schön, Jagrikova & Voigt 2018).

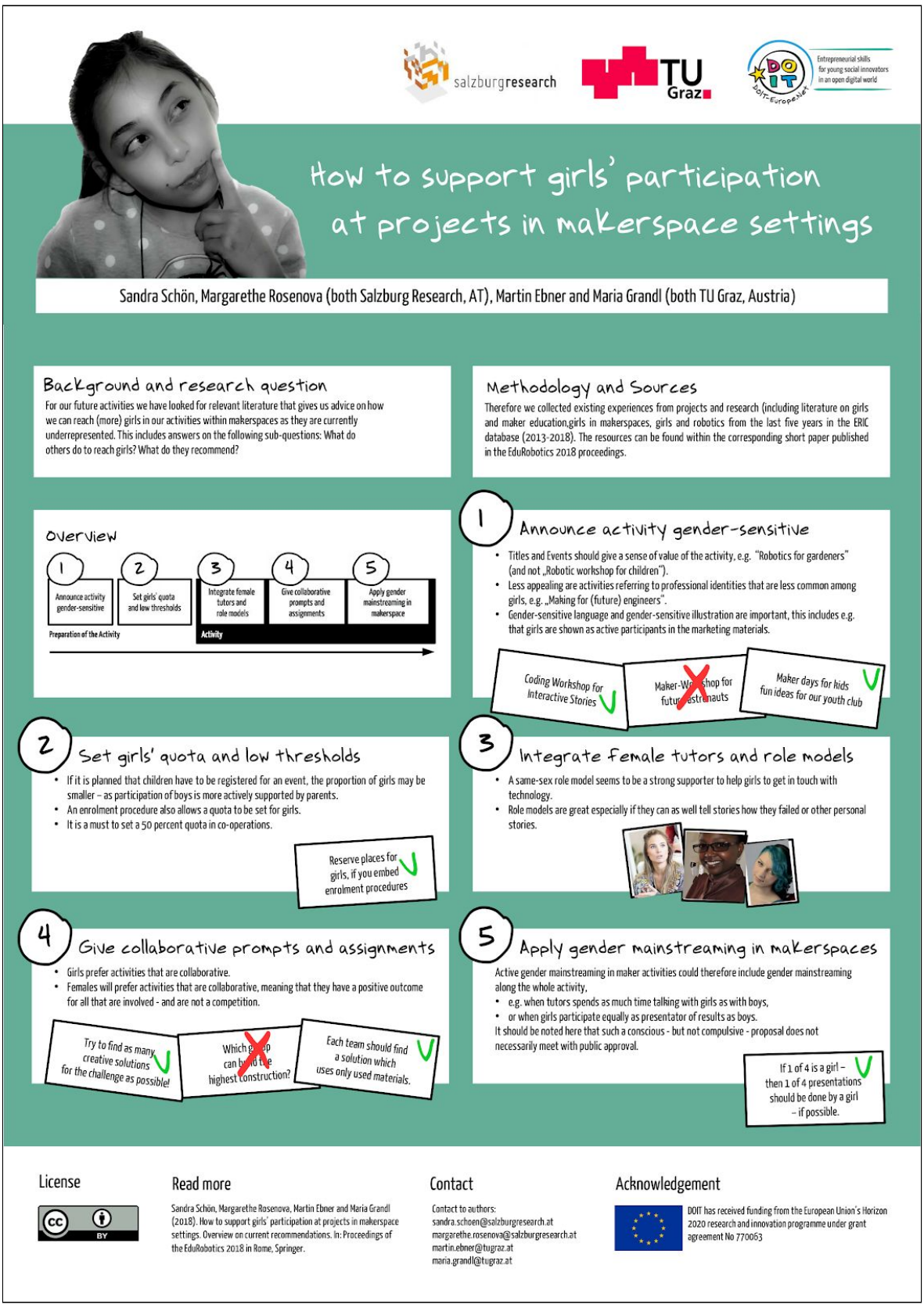

Figure 3. Overview of results as poster. Source: Schön et al. (2018a)

8.3.9 Discussion and open issues

The authors of this overview of existing suggestions from literature wanted to collect research and experience-based recommendations on how to reach more girls, especially when participation in a making activity is voluntary. For this purpose, experiences and lessons learned from a model project concerning gender are presented. For this purpose, results were presented for the first time in English. Additionally, we tried to give an overview about potential strategic measures to raise girls’ participation rates necessary within the development and execution of an activity.

