D5.11 Collaborative Testing and Training

Fraunhofer FIT

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Abstract	The Deliverable presents activities: (1) a collaborative online workshop series, (2) exploratory studies and (3) the resulting findings and Service-Ideas of the German CMDF. We decided to present activities run with the German CMDF as general examples towards the activities ran by the other CMDFs as a way to keep the report concise and focused. The German CMDF has a dedicated focus on Training and Service-Innovation and this report is considered the preliminary version of D5.12, to be published in M33. D5.12 will report on dedicated CMDF Testing and Training related activities, workshops and events organized by all other CMDFs.

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Executive Summary

This Deliverable reports the mid-term results from T5.6 – Collaborative Testing and Training of the iPRODUCE project. It aims at defining and identifying collaborative services and trainings offered by iPRODUCE CMDFs, which could be of interest for different types of companies, especially SMEs. It also aims to open the Maker and Fablab scene in general to a broader public and to endorse communication between producers and consumers.

The Deliverable presents the following activities: (1) a collaborative online workshop series and (2) exploratory studies and (3) the resulting findings and Service-Ideas of the German CMDF.

We decided to present activities run with the German CMDF as general examples towards the activities ran by the other CMDFs as a way to keep the report concise and focused. The German CMDF has a dedicated focus on Training and Service-Innovation and this report is considered the preliminary version of D5.12, to be published in M33. D5.12 will report on dedicated CMDF Testing and Training related activities, workshops and events organized by all other CMDFs.

Chapter 2 of this report presents a series of workshops that was conducted by the German CMDF over the course of 2020. It helped to understand what companies find interesting when looking at CMDFs. Different formats and topics were created and tried out, dedicated feedback about what is of interest for SMEs was collected.

Chapter 3 presents exploratory studies aiming to learn about requirements for the setup of fitting collaboration services. Due to the pandemic remote interviews were held. Interviewed were instructors and start-ups. The interviews revealed the weak points of start-ups in innovation processes. An additional focus group workshop showed that Makers' strengths, mainly lay in the prototyping and testing of product prototypes. An ideation activity, based on those exploratory findings combined the insights in order to define attractive collaboration services.

Chapter 4 and Chapter 5 describe the collaboration services that address the previously identified needs. First, there is the Live-Prototyping service, which extends the well-known concept of rapid prototyping by saying: We (the CMDF) create prototypes even more rapidly; we do it live during the customers' innovation workshops. The concept is fully elaborated and ready for deployment. The second service "Nerd Testing" is a rough concept at the moment and described briefly.

Chapter 6 concludes key takeaways and highlights the task related plans for the second half of the project.

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List of Abbreviations

3D = 3 dimension (hight, width and depth)

BWI = Project partner of the german CMDF, BWI is the IT-service provider of the German Armed Forces

CAD = computer-aided design

CLMS = Fraunhofer network for **C**ocreation **L**abs and **M**aker**S**paces (CLMS community)

CMDF = Collaborative Manufacturing Demonstration Facility

FIT = **F**raunhofer Institute for Applied **I**nformation **T**echnology

MSB = Makerspace Bonn

MURAL = Online Whiteboard Application

SME = Small Medium Enterprise

T = Task

UC = Use Case

WP = Work Package

1. Introduction

1.1. Scope and objectives of the deliverable

This deliverable reports the mid-term results from T5.6 – Collaborative Testing and Training of the iPRODUCE project. T5.6 aims to reach the following two objectives:

1. to open the Fablab scene to a broader public and to endorse communication between producer and consumer of a product on one hand and
2. to identify collaboration services offered by CMDFs that could be of interest for companies, especially SMEs.

The Deliverable presents the following activities: (1) a collaborative online workshop series and (2) exploratory studies and (3) the resulting findings and Service-Ideas of the German CMDF.

We chose to present the activities run with the German CMDF as general examples towards the activities ran by the CMDFs as a way to keep the report concise and focused. The German CMDF has a dedicated focus on Training and Service-Innovation and this report is just the preliminary version of D5.12, to be published in M33. D5.12 will report on dedicated CMDF Testing and Training related activities, workshops and events organized by other CMDFs.

Other partners of T5.6 contributed, during WP5 related meetings, by giving valuable feedback and inputs during informal discussions and dedicated interviews. As the German CMDF has a dedicated focus on Training and Service-Innovation and two German Use Cases (UC1 and UC2) are directly dedicated to Collaborative Testing and Training, we believe that cutting down the work in those two steps helps to increase clarity and replicability.

T5.6 also closely exchanged results and feedback with T5.1 and T5.5. The findings directly fed into D5.1 SAG activities and D5.9 AIDIMME's activities related to the preparation of Life Cycle Management Guidelines and green manufacturing.

1.2. Structure of the deliverable

The deliverable presents two research activities, a collaborative online workshop series and exploratory studies, and the resulting findings and Service-Ideas of the German CMDF.

Chapter 2 of this report presents a series of workshops that were conducted over 2020 as online sessions with interested companies. The idea was to try out different formats and topics for getting feedback about what is of interest for SMEs. This should provide valuable insight of how a successful and exploitable collaboration format between MakerSpaces and SMEs could look like.

Chapter 3 presents two series of exploratory studies that should help learn about requirements for the setup of fitting collaboration services. The first study aimed at revealing the weak points of start-ups in innovation processes. The second study aimed at identifying the strengths of CMDFs. This was concluded by an ideation part, where we tried to combine the insights of both studies in order to define attractive collaboration services.

This resulted into the definition of two services so far, which are described in Chapter 4 and Chapter 5.

Chapter 6 briefly concludes key takeaways and highlights the task related plans for the second half of the project.

2. Collaborative Online Workshop Series in 2020 (German CMDF)

The German CMDF consists of three partners:

(1) MakerSpace Bonn (MSB) represents the physical location of the German CMDF. It is a MakerSpace and as such a non-profit organisation that aims to establish a community and a hub that interconnects individuals and organisations interested in the fields of product creation, education, knowledge transfer, hardware and software design. MSB offers workshops, courses, jam sessions and events.
(2) Zenit acts as a business incubator for the German CMDF. They have a strong expertise in national and local funding opportunities and possess strong connections within the local SME community.
(3) Fraunhofer FIT (FIT) is the research partner of the German CMDF. FIT contributes with methodical skills, service and produce design and innovation skills and general organization and project management within the CMDF.

The idea of the collaborative workshop series within the German CMDF was to try out different formats and topics for getting feedback about what is of interest for SMEs. This should give us valuable insight of how a successful and exploitable collaboration format between MakerSpaces and SMEs could look like.

Furthermore, the workshop series aimed at promoting the German CMDF partners and their skills in order to identify and acquire partner companies who want to collaborate with us.

All workshop contents and formats focussed on user-centered collaboration methods. This is in line with the core expertise of the partners of the German CMDF.

Originally, the workshop series was planned to take place in the premises of Maker Space Bonn. Due to the COVID-19 lockdown, all workshops were held online starting in Spring 2021.

2.1. Workshop 1: Methods and digital tools from the Maker-Community

The first workshop acted as a general introduction to the topics of the German CMDF. As such, we scheduled a virtual tour through Maker Space Bonn. The idea was to give an overall impression of the different possibilities of Maker Space Bonn. We wanted to explore the possibilities that were of particular interest for the audience and then spontaneously dig deeper into those. Alternatively, separate follow-up sessions with interested parties about particular topics could be scheduled.

We combined this with a session about online collaboration tools. The first COVID-19 lockdown had just hit Germany and as such, many companies faced the question about how to transition their office collaboration work to online formats. We expected this to be an interesting topic that would attract the audience. This part again was split into two sub parts. First, we gave an introduction about legal requirements and restrictions of the usage of online tools. This was followed-up by a hands-on exercise in which the participants could try out the online collaboration platform MURAL[1].