Beside these ideas for the practice, we still see a need to consolidate and share experiences and results on how to deal with girls’ participation. For example, for the following paper we more or less ignored the diverse backgrounds of culture and educational systems of the authors of the diverse studies. This could include e.g. a deeper look to countries where they already get very high participation rates for female engineers, e.g. in Latvia and Bulgaria counted 30 percent female engineering workers in 2007 (Eurostat 2009).

Within our own projects we aim to get deeper insights how e.g. design decisions and the availability of female role models will influence girls’ participation and will establish fitting research. In DOIT, therefore an evaluation of activities with about 1.000 children in 10 regions all over Europe is planned and available in the future.

Besides research issue, gender is of course as well an issue for policy. Therefore, e.g. Hyuan (2014) raise the need for more funding and support of pretty early STEM activities already in kindergarten age, audits for materials and classes concerning gender, to influence the availability of female role models for STEM in schools as well as further education for teachers (p. 123).

8.4 Recommendations based on DOIT activities and experiences

All these inputs as described above were already collected within the first pilot phase, and the results were shared amongst all DOIT practice partner. When we discussed these recommendations from literature in the practice partner meeting in Vienna (February 2019), the partners mentioned these additions:

Use teachers for marketing your non-school activities - According to the experiences of our Belgian practice partners, a high girls’ quota is feasible if teachers are involved in the marketing, e.g. if they already know the offers from school and are asked to invite children for a (typically cost-free) activity outside school hosted by the same organisation. If a teacher recommend an activity, the girls tend to join in the same amount as the boys.

Avoid stereotypical distribution of tasks - The partners have introduced observations that girls might behave stereotypically (e.g. focus on design and decoration when building prototypes) when the opportunity is given. Through "plain prototyping", in which no coloured pencils or coloured materials are used, all participants focus on the functionality of their prototype and the typical role distribution of “girls are responsible for aesthetics is avoided.

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9. Special requirements for children in rural areas: The need and usage of mobile and pop-up makerspaces

"Talent can pop up anywhere in the world, it's not just one city block."
Niklas Zennstrom, Swedish entrepreneur and co-founder of Skype (Reuters 2013)

9.1 Introduction and approach

Children in rural areas need the opportunity to participate in making and social innovation activities as well, but miss the opportunities of bigger cities and the infrastructure. The main need for children in rural areas is - from our perspective - the need of makerspaces, which are more often to find in big cities. We bring together lessons learned from literature and the DOIT experiences.

9.2 Needs of the target group and requirements

As the DOIT approach builds upon makerspace settings, DOIT will pay special attention to offer activities for children in rural areas. As a makerspace setting is central for DOIT's activities, for us, a focus within this chapter lies in the availability of makerspaces in rural areas and the need of mobile and pop-up makerspaces. Makerspaces and makerspace infrastructures are rarely available in rural areas (see e.g. for German-speaking countries the map of makerspaces provided by Maker-Faire.de, 2019). Therefore the very special - and we guess - only special needs of children in rural settings are the availability of a makerspace setting.

Alternatives for regular makerspaces as in bigger cities are needed: pop-up or mobile makerspaces - There are two variations of makerspaces that can be used in rural areas, if makerspaces are not available: mobile makerspace (in a vehicle, e.g. a bus) and pop-up makerspaces.

Figure: Pop-Up makerspace, mobile makerspace and stationary makerspaces

Examples for mobile makerspaces:

There are a variety of mobile makerspaces in northern America and Europe (Maker Space, Frysklab). Typical forms of mobility include the usage of **containers** (Maker Space), **trucks** (theSTEAMtruck, Tulatin Mobile Makerspace, uOttawa Maker Mobile, Tech 'n' Tinker Trailer, Mobile Makerspace, SparkTruck), **old busses** (Calgary Maker Bus, Makerbus, Actua Maker Mobile, Frykslab) and **tools** which are sent around (Mobiler Makerspace @Lambton Country). These Makerspaces often address rural areas and socioeconomic less privileged people with their introduction to STEAM education (The Makerbus 2018, Tulatin Mobile Makerspace 2018, Bradshaw Jackson Media, Ilc 2016, Makerspace 2017).

Example: FryskLab in Denmark

The danish mobile Makerspace was built to provide the rural area of Fryslan with maker education and hands on activities. Several projects were enacted such as workshops with children, design challenges or experiments on the four elements. The goal of the project is to foster children in 21th century skills to have qualified workers in rural areas.