Date

[1] https://www.mural.co/

21.04.2020

Title

Discovery Session "Innovation, Digitization and Rapid Prototyping"

Table 1 Participants and Agenda Workshop 1

Participants				
Registered	**SME**	**R&D**	**Maker**	**Bigger Companies**
21	14	4	1	2
Agenda				
17:30	MSB, FIT	- Presentation of selected online tools for the virtual collaboration in your company - Legal requirements and restrictions (e.g., Zoom) - Collaborative tools: MURAL		
18:00	MSB	- Virtual tour of the MakerSpace Bonn. - Presentation of topics like CAD, 3D printing, CNC milling, laser cutting, circuit board layout, etc., according to the interests of the audience - Reaction of the MakerSpace Bonn to Corona: Best practice examples for rapid prototyping and product innovations		
18:30	MSB, FIT, ZENIT	- End of the official part - If necessary, opportunity for questions in the video conference - We are happy to deepen topics touched upon		

2.1.1. Workshop Contents

2.1.1.1. Legal Requirements and Restrictions of using online collaboration tools

The following contents are translated from the talk originally done in German.

- Selection of the tool
- Data subject rights must be observed.
- Claims of employees/affected persons (information, blocking, deletion).
    - Art. 25 DSGVO: Data protection by design and by default
        - State of the art: encryption, opt-in, data protection-friendly default settings
        - Sharing only with consent (screen release)
        - No data use by the provider, protocols

        - Prevent insight into the home (background)
- Legal basis for collection of data
    - §26 para. 1 BDSG: "Necessity" of the data processing
    - Art. 6 para. 1(f) DSGVO: "Legitimate interests".
    - This is opposed by the interests worthy of protection and fundamental rights positions of the employee and the prohibition of employee monitoring.
    - Necessity test
- Order processing contract
    - Art 28, 29 DSGVO, provider confirms that appropriate technical and organizational measures have been taken to ensure rights of data subjects.
    - This is the case if the infrastructure of a third party is used, which processes data on behalf of a third party according to instructions. Responsibility of the client
- Joint responsibility
    - Art. 26 GDPR, service provider can also be responsible. Contents of the agreements must be provided to the data subjects.
- Data protection level
    - For third countries (outside the EU), it must be ensured that the level of data protection complies with the requirements of the GDPR.
    - EU-US Privacy Shield Agreement (self-certification of providers).
- Transparency
    - Purpose, type and scope of the processing of personal data must be made available to the employee (e.g., invitation link)
- Mandatory co-determination right of the Works Council results from §87 para.1 no. 6 BetrVG
    - "Introduction and use of technical equipment intended to monitor the behavior or performance of employees".
    - Case law: measure must be notionally suitable. This is probably always the case (login, time recording, attendance control).
    - Possibly §94 BetrVG (questionnaire)
- Obligation to inform possibly also from §111 sentence 5 BetrVG
    - Introduction of fundamentally new working methods.

2.1.1.2. Collaboration Tools: MURAL

The MURAL session consisted of two simple exercises that should help participants to get a feeling about how to work with an online whiteboard tool. The participants were asked to try out two simple tasks by themselves in breakout sessions. The moderators from FIT jumped from breakout room to breakout room to give tips and solve problems.

The tasks were:

1. (3 minutes) Familiarize yourself with the tool.
    a. Hold down the mouse button and move and use the mouse wheel to zoom in and out.
    b. Find the Brainstorm areas 1, 2, 3 and 4.
    c. Add a Post-it at any place by double clicking on it.
    d. Write a text on the Post-it
    e. Delete the Post-it again

2. (7 minutes) Write down all the ideas that come to your mind about the question. As a reminder, the main ground rules of brainstorming are:
    a. There are no bad ideas
    b. Quantity before quality
    c. Build on top of other participants' ideas
    d. No judgement
    e. Wild ideas welcome

2.1.1.3. Virtual tour of the MakerSpace Bonn

The following contents are translated from the talk originally done in German:

- FabLab, MakerSpace, DIY… What is it all about?
    - Tremendous growth in society AND business, not negligible for Corps
    - A culture combining powers of open source and DIY
    - MSB portfolio (incomplete list) – picking examples from corporate perspective
- Are MakerSpaces all the same? What is offered?
    - MakerSpaces differ in terms of equipment / orientation: From a group of a few amateurs to production sites worth millions. Important: We are networked.
    - The focus in the MakerSpace Bonn is on STEM education. For this we have
        - 15 3D printers, 1 laser cutter, 1 CNC milling machines.
        - >30 loaner notebooks, server farm (500 cores).
        - Wood workshop (metal workshop in preparation)
        - Several lecture and workshop areas on more than 250sqm
        - 50 Arduinos/ESP32/Raspberry Pi including sensors and actuators.
    - We are experienced in programming, microcomputer applications, PCB design and manufacturing, CAD & 3D design, robotics, IoT.
    - New to our portfolio are AR/VR, AI, remote collaboration.
- A concrete example for fast products & the transition from small series to industrial production
    - The MakerSpace started its Corona task force on March 24th We directly started the production of first products:
        - Mouth-nose protection: production of 5,000 pieces initially, created by volunteers and sewing studios (livelihood support), a large part will be given away to those in need.
        - Face shields: initially production of a few hundred with own 3D printing farm, since the beginning of that week Bosch produces Bosch parts with design provided by us in injection molding, we delivered the first 10,000 pieces to a district office in early May 2020.
    - We are proud to having achieved these figures in less than a month.
- More Corona Emergency Products
    - We have also reproduced a part of the products produced in other countries which had already saved lives:
        - Mask adapters
        - Valves
        - 1-2 and 1-4 adapters
    - As a "gimmick" we have produced a Curve Flattener, of which about 50 pieces have been sold to private customers and MSB members.

- We have also dealt with the technical details for the construction of ventilators and UV sterilization.

- Corona will probably be with us for a while yet. Will that change the way we work?
  - Social distancing increases digitization: Video conferencing and online collaboration are gaining more attention than ever before by environmental activists.
  - We both needed and were able to decentralize our production. This is going much better than expected.
  - In the context of the hackathon WirVsVirus (German government) and the very effective merger of German maker in makervsvirus.org as well as in our main jobs, we have got to know many tools in a very short time, which often let us work together more effectively online than in the office. Besides we save the environment, by reduced driving.

2.1.2. Workshop Enrolment

The participants gave positive feedback about the workshop in general and about the online tool part in particular. One participant requested a deeper dive in the form of a comparison of the strengths and weaknesses of dedicated online tools. Further requests were about the cost structure of some tools, the compliance of the Zoom software with data protection rules, and whether MURAL work with the MS Surface pen.

We experienced that we tried to cover too many topics within this first workshop. As a consequence, the focus was not clear to the audience. Some parts did not feel connected to the others. Furthermore, the time for the individual topics was too restricted for getting towards the interesting parts.

So, we decided to conduct future workshops of this series with one topic per session.

As a second insight, the “guided tour” through the MakerSpace felt more like a talk and thus not very interactive and “tour-like”. One participant particularly requested to see more of the physical lab. We concluded that we would do a real tour in a later workshop and already started discussing how that could look like in lockdown times. Our plan was to have two people streaming from the MSB premises. One person would hold the camera and show around in the MakerSpace. The other person would be the moderating tour guide.

From the questions at the end of the workshop, we realized that information about online collaboration in home office settings is of high relevance for the audience. So, we decided to focus the next session on a topic from this area.

When discussing some participants’ statements, we realized that we needed more background knowledge about the requesting parties in order to interpret the requests optimally. We chose to always start with a short introduction round in order to get to know the participants better. This would especially work with a similar audience size in the next sessions.

2.2. Workshop 2: Advantages and disadvantages of collaborative online tools

As we realized during the first online workshop, that information about online collaboration tools was highly attractive for our audience, we decided to focus on this topic for the next session. The second workshop therefore aimed to share remote collaboration best practices and experiences made by the German CMDF partners. We wanted to provide a concise overview of tools available to support remote work and position the CMDF as a technically competent professional partner .

The full session was split into two parts. The first 40 Minutes was a talk presenting various collaborative online tools and discussing their possible use, discussing their service based on our experiences and various factors, such as performance, data security and features available. The second part of the workshop was an open discussion, offering participants to bring up their questions and share their current challenges and if possible, get instant answers, a recommendation or support on their matter.