The truck houses *digital fabrication tools* (such as 3D printers, 3D scanner, laser cutter, vinyl cutter, 3Doodler pen), *tools for designing* (Macbook Airs, 15 Dell laptops, Apple TV, MakeyMakey, Arduinos, little Bits kits, Strawbees), *software* (Scratch, Doodle3D, Cura, Repetier, 123Design, Inkscape, Photoshop Elements, Tinkercad, SketchUp Make, Sculptis, Mozilla Webmaker) and a 4G Networking router for fast internet.

Source: de Boer (2015)

Figure: Screenshot from FryskLab July 2019, URL: https://www.slideshare.net/waaier/frysklab-make-or-die-conference-roskilde, July 2019, CC Attribution-NonCommercial-ShareAlike License

9.3 Recommendations from existing literature and practice

Use or install an own mobile makerspace in your region - If there is already a mobile makespace, you hopefully will be able to rent it or use it. If there is a need for a new mobile makerspace, it is important not only to buy the tools and provide the accommodation, but also care for the ongoing expenses such as staff and use materials (de Boer 2015, SparkTruck 2019, Makezine 2012).

These recommendations come from the experiences with the FryskLab (de Boer 2015, p. 516):

- Have an autonomous power supply for the mobile makerspace: Electricity is not always available in some rural areas, so it's best to have batteries prepared for a few hours of power supply.

- Several small projects - make different small projects. Institutions are more likely to fund one small project than a big one
- Product development - in order to get money, new products for example for educational institutions can be made

The following recommendations come from SparkTruck (2019):

- Prepare for different degrees of difficulty - even basic tasks with only cardboard can have great effects on children (e.g. build a birdhouse with cardboard, build a wiggle bot) (see also Makerspace 2019, IOWA State University 2018)
- Plan your format - do you plan to do workshops, presentations, have a stand at an exhibition fair, what are your time-slots for the format?
- Plan your target audience - do you address children, facilitators or other makers? What countries do you plan to address? Prepare the learning materials in the chosen language.
- Plan for short and long term funding - use crowdsourcing to get your stuff and get cooperation for long term

Known business models recommendations for mobile Makerspaces are presented by de Boer (2015):

- Funding from local economic infrastructure
    - companies pay and get good students to work with them
- for grand based financing:
    - take time to gather knowledge of funding and sponsorship opportunities
    - (some) entrepreneurial skills are essential and
    - take time to continuously develop project proposals.
- Embedded in institutions:
    - approach employees that are known to be willing to work in the library lab
    - you will discover that colleagues from whom you might not expect it are willing and able to contribute and
    - make the lab an essential part of business operations and try to find as much support as possible within the organization.
- Educational activities (that are paid for):
    - Think of good ideas for your educational offering that is distinctive from other providers.
    - Work on a good lasting cooperation with educational and other (social) partners.
    - Make use of the fact that schools can make use of the lab facilities. Often educational institutions lack these possibilities.

Collect tools and materials for a pop-up makerspace - As a single teacher or without a car or bus etc. a pop-up makerspace is the alternative for a mobile makerspace. Everything can be packed in boxes - but it is still a good question what should be the basic content? Several lists are available, such as by Makerspace (2019) that gives examples for tools and materials in mobile makerspace, but could as well part of a pop-up makerspace:

- Basic tools and materials for brainstorming (paper, flipchart, post-its, cutter, scissors, ...)
- Measurement tools (thermometer, ruler,...)
- Advanced tools and materials (e.g. metal and wood working, Laser Cutter, Textile working (sewing machine) 3D printer, Robotic kit e.g. LEGO Mindstorm roboter kit, Electronic prototyping e.g. soldering tools, pincers; Welding station

- Safety clothing - depending on the danger of your tools, safety clothing may be necessary (e.g. glasses, gloves)

Organize minimal requirements of a pop-up makerspace as a good Internet connection, some computers, open tools - and some cool toys - These are at least the advice for pop-up makerspaces for children by Makezine (2012). They as well suggest to ask children to teach each other and to ask parents for their support. Teach kids to teach others (win-win, they learn and facilitators have more time to check on other things) .

If you use transportable boxes, the recommendations of a pop-up makerspace project with boxes might help (Schuldt & Mumenthaler 2017):

- Select robust materials - the machines and tools in it should be considered relevant/ important by past experiences,
- Never buy the newest technology - at least 1 year old, because it is cheaper and has handling advice available on the internet usable without much pre existing knowledge
- Everything should fit into the box or one of the boxes - in order to be transportable for a quick setting up
- Plan with small budget- e.g. not more than 5,000 €, because not every institution can afford to spend much on maker materials

Example for Boxes: Swiss pop-up makerspace boxes for libraries

Lessons learned:

- For the future: more planning for specific projects, more time for working on projects
- Participants were regular users of libraries
- Staff did not read scientific literature on topic
- Worked in communities with more than 5,000 inhabitants
- Local infrastructure was a great help
- Children did not participate on their own initiative, they needed to be invited by the facilitators

Source: Schuldt & Mumenthaler (2017)

For further experiences on Maker boxes see MakEY (2019). Maker Boxes. https://makeyproject.eu/resources/maker-boxes/ (Accessed: 16.07.2019).

Ingredients of boxes:

Box 1:
- Ozobot
- Sphero 2.0
- MakeyMakey
- LittleBits
- Cubelets
- MOSS
- Handbooks

Box 3:
- Makerbot 2 go
- Brother Scan N Cut
- Lego Mindstorm
- LittleBits
- Handbooks

Figure: 3D printer from box 3. Source: Schuldt & Mumenthaler (2017, p. 17), published under CC BY 4.0

FabLab Zagreb developed “FabBoxes” within the FabLabNet (2019) project.

Example for Boxes by the FabLabNet project

1. FabCut FabBox - including Vinyl cutting machine and thermal transfer related equipment, notebook with related software, small tools like scissors, pens and including consumables like cotton bags and vinyl foil and papers to make drawings
2. FabLaser FabBox - Including small Laser engraving and cutting machine, notebook with related software, small hand tools and consumables like cardboard, papers, leather and rubber
3. FabMill FabBox - including small CNC milling machine, notebook with related software, and necessary small tools and related consumables like rubber, soft wood, soap
4. FabPrint FabBox - including simple 3D scanning device (Structure sensor) and 3D printing machine (Ultimaker2Go/Ultimaker 2+), notebook with related software, related tools, related toolbox
5. Fabtronic FabBox - including electronics, different sensors, wearable electronics, soldering and programing related toolbox with collection of carefully chosen sets such as Arduino, RPi, sensors, uArm open source robotic hand, BackYard Brain, Little Bits or similar, Lego Education Sets, notebook with related software, or other controlling electronics such as ipad, smartphones etc.

Source: Roberto Vlodic, FabLab Zagreb/ FabLabNet (2019)

Collaborate and ask for help and support - Staff from libraries and schools can easily learn the basics of the tools with the help of handbooks and testing (Schuldt & Mumenthaler 2017). Or ask children to teach each other (win-win, they learn and facilitators have more time to check on other things) and ask parents for their support (Makezine 2012).

Have different activities planned - screen-based and hands on activities widen the horizon and can bring fresh new ideas (e.g. Makezine 2012, SparkTruck 2019, IOWA State University 2018)

Plan for short and long term funding - Buy or rent the machines and tools you will need most often and calculate the expenses for keeping them running. Plan to buy replacement parts as some things will break during usage. It is possible to use crowdsourcing to get your stuff and get cooperation for long term (materials, manpower costs) (e.g. SparkTruck 2019, Makezine 2012, Schuldt & Mumenthaler 2017).

9.4 Recommendations based on DOIT activities and experiences

Develop a checklist for your own pop-up makerspace events - According to DOIT experiences, it is helpful to have a list of aspects to check with the partners, typically a visit of the locations works best. Aspects that should be clear are e.g. if there are (enough) plug-ins, free Wi-Fi, and a place to clean something, e.g. brushes.

Provide boxes with your basics - up to the needs of your target group, the children's prior knowledge and the organisations’ focus and possibilities, it is helpful to have prepared sets of tools (details in the following box).

Example for Boxes: DOIT boxes (Salzburg Research)

For DOIT activities, the team at Salzburg Research prepared different boxes with tools and materials. That way, they could easily take all needed resources to the events, e.g. the pilot in a school daycare, or at the roll-out activity at Kinderstadt Salzburg.

These boxes contain the robot Cubetto, 3 MakeyMakey kits templates and material for VR-glasses, (lenses + preprints), basic crafting tools like glue gun, scissors, pens, cutting mats, and DOIT templates from the toolbox.