Date

19.05.2020

Title

Session #2 "Innovation from home: discussing advantages and disadvantages of collaborative online tools"

Table 2 Participants and Agenda Workshop 2

Participants				
Registered	**SME**	**R&D**	**Maker**	**Bigger Companies**
35	23	8	-	4
Agenda				
17:30	FIT	- Talk on advantages and disadvantages of collaborative online tools - Definition: Tools for Communication vs. Collaboration - presenting 6 types of typical usage		
18:10	ZENIT	- Moderated question session - 3 companies shared their challenges		
18:30	MSB, FIT, ZENIT	- End of the official part		

2.2.1. Workshop Contents

The following contents are translated from the talk originally done in German:

General introduction and definition of the term Collaborative Online Tools. Collaborative means they should enable collaboration in a team or with business partners, Online means that they are

available via the Internet, and therefore 100% flexible in terms of time and location. Finally, they are tools, and therefore the task to be done with it, needs to be considered. Innovation workers are problem solvers and therefore need tools for communication and collaboration.

The first part of the talk discussed communication tools. They are used (1) for **video conferencing**, usually interactive with not more than 20 participants. Next to email, (2) **asynchronous chat** or messaging services are used, to replace the "quick office chat" instead of email ping-pong and allowing topic-related asynchronous group discussions. And (3) **online seminars**, either live or as a video stream, are used for sharing knowledge and focus on a large audience that is mostly passive. It is also used for social media marketing.

The second part of the talk discussed collaboration tools. Those are (4) **File sharing** tools for sharing or working on the same documents together, (5) **Wikis**, for generating, sharing and storing knowledge in (larger) groups and (6) **Online whiteboards**, similar to a virtual pin boards, are used to share and discuss visual ideas and drafts and work as a group with virtual sticky notes in a live or deferred setting.

We recommended to consider the following questions, when opting for or against a tool:

- Should existing hardware / systems be integrated?
- Are there any framework agreements in the purchase ? Or do other contractual conditions have to be met?
- External partner / contractual requirements?

(1) Start with the topic: video conferencing, we consider a stable picture and sound quality as being the most important feature. The current market leader ZOOM offers an effective algorithm for the smallest price at the moment. Other providers like GoToMeeting and Microsoft also offer excellent performance, but are more costly. The number of participants allowed varies widely. A maximum for large conferences is offered by large fee-based providers such as Microsoft (up to 10,000 participants) or Google paid service (up to 100,000 participants for live streaming), but almost every other provider manages around 100 participants. Some "free providers" limit their number, such as: Skype (for Business with 250 participants), Facebook (50 participants) and Google *Meet* to (100 participants).[2]

- For small teams with up to 25 participants, Discord can be an interesting option. It is free of charge for private use, optimized for minimal latency and provides sound only, combined with the text chat feature.
- For up to 5 participants: BLIZZ-TeamViewer is also free of charge. According to the number of participants needed: 10, 25 or 300 participants they also offer a staggered monthly payment. To increase social presence and allow perceiving non-verbal signals, the display of video images of all participants at the same screen is important.

ZOOM shows up to 49 video images at the same time and is the leader in this field. Microsoft Teams update in May increased this number as well, and we expect other providers to follow. In terms of data protection and data security, self-hosting offers the highest level of security. Open-source tools such as Jitsi or BigBlueButton offer 100% control if self-hosted. Jitsi also offers nice additional functions, like raise hands, speaker statistics, recording or direct upload to YouTube! We just found one German provider making a GDPR-compliant offer: BLIZZ-TeamViewer. Features particularly interesting for

[2] Numbers represent the status in June 2021, while the workshop was held in May 2020.

interactive workshops and creative workers: breakout rooms. Currently ZOOM, Webex and BigBlueButton offer this.[3]

(2) Text chat tools show large differences, especially in the range of functions: On the one hand, All-In-One tools like MS Teams, Slack or BigBlueButton offer much more than chat, whereas on the other hand, chat-only tools like RocketChat or Mattermost, serve as simple messenger services. All of those allow sub-groups and thematic "channels" to be set up and have a kind of status function, displaying available, busy or offline status. For large user groups of up to 10,000 it is recommended to use established providers such as Microsoft or Slack. The “free provider” Google *Hangouts* has limited the maximum number to 150 participants. Open-source tools such as RocketChat may carry up to 1000 users but when self-hosting, consider that your network needs to stand the traffic. Self-hosted open-source tools are the best option in terms of data protection. When considering “budget free” alternatives like: Skype and Google Chat, keep in mind that you pay with your data.[4]

(3) Addressing a large audience, participants are mostly passive viewers and hardly interact with the speaker, except for question-and-answer functions such as via chat. Most providers offer an option for Telephone dial-in, next to joining on a PC or smart device. The software GoToWebinar comprehensive analysis tools, for example to track participants attention. It also offers three roles: organizer (omnipotent), panellists (receive individual invitation, incl. password, can speak, present from their PC, etc.) and attendee (passive, silent, chat function and raise hands possible). Recording the event is possible and an mp4 file can be downloaded afterwards. WebinarJam and Webinaris offer extensive customization features, like an individual welcome page in company design and automated webinar recording. As Webinaris is optimized for online marketing, it can be used for fully automated webinar creation. The files are live streamed and directly uploaded and available on social media. We found one German provider from Aachen, that promises GDPR-compliant services: Edudip. Almost all providers provide the webinar room and bill according to the number of participants. Two exceptions are Webinaris and Mikogo. Webinaris, depending on the package, bills the amount of manageable webinars, whereas the number of participants is unlimited. Mikogo, offers up to five webinar sessions with 25 participants each at the same time for 15 € / month.[5]

(4) Online file sharing services are widely known and were also used pre-COVID-19. The main feature is the amount of memory offered. “Free providers” such as Dropbox provide 2GB, 5GB for Apple iCloud and Microsoft OneDrive, Box offers 10GB and at the moment GoogleDrive offers a maximum for 15GB per user. Be aware that you pay for those “free services” with your usage data. Self-hosting with an own file server should always be your first choice. That is why it is worth looking at the open-source tools. OwnCloud for example is the one used by FIT. TeamDrive is a service provider from Hamburg, following standard data protection regulations. They offer a 30-day free trial version, and then demand moderate prices of € 60 per user per year for 10GB. If you do not possess any budget and you cannot host on your own, an inexpensive provider for small teams is: Zoho. They even offer an integrated office suite for editing documents online[6].

(5) A Wiki is searchable knowledge database with collaborative features. It serves as an internal knowledge documentation that can be edited together. It can be integrated in intranet solutions. Well

[3] zoom.us, www.gotomeeting.com, www.microsoft.com/de-de/microsoft-teams, hangouts.google.com, www.facebook.com, www.skype.com, discord.com, www.teamviewer.com, jitsi.org, bigbluebutton.org, www.youtube.com, www.webex.com
[4] www.microsoft.com/de-de/microsoft-teams, slack.com, bigbluebutton.org, rocket.chat, mattermost.com, hangouts.google.com, www.skype.com, chat.google.com
[5] www.gotomeeting.com, home.webinarjam.com, www.webinaris.com, www.edudip.com, mikogo.de
[6] www.dropbox.com, drive.google.com, owncloud.com, teamdrive.com, www.zoho.com

known providers are Atlassian Confluence, MS Teams and Guru. They all offer a tagging or taxonomy system for sorting and searching articles and allow various types of files and content to be uploaded or attached, such as training materials, project outlines, etc. Some companies also use wikis as a self-service software option for customers or external parties. Confluence is most popular in IT circles, because of its seamless integration with Jira, a project management software for agile software development teams. Confluence is easy to learn, has dedicated areas, comment functions, notifications, a calendar function, that supports setting due dates of tasks, and runs platform-independently, even on the mobile phone. MS Teams also offers wiki-functionalities. The sad news – both are quite expensive with about $ 10 / month. Guru is a wiki software, based on algorithms that proactively suggests question & answer examples as a new wiki page based on an integrated FAQ chat[7].

(6) Online whiteboards like MURAL, Miro, Conceptboard and the open-source tool OpenBoard, are virtual design spaces made for the visual exchange of ideas and collaboration. Other tools like ideaflip, Excalidraw and AWW board[8] are simple online sticky-note tools or simple online drawing tools. Excalidraw and AWW board can be used online directly (without any login), and the AWW board is optimized for touch devices.