Building upon these and other experiences with pop-up makerspace the team in Austria suggest to:

- Always bring own multiple plugs and extension cables
- If possible, provide an own Internet connection.
- Do never rely on the existence of tools and materials.
- Coloured pennant chains and badges are great ways to clearly show: Today is different!

Figure: Boxes of DOIT partner Salzburg Research. Source: Luisa Friebel (2019)

9.5 Summary

To sum up, the following illustration lists the identified needs of the target group for children in rural areas, especially addressing the need of a mobile makerspace, within activities on social innovation in makerspaces, as well as all recommendations, including the ones which we have found in the literature or derived from it, and on the experience of DOIT practice partners.

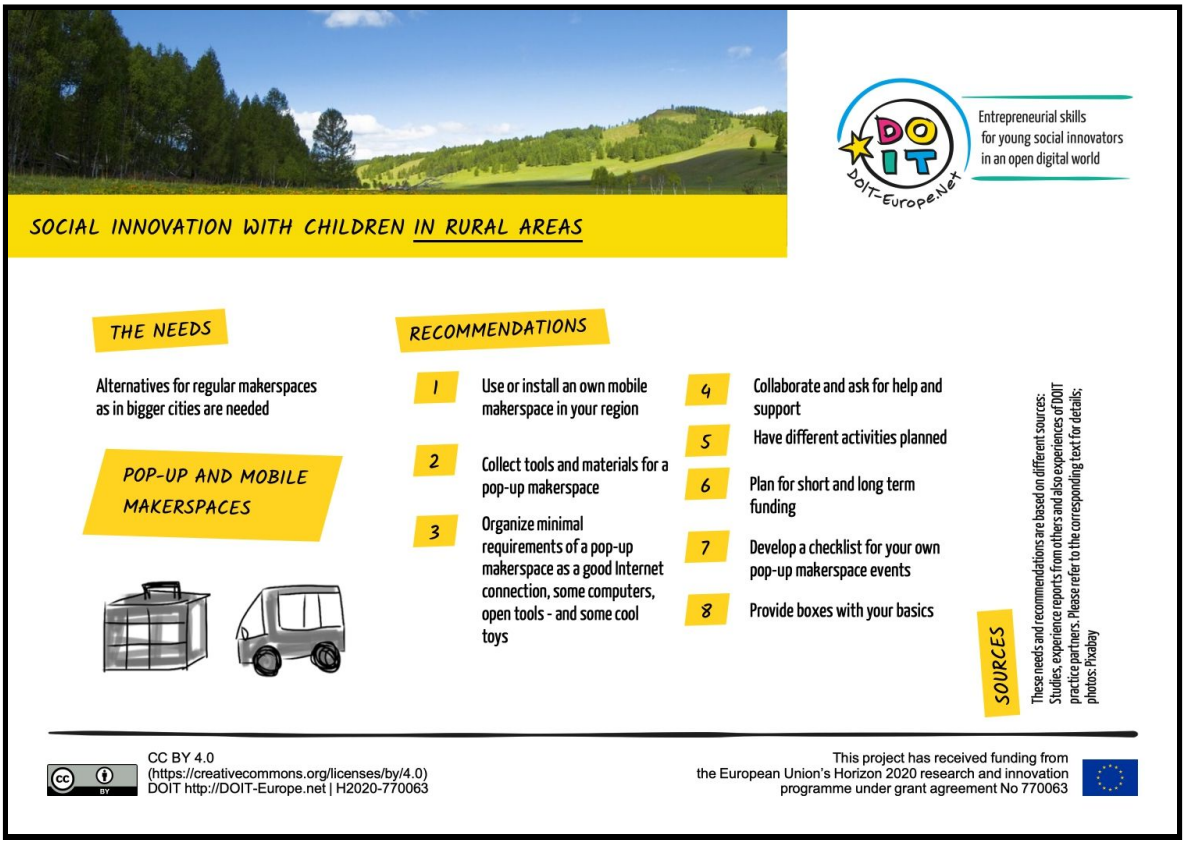

Figure: Overview of needs of children in rural areas and recommendations for social innovation in makerspaces

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10. Special requirements for advanced young makers and social entrepreneurs

"What is the greatest sign of success for a teacher thus transformed?
It is to be able to say, 'The children are now working as if I did not exist.'"
Maria Montessori, educational reformer (Montessori 1949, p. 404)

10.1 Introduction and approach

When children are already advanced makers or social innovators, for example, because they already have coding expertise, it is not easy for them to find potentially interesting events or occasions to learn with children at the same level (especially in rural areas). Therefore we address their needs with solutions from literature and our own experience with DOIT.