From the acquired experience, it is valuable to point out that all of these tools are best used with just a few people or just a handful of ideas at a time, more than 5 people at the same time may create chaos. Notes revolve around notes, colours change, and participants and instructors may lose sight of the subject. If you just need to scribble, GoToMeeting, WebEx and MS Teams video conferencing tools also allow the organizer to draw something live on the screen and provide a virtual board picture![9]

Finally, one basic advice: Take it slow! – all online tasks require more time to prepare but are more efficient afterwards.

2.2.2. Workshop Enrolment

After the talk, we opened the session for questions. Four people spoke up. The first person was self-employed and asked about compatibility of video conferencing with online whiteboarding tools. The second person shared their experiences during the fast shift to remote work and that their team was struggling with the large number of tools they had to deal with now. The third person was interested to understand more about what the CMDF could do for his company. We presented the CMDF partners and our planned service offerings, related to prototyping and design Thinking innovation workshops. The fourth person asked whether test versions of the tools can be recommended and whether there are any cost traps.

[7] www.atlassian.com/software/confluence, www.microsoft.com/de-de/microsoft-teams/group-chat-software, www.getguru.com
[8] In the meantime AWW board has been acquired by Miro. https://help.miro.com/hc/en-us/articles/360019015039-Moving-from-AWW-App-to-Miro
[9] MURAL.com, miro.com, conceptboard.com, openboard.de, ideaflip.com, plus.excalidraw.com, ideaflip.com, plus.excalidraw.com

2.3. Workshop 3: rapid-innovation, -production and -distribution & funding opportunities in Germany

The third workshop (mainly arranged by MSB) aimed to share CMDF activities related to the project "maker vs. virus"[10]. MSB successfully contributed to producing urgently needed medical supplies and various consumer health care protection products that were not available at the market at the time. We chose this topic as the one for this workshop because we felt it is of rather short-lived relevance. Other topics in our backlog would be relevant at a later time, too.

The project was presented to leverage a successful example for remote collaboration and the newly established regional production chain. We shared the story in the form of a best practice for agile decentralized production.

As a second part of the workshop, ZENIT shared information on national and local funding opportunities. The relevant funding programs selection was presented in a short concise talk, with on demand distribution of information materials and links via email afterwards.

Date

16.06.2020

Title

Session #3 " Innovation from home: SPECIAL: Maker versus Corona"

Table 3 Participants and Agenda Workshop 3

Participants				
Registered	**SME**	**R&D**	**Maker**	**Bigger Companies**
10	2	6	1	1
Agenda				
17:30	MSB	- talk on the project Maker vs. Virus - live virtual walking tour of the MakerSpace facility		
18:10	ZENIT	- National and regional funding opportunities for german companies		
18:30	MSB, FIT, ZENIT	- End of the official part		

[10] https://www.makervsvirus.org/

1.1.1. Workshop Contents

1.1.1.1. Presentation of "Maker vs. Virus" project

The following contents are translated from the talk originally done in German.

In other countries, emergency ventilation products have saved lives, which is why MSB started developing those. In a worst-case scenario, MSB would have been capable of producing hundreds of those ventilator devices. Through the collaborative development, we built know-how, which would be available at an aggravation of the situation . As a small NGO, we have transitioned from small series to industrial production super-fast. The Corona task force started on March 24th 20204. Our volunteers and sewing studios (livelihood support) produced immediately more than 3,000 community masks. We also used our 3D- printing farm to produce a few hundred face shields (see Figure 1). In order to increase the volume, we then collaborated with Bosch. They now produce the parts designed by us, using injection molding method. A total 15,000 pieces was delivered to the local district office and then distributed by them by (date).

Figure 1 Example face shield

In addition to the prototypes for emergency ventilation, we produced 400 door handle avoiders, 500 Ear Savers, recipes for hand and surface disinfection, we evaluated an UV sterilizer, developed concepts for indoor ventilation systems and created a prototype "CO2 traffic light".

We learned a lot about bureaucracy – but also united a network of selfless people and pragmatists that successfully collaborated from their home offices.

The MSB participated with a small group in the Hackathon WirVsVirus. In this group, which continued to collaborate long after the hackathon, we started simple CPAP ventilators (continuous positive airway pressure). These devices keep the pressure constant when inhaled. Ultimately, a small overpressure ensures that the alveoli are open and so more oxygen can enter the bloodstream.

Our work in detail:

- Information gathering (especially CPAP)
- Analysis of existing solutions and historical development

- Discussion with physicians
- Participation of several members in MedCram course for medicine of the mechanical ventilation and the special requirements of COVID-19. Goal: to understand what the machines need to be able to do (pressure ratios, ventilation frequency, ratio of inhalation to exhalation, Saturation O2 and CO2, flow rate, ...).
- Selection and procurement of components for production
- Construction of the first submodules (CO2 sensor, mask, pressure generation via turbine)
- Evaluation of test possibilities (physicians offer test on corpses)
- Consulting of other groups and support in design and production of valves
- We have pursued and supported various approaches worldwide. We also had contact with several other initiatives and German universities.

We perceived a high effort for the temporary conversion of MSB to an emergency production facility with output of more than ten thousand aid goods (decentralization of production, Securing logistics, establishing tools and related communication). Reorganizing the normal MSB activities, by shifting to online communication, drawing up the hygiene plan and searching for new funding opportunities.

2.3.1.1. funding opportunities for SMEs

In the second part of the workshop ZENIT shared basic information about funding opportunities in North-Rhine Westphalia and Germany. At state, federal and EU level there are more than 500 funding programs that can be relevant for small and medium-sized companies. Some are topic-related, others open-ended, in some you need partners, in others an individual application is possible.

ZENIT´s general funding advice is part of the publicly financed services and therefore free of charge for companies from North Rhine-Westphalia. We do provide intensive help with the application process and support, for example in project management. The following services are available:

Free initial information (e.g., ZIM advice), information about the existing programs, which programs fit and what conditions have to be met. We perform preliminary examinations of application opportunities, we assess project ideas for public funding programs, develop strategic application development and application support for innovation, research and development projects. We also support the search for cooperation partners and try to help with questions about project implementation.

2.3.2. Workshop Enrolment

The workshop was for the most part quite interactive as one maker participant and two people working at SME company asked questions to better understand the production facilities and tools available at MSB. Due to the pandemic situation opening hours of the MakerSpace were restricted and one participant asked for a possible appointment.

2.4. Workshop 4: Design thinking to foster innovation & interactive production design

Workshop four was dedicated to a high-level introduction to Design Thinking first and a short CAD-exercise introducing the software Tinkercad. FIT regularly provides training and workshops on Design Thinking Methodology in various industries and organizations. The FIT one-day workshop "Design Thinking Crashcourse" was presented to the audience and the basic Design Thinking Process was discussed.

The CAD exercise was moderated by MSB. The software was first briefly introduced to the audience. Then interim login credentials were provided, in order to allow all participants to follow the step-by-step instructions. A short Q&A session was held at the end of the session.

Date

18.08.2020

Title

Session #4 "Innovations from home: Using design thinking to innovate"

Table 4 Participants and Agenda Workshop 4[11]

Participants				
Registered	**SME**	**R&D**	**Maker**	**Bigger Companies**
12	2	10	-	-
Agenda				
17:30	ZENIT	- Short introduction with all the participants Who are we, what can we do, what are we looking for?		
17:40	FIT MSB	- With design thinking to innovation How does the design thinking process work? Short practical exercise Implementation of a product with Tinkercad		
18:30	ZENIT	Feedback & networking Critics, open questions and requests Outlook & suggestions for the next workshops		

[11] The relatively low number of participants was probably also related to the summer vacation period.

2.4.1. Workshop Contents

In our fourth virtual workshop we wanted to get into doing with our audience. The question: “How can I actually work innovatively from the home office? Was a focal point of the workshop.

FIT showed an example of a design thinking process, you can develop innovative ideas and find solutions to a problem. In a second step, your "new product" will be technically processed with web-based open-source software during the online seminar. Each participant has the opportunity to design their own individual product.

The MakerSpace Bonn would print and send the file for the attendee after it has been submitted.

2.4.1.1. Why design thinking?

The following contents are translated from the talk originally done in German. The talk was dedicated to a general – non-scientific – audience, to provide a general high level introduction to the concept. For the dedicated Design Thinking Methodology and the approach applied within iPRODUCE refer to D2.4 Report on Co-creation and Open Innovation Methods for social manufacturing.

Innovation, in the past, was characterized by technical specialists mostly from an engineers’ point of view. Later on, designers came along and designed the inventions, often in a quiet room and according to more artistic criteria. But with increasing complexity, especially with electronic products, problems were encountered: There was a lack of user acceptance and improvements had to be made. Design thinking came up in the 1990s. Design thinking is based on three assumptions:

- Multidisciplinary teams encourage creativity
- Human-centeredness: human needs and motivations are consistently taken into account
- Iteration: Fast and frequent testing of first ideas and which can be run through several times if necessary

Design thinking is a methodically structured way of solving problems or challenges in a way that thinks outside the box, constantly includes people / users and works iteratively towards a successful innovation.

Every design thinking process starts with a challenge: Here is an example from MakerSpace Bonn. COVID-19 has kept us busy over the past few months. Hygiene was suddenly really important and touching doorknobs was a potential hazard. But how can you open a door and press the handle? Here you can see the solution from MSB (see Figure 2)!

Figure 2 Door opener MSB 3D-print example

Not everything in Design Thinking is brand-new. Existing methods and strategies from the social sciences and design were systematically strung together. The concept consists of five phases.

As already mentioned in the previous paragraph, D2.4 Report on Co-creation and Open Innovation Methods for social manufacturing introduces Design Thinking Methodology in general and the approach applied within iPRODUCE. The contents are translated from the talk originally done in German for a – non-scientific – audience, with the aim to provide a high level introduction to the concept.

The first phase: **Empathize** serves to UNDERSTAND our challenge. We may use methods like, observation, peer conversation / interview, questionnaires (electronic or on paper) or participatory observation / trying it out yourself. Sometimes you may also use diaries to understand problems that have a more longitudinal nature. When is this empathy phase completed? At some point there will be a moment of saturation: people repeat statements that previous observations or interviews already revealed. You are able to answer the 6-W-Questions: who? Why? What? When? Where? How? Or simply your budget and time frame are exhausted.

In the **define** phase, the information collected in Empathize is evaluated and condensed into a problem definition. The standard method of structuring information about goals and problems is affinity mapping. But also qualitative content analysis and clustering is performed. Typical results are:

- Customer Journey Map
- Empathy Map
- Persona

The result is then condensed into a so-called problem statement. This is a short text of approx. 0.5 pages, summarizing the problem (or challenge), the user group, their goals and motivation, tools and working methods used, restrictions and processes are considered.

Example problem statement for challenge “How might we reduce infection risk when opening doors?”

“Germany has been in the corona pandemic since spring 2020. Disinfection, virus protection and individual hygiene therefore have high priority in social interaction. Doorknobs represent a high risk of infection for people in office buildings [user group] because touching the doorknobs can transmit viruses. Avoiding touching doorknobs reduces the risk of infection and can save lives in the long term.”

Having a clear idea of what the problem is, we started with **Ideation**. But before let us take a look at the two spaces (grey circles) the Design Thinking Process is split into. The problem space on the one hand and the solution space on the other. Figure 3 shows the FIT Design Thinking Process. When starting with ideation, we are exactly at their intersection.

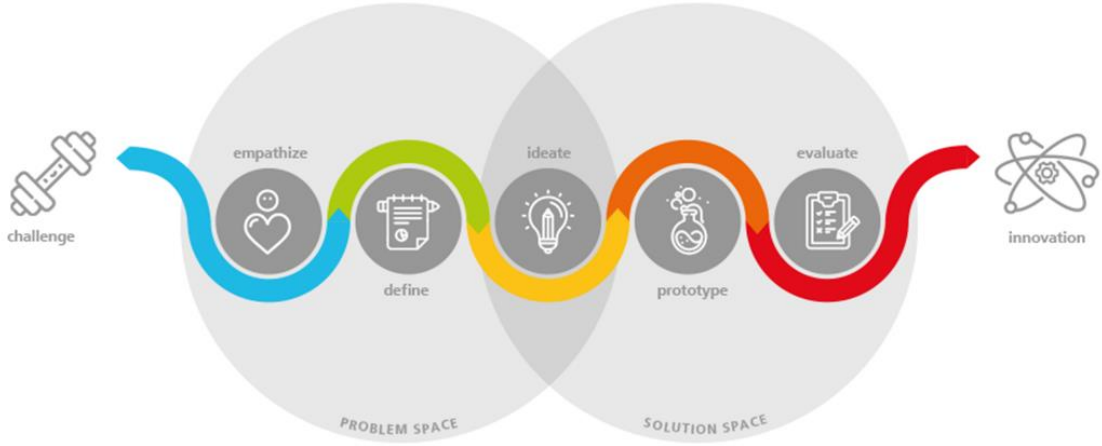

Figure 3 Design Thinking Process

Those spaces symbolize the amount of data we are dealing with. At the beginning (empathize) we have just the challenge and start collecting information and thus gather more and more. Until we reach saturation and start analyzing and synthesizing (define) to get to the concise problem statement. Based on the Problem statement we built the initial question for ideating solution ideas. Often related to as How-Might-We question (HMW). Then ideation leads again to an increased number of ideas and information, while prototyping is all about deciding which idea gets to be prototyped and later on tested.

Why does the Design Thinking approach so clearly separate these two stages? To focus all activities on understanding the problem first, rather than thinking in terms of solutions from the very beginning.

During ideation Brainstorming, Questorming (collecting questions), Mind Mapping and similar methods are used to generate as many ideas as possible. Methods like Innovation portfolio ("feasibility" vs. "potential") are then used to support improving and selecting ideas.

Basic best practices are:

- Think broadly at the beginning, only distill and evaluate in a second step.
- Giving ideas space to develop: first individual / silent work, then plenary
- Take different perspectives
- Borrow concepts from other domains
- Getting people to talk to each other

Now we reached the solution space. Our challenge was examined empathically. It was defined what the core of the challenge is and the problem statement was formulated. And finally, creative approaches were sought and a solution idea was nominated to be the first to be implemented!

The **prototype** phase simply means making the idea tangible. Paper prototyping is particularly popular in the development of electronic devices with screens. In design thinking, however, prototyping is used somewhat broader. We may use simple mock-up or clickable wireframes too. Prototypes can also be created in 3D. This adds value as it makes the concept tangible and helps understanding its' proportions and handling. Any material suitable is possible and Makers are certainly skilled here. There is also the possibility of developing abstract prototypes in order to test service ideas. One method is the storyboard: a kind of comic that makes an innovative process or service tangible, other methods are puppet shows or role playing, e.g., using Lego serious play.

Once the prototype is completed, the next phase is **evaluate**. It is related to testing and evaluating the selected solution idea. Again, methods of social research are used: observation, interviewing and behavioral observation of real users (usability test, eye tracking, click analysis). User opinions and statements (interview, online survey) are often collected using the *Thinking Aloud* method. This method is quite common when it comes to testing interface prototypes. It can evoke incredibly helpful feedback. In Design Thinking as generally in User Centered Design, we are interested in why things happen. Testing prototypes early and quickly helps to understand the context even better!

The 5 phases presented can be completed in one day during the Design Thinking Crash Course. But please keep in mind that the process is not linear. It is an iterative approach, and depending on the focus, the process might be run several times. Please do get in touch, if you are interested.

2.4.1.2. 3D-design: introduction to TinkerCAD

In order to get to practice, during the second part of the workshop, MSB introduced the software Tikercad[12]. Tinkercad is a free 3D design, electronics, and coding app. Teachers, children, hobbyists and designers use it to bring their ideas to life.

The tool can be opened in any standard browser on a login basis. In order to enable easy participation in the exercise, MSB shared the link and login credentials that they use for workshops and MSB educational activities solely, with workshop participants first. Then all participants were instructed step-by-step to open a first file and customize it to their preferences. The example exercise aimed to create a name tag for a key chain. At the end of the exercise, participants were invited to save their CAD-file and send it to MSB. The MakerSpace would then print it using their 3D-printing farm and send the final name tag to the post address of the person.