10.2 Needs of the target group and requirements

Advanced young makers or social entrepreneurs already developed skills and competencies within making, coding or entrepreneurship well above average. They have skills that make it unattractive for them to sign up for or participate in entry-level offers for young people of their age. Although they might already work together with adults, they have the need, regardless, to meet with peers who are already similarly experienced: For exchange, stimulation, for common experiences. Just because this special sub-group has already some advanced skills, they still have the same needs as all other adolescents (see OWA State University 2018).

Need to meet and learn with other advanced youth - Advanced makers or social entrepreneurs should get into contact and work together with peers and feel a sense of connection (cf. IOWA State University 2018).

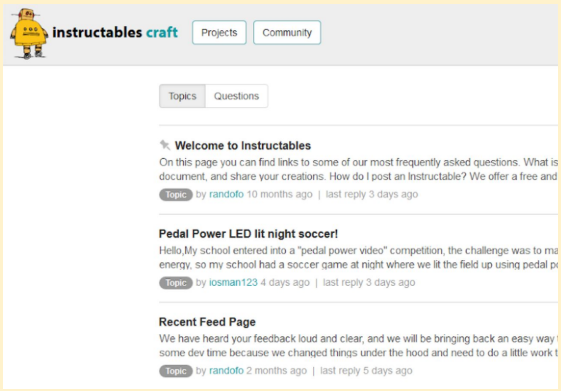
Need to show own competencies and share new learning experiences with peers - Advanced makers and social entrepreneurs need as well as peers to be able to be aware that they can influence events and people with their decisions (cf. IOWA State University 2018).

Example of an advanced maker: Naeem (18 years) and his wooden book cover

Naeem works as a Fab Steward and is a maker who creates many things himself. He posted his work-in-progress, a wooden book cover made out of a single piece of wood with the help of a laser cutter, on the "Instructables" website. This is a place where youth can share and comment on the work of peers. He wanted to share his ideas and inspire others. Some of the shared work consists of much text and step-by-step instructions. Naeem thinks that these detailed instructions scare others from uploading their simple work so he shared what he had so far. His goal was to inspire the community with his approach to combining different techniques.

Source: Tucker-Raymond et al. 2016.

Source: Tucker-Raymond et al. (2016)



Source: Instructables 2019

10.3 Recommendations from existing literature and practice

Foster participation, peer learning and co-design as well as leadership opportunities for all - All children and youth need the possibility to actively participate, learn from peers, etc. So this recommendation is not only meant for this special target group. But, especially if your activities address quite “normal children” these principles are the base to at least reach the advanced children as well because they might be able to serve as peer tutors, experts etc., as they will not be interested to be to learn something they already know.

Guidelines and recommendations are available e.g. by IOWA State University (2018) and Jordan’s Change for Children Consultancy Ltd. (2008):

- Create a supportive community - mentors should strive to include all young adults in a welcoming way while giving them the tools to create their experience. It is important to have a supportive community where the participants can relate to and work together in a meaningful way (IOWA State University 2018).
- Explain the role of facilitators and leadership opportunities - create opportunities where children and young adults can teach other kids. That way they can better understand the connection between independence and responsibility (IOWA State University 2018). Give opportunities where youth can present their success to others, maybe they can even be involved in creating instructions on how to replicate their success (Jordan’s Change for Children Consultancy Ltd. 2008, Appendix H)
- Include youth as soon as possible in the decision-making process - Then they understand better, what it is all about and can influence the program to fit their needs. Give them feedback on how their input has changed the original plans (Jordan’s Change for Children Consultancy Ltd. 2008, p. 10)
- Balance fun and more serious work - (Jordan’s Change for Children Consultancy Ltd. 2008, p. 11)
- Time - is the time suitable for the school schedule and leisure activities. Youth may have a variety of activities planned (Jordan’s Change for Children Consultancy Ltd. 2008, p. 22)

Arrange opportunities to work and learn with other advanced peers, e.g. in hackathons for U18 - Although this is not widely spread, there are initiatives that try to bring advanced young makers and social innovators together, exemplarily the initiative “Jugend hackt” which organizes weekends for advanced coders and makers under 18 years in Germany, Switzerland, and Austria for several years now (see next box). Special offers for advanced social entrepreneurs are as well available, for example by the Austrian organization on entrepreneurship education in Austria “ifte.at”. These are for example the “Idea Challenge”, the “Global Entrepreneurship Week” or the “Change Maker

programme”.These events are meant to bring youth together and assist them during the development of their own ideas at different stages of the process. Some projects start at the idea creation while others address the founding of a start-up (ifte 2019).

“Jugend hackt” as an example for structured events for advanced youth

Since 2013, the project is organized by the Open Knowledge Foundation and Mediale-pfade.org. With the help of voluntary mentors, young people are working on their ideas for a better world under the motto Improve the world with code. Jugend hackt uses the hackathon format. Hackathons are characterized by their clear formatting and product orientation: Interdisciplinary teams work on specific products within a fixed of time. The goal at the end of the hackathon is to present an executable software and/or hardware hack or at least a prototype that deals with a social problem.

Lessons learned are:

- Registered participants - the same people are working for a fixed period of time and can work undisturbed.
- Cooperative learning setting
- Pre-organised and useable data - easier working with the open data
- Topics are chosen by youth - motivated engagement in significant topics
- No “best prototype” award - because there is already enough pressure on youth nowadays. Now there is more exchange between groups.
- Reward system for gained knowledge (badges) - makes the learning process visible and
- Clear structure - everybody knows what to expect

Source: Hollauf & Schön (2019).

10.4 Recommendations based on DOIT activities and experiences

Within DOIT, one activity was directly addressing advanced young makers and social innovators: the online pilot.

Use the Internet and social media to allow to build online contacts of the distributed experienced target group member, e.g. the DOIT online pilot and let them share experiences and ideas - The DOIT online pilot is directly addressing this special target group. Therefore we developed a setting - together with some of our target group, incorporated as DOIT’s young social advisors, where we asked some advanced makers and entrepreneurs to share their ideas and experts within videos and invited others to discuss these inputs in a moderated Webchat. As concept designs for the DOIT online pilot as well the platform was extremely influenced by necessities from child and youth protection and the new European regulation on data protection (May 2018), we could not e.g. allow video chats without parents’ signatures of all participants or private chats - which seems to fit to the target group. The first online pilot was therefore a four weeks long open available (no registration needed) event with regular updates of new content (videos, examples, tools) and 2 webchats each week. As we did not reach the number of expected participants with this approach, we currently develop a different setting, which allows intense contact, but without public participation.

Lessons learned from the first online pilot are, which might be helpful to arrange other Internet-based opportunities to connect advanced young makers and social entrepreneurs are:

- Time of events is critical - pupils have school and do not have time before the afternoon
- Advertize early - The target group is tricky to reach, as they are not already connected. They need to know about an event at least a few months before it happens so that they can align their activities with it.
- Encourage conversation - Welcome new participants and invite them to participate.
- Address interesting topics - Youth want to engage in topics that are relevant to them.
- A common language is important - and being an advanced maker or social entrepreneur does not necessarily include fluent English.

Roberta, Josib, Leona & Isat (Slava Raskaj Secondary School, CR) and “Get to know us” (DOIT’s first online pilot, April 2019)

Students from Slava Raskaj Secondary School made a prototype for getting to know other people easier. They implemented a light system within a box where everyone puts their hand into which indicates if there are prejudices between the dialogue partners. It is their aim to bring together people from different ethnicities, religions, nations, genders, and ages to talk about their lives. This supports tolerance for different lifestyles and reduces prejudices.

Source: DOIT Europe 2019

Neli Merkuzic (17), Ljubljana, Slovenia and her tiny house (DOIT’s first online pilot, April 2019)

In their course about design thinking, the students were challenged to build a prototype for a tiny house on 25 square meters, which could be useful in real life. Tiny houses are meant to be affordable for people who don’t have that much money. The house includes a bathroom, a bedroom, a kitchen, and a living space. Neli worked with natural resources such as wood to make her furniture. She sees the tiny house as an opportunity to have her own space to move into and actually thinks about how to build one. The challenge Neli encountered was to measure

everything very accurate to fit in everything that she planned. She used wood and recycling materials for the furniture and thought about ways to make it cheaper, e.g. using pallets that are no longer needed.

Source: Merkuzic 2019

10.5 Summary

To sum up, the following illustration lists the identified needs of the target group for advanced young makers and social entrepreneurs within activities on social innovation in makerspaces, as well as all recommendations, including the ones which we have found in the literature or derived from it, and on the experience of DOIT practice partners.