2.4.2. Workshop Enrolment

During this workshop the German CMDF acquired a first relationship to the new Fraunhofer network for Cocreation Labs and MakerSpaces (CLMS community). FIT actively supported the kick-off for this special interest group from the very beginning. A first meeting in person was scheduled in March 2020 but was canceled due to COVID-19. An email-distribution list was created, and from the beginning of August all iPRODUCE events and German CMDF workshop invitations were shared with the Fraunhofer CLMS community.

The official kick-off took place virtually in October. The community is spread all over Germany and the Fraunhofer headquarter officially launched this community on CLMS topics, as they fit perfectly in its breadth with the different transfer formats within Fraunhofer. The offers developed in the context of CLMS, considered almost all transfer paths targeted by Fraunhofer and thus make a comprehensive contribution to the further development of Fraunhofer in, for and with society in Germany and beyond.

[12] www.tinkercad.com

2.5. Workshop 5: Virtual hands-on workshop to TinkerCad and construction of a 3D-print for giveaways

In order to attract more participants from industry and SMEs, the fifth workshop aimed to present the CMDF with a hands-on topic. The idea to invite SMEs creating 3D-printed Christmas give-aways was a result of a brainstorming session within CMDF partners and feedback collected during the previous workshop. One participant mentioned that he had not imagined that producing a simple name tag in 3D is as easy. Therefore, this workshop was solely dedicated to instructing participants step-by-step to 3D-design using Tinkercad and then offering to produce a small number of 3D-prints and send them to the company by parcel. We expected that offering this workshop 8 weeks before Christmas might evoke a larger number of participants.

Date

28.10.2020

Title

Session #5 " Creating innovations from the home office: 3D printing for giveaways – Christmas special"

Table 5 Participants and Agenda Workshop 5

Participants				
Registered	**SME**	**R&D**	**Maker**	**Bigger Companies**
5	5	-	-	-
Agenda				
17:30	ZENIT	- Short introduction with all participants Who are we, what can we do, what are we looking for?		
17:40	MSB	- Step-by-step Tinkercad and 3D-print model design		
18:30	ZENIT	Q&A and Networking		

2.5.1. Workshop Contents

MSB introduced the software Tinkercad. MSB shared the link and login credentials with the five workshop participants first. Then all participants were instructed to the same example exercise as described with Workshop #4. The instructor helped step-by-step to open a file (name tag for a key chain) and customize it. Once completed, all participants saved their Tinkercad-file and sent it to MSB.

Upon request, MSB printed three of them using their 3D-printing farm and sent them to the post address of the respective participant.

2.5.2. Workshop Enrolment

All 5 participants had heard about MakerSpaces previously and wanted to "see" how 3D-printing works and what they could do with it. None of them claimed interest in creating a Christmas Gift, as foreseen.

Therefore, the name tag exercise, done during the previous workshop, was repeated, as it would allow all participants doing first steps using Tinkercad software and creating a personalized name tag, thus finishing their first 3D-print project within 1 hour. During the workshop step-by-step-instructions were given to make sure all participants could follow the presentation, screen sharing was used and given the small group size all participants were able to finalize the personalized name tag, save the file and send it to MSB.

After having completed the exercise, one participant asked for more example 3D-prints done by MSB. He wanted to understand the capacity and technical facts of their 3D-printing farm. To answer this request the instructor spontaneously presented the 3D-printers available at the moment and discussed MSBs' purchasing plans.

2.6. Reflections and Results of the Workshop Series

In autumn the number of interested participants was very low, in spite of strong marketing activities. We assumed that potential SME's are occupied organizing changes due to COVID-19 pandemic. Although the pandemic situation in Germany was under control, some participants shared that their company was struggling with implementing hygiene related activities, that longer term activities or even innovation projects previously planned were postponed to free capacities to accommodate employees' home office situation.

During the course of the workshop series, participants' registrations decreased continuously. In spite of the promising large participant numbers in the beginning of the workshop series. One exception was the acquisition of members of the Fraunhofer CLMS community that were actively connecting and are regularly collaborating now.

In early October, the German CMDF (MSB) received a direct Email request to collaborate on a project with BWI[13]. Being the IT-service provider of the German Bundeswehr (armed forces), they contacted the CMDF based on a search in Google and an extensive prototyping project was carried out.

As a conclusion of the decreasing number of participants and the direct contact to BWI, we decided to discontinue the workshop series after 5 sessions.

Other possible reasons for less participants during the last workshops are: (a) vacation time in August; (b) very specific topics at the last workshops, earlier workshops had more general topics and discussions. This was considered as one finding and communicated as recommendation to other CMDFs.

[13] https://www.bwi.de/

3. Exploratory studies on Collaborative Testing and Training in MakerSpaces/ FabLabs

FIT had planned to do an ethnographic study within MakerSpace Bonn (MSB) during the first year of the iPRODUCE project. The qualitative data collected should have revealed: (1) tools and machinery most frequently used in FabLabs, (2) educational approaches used during the hands-on workshops and DIY-sessions, and (3) experiences on frequently asked questions by FabLab users.

Due to COVID-19 restrictions the planned study design had to be adopted and FIT decided to use remote semi-structured interviews to gather the required information (Section 3.1).

Moreover, in the course of FIT's design thinking activities, an additional focus group was set up to further support the development of information about MakerSpaces' potential for collaborative services (Section 3.2).

3.1. Interviews with instructors/start-ups on the topic innovation in MakerSpaces November 2021

3.1.1. Research Method

FIT conducted four interviews with instructors (responsible for teaching machine use) from MakerSpaces, namely FabLab Vosges and Excelcar, as well as a representative of the start-up Cairn-Devices, all situated in France. The remote interview series was set up to highlight the innovation processes of start-ups (both from the view of their instructors at the MakerSpace as well as the the-up's view itself) and elicit associated pain points and thus, needs for supportive collaborative services. The central question was, in which way can the innovation processes be supported? In this way, the focus was not on the use of machines and tools in the MakerSpaces, that is the technical knowledge, but on the procedural knowledge regarding collaboration with stakeholders, transfer of knowledge, and development of ideas.

The interviews took place online via MS Teams due to the COVID-19 pandemic's restrictions. Each interview took approximately one hour and included the interviewee and two researchers from FIT in the roles of interviewer and recorder. In addition to taking notes manually, the interviews were recorded with the interviewee's permission for subsequent consultation. The interview was semi-structured, being oriented by an introductory section including demographics and several questions about the process of initiating and following through with collaborations with clients and partners, creating prototypes, and the knowledge and skill exchange during production. From the interview data, pain points that address needs within the collaborative process were extracted and further refined to explore concrete needs for collaborative services.

3.1.2. Trigger Questions

The following questions were used to trigger the discussion:

- Demographic questions
- How old are you?
- What is your gender?

- In which domain are you working?
- What is your official job title?
- What is your background?
- How much experience do you have in the topics you are working on in the FabLab?
- Research Questions
- What is your organization doing?
- Tell me what is your role?

o fulltime/ hobby?

o skills

- Have you experienced situations with people from companies, entrepreneurs, students or inventors who asked you for support in building a first demonstrator or prototype of their idea / innovation?
- Please think of one of those experiences and tell me about this collaboration:

o How did the entrepreneur get to know you?

o Who actually initiated your collaboration?

o What were the production steps done to build the prototype:

o Do you have a picture of the prototype?

▪ Picture of Final product?

▪ Website

o How long did it take from the first contact between the entrepreneur and you to having the final prototype?

o What exactly was the SME / entrepreneur looking for?

▪ Skills/ knowledge?

▪ Tools?

▪ Material?

o How did the entrepreneur know, who is the expert on this/ who he should ask?

o What resources (material, knowledge, book, online platform, etc.) were used during the production process?

Table 6 Overview of participants' demographic data

#	Date	Job Title	Age	Gender	Role / Tasks	What is your professional background?	How much experience do you have in the topics you are working on in the fablab?
1	11.11.2020	Instructor / Research	23	male	„Living Lab Manager" Instructor Maintenance of the machines 50% part time job	Mechanical design engineering (actually have a degree) Product Design and Manufacturing Processes Master to be done soon	1 year
2	11.11.2020	Director	62	male	Director	electronics engineer and a computer science master applied to management	5 years
3	17.11.2020	Project Leader	27	male	support partners to set up industrial projects, put in place industrial equipment that they invest for their project Project engineering for Industry and Automotive	Masters Degree in energy / Masters in innovation and entrepreneurship	3 years
4	18.11.2020	CTO	27	male	Chief Technology Officer (CTO), lead design	aeronautics	4 years since founding the company

3.1.3. Results (Pain Points)

The interviews revealed two major pain points as critical points in the manufacturing process that start-up DIY people could use support. A first aspect to be highlighted when, creating a novel product is always the matter of the budget available. One of the most important tenets to follow is to prototype and test early and often. The sooner the maker/start-up faces reality, the better the end result will be. However, prototyping requires expensive hardware, which is one reason why different start-ups come together when their businesses mutually correspond, or they revert to MakerSpaces which offer the necessary machines and tools that the start-ups need to prototype and produce effectively. This may include the production of all prototype parts, from the big, individual (e.g., shell) to the small, staple part (e.g., bolts and screws). For that reason, start-up people often acquire a membership in MakerSpaces to access all the equipment and material. On that account, MakerSpaces and FabLabs offer specific training for machine use (e.g., laser cutting machine) in order to impart the right knowledge. When their clientele (e.g., start-ups), is still new to the MakerSpace, they might offer support in producing the needed part; later, the start-ups can use the MakerSpace environment on their own. Thus, for start-ups, the MakerSpaces' support and resources are crucial for their manufacturing process, whereas the interaction with makers is often essential in imparting them the right practical knowledge. Moreover, several start-ups might come together with other start-ups to share hardware/machines.

Another aspect concerns feasibility and proof of concept. The interviews revealed that one of the most important milestones in the manufacturing process is the verification of the product's use and purpose, the so-called proof of concept. Until that point, the project so to say still 'hangs in the air'. In fact, the start-up member told how difficult the process of finding funding is, as potential funders may not realize the potential of a project. Also for the start-up itself it is crucial to see if it is on the right track or should change or adapt directions. This is where the human-centeredness aspect of the manufacturing process comes into play: The start-up or maker must ascertain whether the product (prototype) fulfills the user needs and, in this way, does what it is supposed to do. On the one hand, start-ups struggle to gain information about feasibility and market interest via surveys and interviews. On the other hand, the proof of concept also requires extensive prototyping and testing. For this, again, they make use of the environment and expertise of MakerSpaces.

Thus, the interviews revealed two major weaknesses of entrepreneurial manufacturing: First, these manufacturers struggle with high hardware cost combined with generally low budgets. Second, and most importantly at this point, they struggle to prove the feasibility and usefulness of their product ideas, for which close cooperation with MakerSpace can be helpful (see Section 5: CMDF Service "Live-Prototyping").

3.2. Focus Group with MakerSpace Bonn for Discovering Strengths of MakerSpaces in Collaborative Services

3.2.1. Research method: online focus group (methodological considerations)

As an introduction to the concept and application of design thinking, a workshop was conducted with makers from the MakerSpace Bonn (MSB) in the form of a focus group. The workshop served two main purposes: First, it should inform the planning and development of collaborative services of the German CMDF in the MSB by discovering the methodological strengths and foci of makers and accordingly, MakerSpaces. Second, it should directly provide makers with insights and information regarding the applicability of design thinking in the MSB and elicit discussions around their current practice, its benefits and shortcomings, and possibilities of improvement. Hence, it also served as a preparation and data collection for the development of a design thinking training, to be presented in D3.4. The training is developed and applied in MakerSpaces in order to impart those design thinking methods that are suitable to the specific work and context of MakerSpaces. The focus group methodology was chosen for all that in order to encourage open discussions by bringing the makers together, asking open-ended questions, and challenging their ways of doing things. In fact, this workshop represented one of the rare occasions that a considerable number of makers from the MSB come together – may it be virtually or physically.

The focus group workshop took place online due to the regulations in the course of the COVID-19 pandemic. The browser application MURAL served as a digital whiteboard with which the phases and methods of design thinking could be presented and information added by the participants. MURAL allows for an easy use of multiple composition and presentation features such as sticky notes, text fields, lines, and arrows. Thus, MURAL served both as a presentation tool and an online collaboration platform. Regarding the former, MURAL allows to arrange information in a structured way and includes a presentation mode that shifts the view of the other participants to the facilitator's slides or point of view. As a tool to facilitate collaboration, MURAL provides an open space to share ideas and contributions for all participants to see, complement, and mutually discuss. Via the collaboration features on MURAL, contributions can be elicited also from those individuals who are rather reserved in open (face-to-face) discussions. The conduction of the workshop took four hours with a break of 20 minutes in between. Seven makers attended, whereas two researchers from Fraunhofer FIT led the discussions and took notes. In addition, the audio was recorded.

3.2.2. The setup of the online focus group (practical considerations)

At the beginning, the makers were asked to state their occupation, what they do at the MSB, and what they already know about design thinking. As with the following tasks, the answers were put on virtual sticky notes, which were differently colored for each participating maker. The ensuing discussion showed that only one of the seven makers had had concrete experience with the design thinking methodology and successfully applied it in his work. Another one had some knowledge and training but no practical experience. Makers were rather skeptical whether design thinking could be applied to a context that is as technical as MakerSpaces and whether it would have a benefit over old, established methods.

The workshop was centered on several voting sessions in which the makers had to rate the design thinking phases and methods according to different dimensions. After the initial discussion, the five phases of design thinking – empathize, define, ideate, prototype, and evaluate – were shortly presented to give the makers a primary understanding. They were then asked to rate each phase on

two scales each, that is importance and applicability in the MakerSpace. The individual votes were indicated by the sticky notes in the color of the participants. A respective voting session took place at the very end of the workshop in order to determine any change in perspective and learning regarding the design thinking methodology in the context of makers' work.

The main part of the workshop (between the initial and the conclusive voting) consisted of an introduction to the different methods and an ensuing discussion for each of the five phases, respectively. For this purpose, methods of each phase were presented and explained, when necessary, with examples. The participants were then asked to discuss these and virtually stick a note with the name of the method in a coordinate system with the already known dimensions, applicability and importance. In this way, the two dimensions served as topics for eliciting the makers' knowledge of their everyday work. Indeed, this method directly elicited extensive and substantial discussions which provided insights into the distinct MakerSpace procedures of project work and interacting with visitors and other stakeholders.

3.2.3. Results (analytical considerations)

It was shown that the focus group methodology was suitable to elicit open and stimulating discussions centered on the different methods and the concept of design thinking with regards to how makers carry out projects. Notably, in the discussion, the makers made a difference between two main groups of clientele or "users" in the MakerSpace:

The first kind of clientele are those visitors who come on their own with some rather small work to be done to the MSB (e.g., a single, individual 3D print) for an individual project. The part of the makers is then to help them use the machine as well as enrich and implement their ideas. Thus, it is more of a collaborative approach to the maker-visitor interaction.

The second user group constitutes those groups or organizations (e.g., teacher with students or sponsors) with a more or less defined project and agenda (e.g., a teaching course, a project to develop a product, or components for a product of their own). In contrast to the first group, hereby, makers realize the projects to a large part themselves and not just help the client out with them.

Altogether, it was shown that the clientele in the MakerSpace is very diverse. No two makers/projects are the same, and every project requires a new way of approaching it. This diversity makes it difficult for some makers to achieve a common ground with the clientele, often resulting in misunderstandings. Thus, the results showed the need for communication and empathizing skills with visitors on the one hand and organization and decision-making procedures in the course of internal project meetings and discussions with fellow makers on the other hand. This led to the conclusion to design not only a design thinking methods' training for makers but also a training dedicated to quick and democratic decision making in a MakerSpace context. Both are summarized and evaluated in Task 3.4.

Moreover, the focus group highlighted the makers' practical expertise with prototyping and testing. Whereas the knowledge of the other design thinking phases is limited (albeit considerable from a practical standpoint), prototyping is where makers obviously excel – due to their expertise as well as the technical MakerSpace environment. This emphasizes the benefits stakeholders may gain from engaging in various services conducted by and with the help of MSB (see Section 5: CMDF Service "Live-Prototyping"). Besides, although the approach to user testing may be less conceptually defined than the scientific approach in HCI research, makers possess extensive practical knowledge of how to test the artifacts that are created in the MakerSpace. Especially when the focus of software or hardware is not necessarily on the end-user and seamless real-world integration (e.g., a mobile app)

but rather on tool and gadget use for further implementation of solutions (e.g., a technical toolkit), makers bring all the know how to act as test users with an eye for improvements (see Section 6: CMDF Service "Nerd Testing").