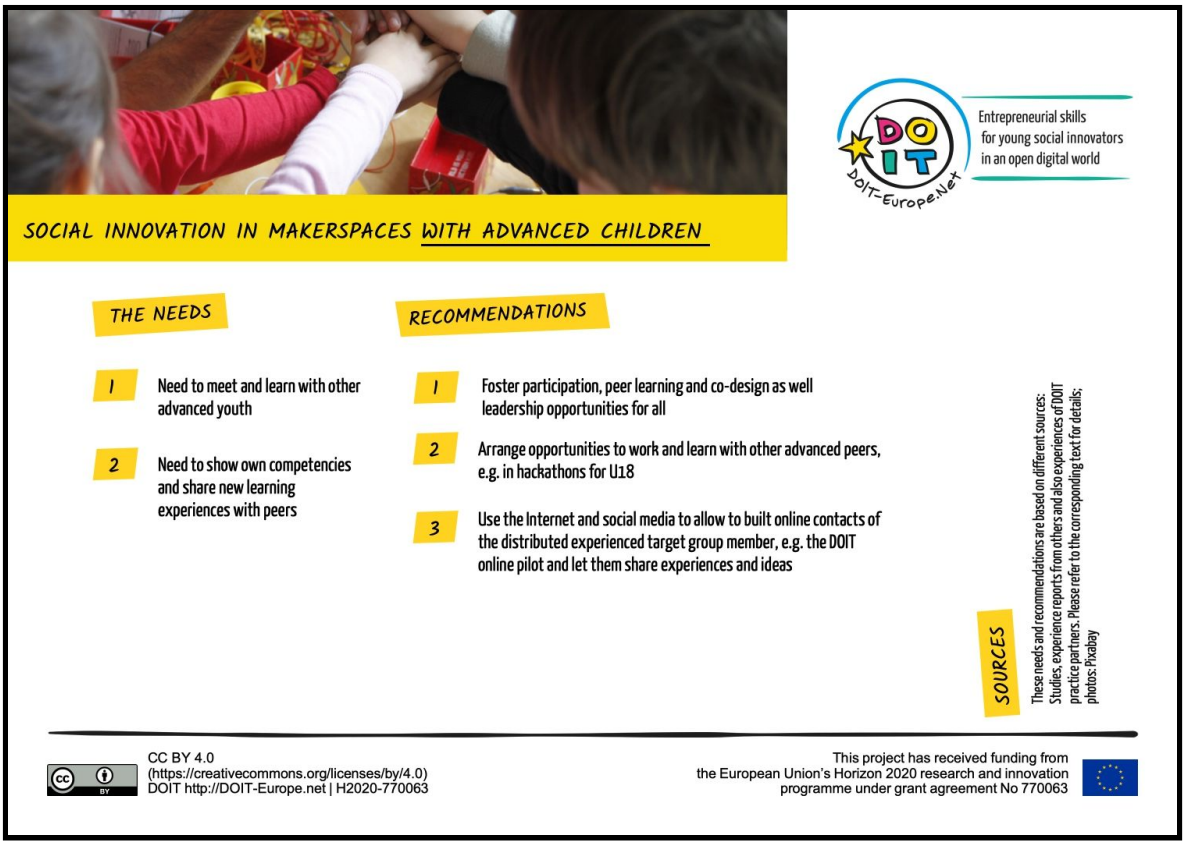


Figure: Overview of needs of advanced children for social innovation in makerspaces

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11. Discussion

This report on issues to reach special requirements for special target groups and settings is a combination of recommendations we found in literature and other project reports, as well as experiences we shared within our practice partner exchanges and documentation.

Positively seen, we are happy to be able to provide now lists with recommendations for the work with special target groups. Nevertheless, we see as well some limitations with this report:

- Practically, the experiences of our partners are limited, e.g. if pilots with less-privileged are compared with a pilot with children with a privileged background. We are not always sure, we are unsure whether our experiences can really be generalized.
- In an exchange about special target groups and the associated requirements, sometimes completely different conditions of the DOIT pilots - in different regions, cultures and school systems - are overlooked. However, these could also influence our perceptions or the situation itself.
- Our approach was to clearly define the needs of our certain target groups to then give clear recommendations. After finishing and reading our contribution, we get the impression that the analysis tends to concentrate too much on the problems and less on the strengths of the respective target group.

So, we are happy to deliver such an overview but we still see the need to invest in research according to special target groups in our special setting, there are few systematic studies and research on the special needs of our target audience.

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