3.2.4. Key Learnings

This focus group with makers from the MSB provided deep insights into the makers' approaches to innovation and creation and thereby informed the planning of both maker training (see D3.4) and services to be offered in MSB (see Sections 5 and 6).

On the one hand, by pointing out those methods suitable for the MakerSpace context and the apparent already-existing expertise in prototyping and testing, a subsequent design thinking training focusing on empathize, define, and ideate was developed and applied. Besides, the diverse range of stakeholders and clientele gave rise to the second kind of training for decision-making and communication (see D.3.4).

On the other hand, this expertise supports the development of services offered by the German CMDF in the MSB, making use of the makers' capacity to prototype and evaluate/test. In this way, the focus group elicited the strengths of makers, whereas the interviews with instructors and start-ups (Section 3.1) elicited the weaknesses of possible clientele. Both parts were integrated to inform the development of the German CMDF's services.

3.3. Analysis collaborative testing and training

Finally, we conducted an ideation session where we tried to generate ideas for new collaborative services that could be offered by the German CMDF. For this, we combined the results of the two sections held beforehand. Section 3.1 revealed the weak points of start-ups in innovation processes. In particular, how they struggle to show that an idea really works, i.e., whether the product does what it is supposed to do and whether it suits its users' needs. Section 3.2 showed the strengths of MakerSpaces. These lay mainly in the phases *prototype* and *evaluate* of the design thinking process.

Hence, we attempted to ideate how to address the weak points of Section 3.1 with the strengths of Section 3.2.

Building prototypes and running user tests is an approved approach for testing and proving if a product suits its users' needs. Since prototyping and evaluating are the strong sides of MakerSpaces, offering services from that range would make sense in order to address the aforementioned needs of start-ups. Besides providing knowledge and consultancy about prototyping and evaluation processes, we thought about how we can exploit a characteristic that is unique to MakerSpaces. This characteristic is its members. MakerSpace members are often a very particular type of person, highly motivated to try out new things, especially when it comes to technology. Since finding test users is often a problem when conducting user evaluations, the idea grew to offer a service for testing especially those products that are of interest for techies or "Nerds" as we chose the self-ironic term for the "Nerd Testing" service that is further described in Chapter 5.

The second service was born from a concrete request that reached MSB. It is fully in line with the strengths that are identified in Section 3.2, i.e., with the huge expertise of MakerSpaces to create prototypes of different kinds and to do this fast and efficiently. The service extends the well-known

concept of rapid prototyping by saying: We create prototypes even more rapidly; we do it live during the customers' innovation workshops. This "Live-Prototyping" service is further described in Chapter 4.

4. CMDF Service "Live-Prototyping"

Next to our assumptions and feedback collected during the workshop-series in 2020 and the exploratory study undertaken in October and November 2020, the Prototyping project with BWI was an inspirational starting point for creating the "Live-Prototyping Service".

The following section describes how BWI got in touch with the German CMDF, the project course and our related assumptions and conclusions. As in person observation was not possible due to the pandemic situation, the information was collected during two dedicated reflection sessions:

1. Remote Interview with instructor from MSB in January 2021

2. Remote participatory observation and group interview of the status meeting with BWI on February 18, 2021

4.1. Prototyping Cooperation with an SME

BWI is the IT service provider of the German armed forces and also supports other IT related projects for the German Government. They have their headquarters in Bonn and offices in Munich and Berlin. BWI has about approx. 5000 employees throughout Germany.

How did the project come about?

Within BWI an internal ideas' competition "Property of the future – this is where I want to serve, live and work" took place in early summer 2020. From a total of approx. 100 ideas, 10 were invited to pitch their idea in front of a steering committee in BWI. The 5 best ideas were selected, and a corresponding budget was made available to the project team.

One of the teams had pitched their idea for a "Real Estate Model" project. The model should serve as a demonstrator, rendering tangible the potential of IoT technologies for better "serving, living and working". The team consists of 5 IoT-enthusiasts, a part of the small maker community within BWI. They meet regularly in BWI-premises in Munich after official hours, to discuss maker topics and collaborate on their private IoT-projects. This informal community unites different hierarchical levels and business areas. The team leader works in the innovation management department of BWI and acted as a project manager to the maker group. He initiated the application idea for the "Real Estate Model" project.

How has the project progressed so far?

The two events ("Hackathons") in the MSB facility were preceded by design thinking workshops. The workshop sharpened the idea and BWI decided that the team wanted to build a transportable model. The project is seen as an experiment, to test the ideas. Two personas were created to guide the ideation process. The first one presented BWI office workers and the second one BWI property managers.

The decision that the project team should build the "Real Estate Model" on their own was taken for the following two reasons:

1. Edutainment: The event character / hackathon format serves to retain employees and motivate them through the mixture of learning and fun.

2. Personnel marketing: The "Communication & Marketing" department uses the project for personnel marketing. “They were happy that they could show something other than server racks” A video film and professional photos were made. The publication of the video on the BWI YouTube channel has been postponed due to the pandemic situation.

BWI is considering applying IoT technology to their Real Estate in the future. They aim to establish further expertise in this field and strategically imagine building up a new line of business.

In early October BWI searched Google for “MakerSpace Bonn” and found MSB directly. The team lead contacted MSB by email. Only 6 weeks passed for processing the complete offer and planning the activities.

The first BWI-hackathon took place in October 2020.

BWI decided to hire a MakerSpace because:

- Location: Employees from Bonn and Munich were involved, so a common place of work was needed. BWI offices in Bonn had already served as a meeting point, but there was no equipment (3D printer, workshop, and tools) to build prototypes of the targeted size and scope.
- Cost savings: The commissioning of MakerSpace Bonn was very inexpensive compared to conference hotels.
- Easy handling: BWI received an “All-In-One” proposal from MSB. It included procurement of consumables (handicraft material, IT consumables), use of the location including all tools (3D printer and workshop) and know-how support (daily changing association members of the MSB provided support with Tinkercad methodology, 3D printing and programming if required and ad hoc).
- Outsourcing of partial tasks: In order to enable safe transportation of the final “Real Estate Model”, MSB procured two metal transport boxes and during construction performed all measures needed to construct the model in a way, to be safely dismantled and transported after completion.

Reflecting on the first hackathon BWI adds the following two reasons:

- Flexibility: When the second face-to-face meeting in December threatened to fail due to Corona, MSB sent small work packages to individual team members by post, making it possible for 5 employees on site and 15 employees to continue working on the project remotely.
- On-site inspiration: One MSB member added his IoT-invention a “Plant Irrigation System” to the model. This happened spontaneously in consultation with BWI.

During the two hackathons collaboration tools such as Trello, Slack and Discord were used. The second hackathon in early December had taken place under strict pandemic restrictions, with only 3 MSB members present in the MSB facility and all other team members collaborating remotely. In order to keep track of the progress and distribute tasks status meetings with all team members were held 3 times a day. If necessary, work was carried out in small groups in order to impart certain knowledge and to cope with specific problems. Depending on the progress, the project backlog has been continuously adapted, some desired features therefore are not built into the model.

4.2. Promoting Live-Prototyping as a CMDF Service

As a result of the BWI project the German CMDF decided to develop a new approach. The story of BWI building and shaping their IoT-model with the help of the German CMDF was found to be an excellent project example that can be used to promote the related services as a best practice.

The German CMDFs' focus is to acquire more industry partners or SMEs for similar collaboration projects. In order to increase acquisitions on a local level, the German CMDF decided to launch two promotional activities: (1) creating a Service-Flyer and (2) presenting the Service at virtual public talks.

Figure 4. shows the final version of the Live Prototyping Service Flyer.

Figure 4 iPRODUCE Live Prototyping Service – 2 pages flyer

The first page of the flyer contains a brief description of the service offered, followed by a more detailed explanation of tools available and support activities that can be performed by the CMDF. The second page tells the story of the successful BWI collaborative project.

The service offering has been presented during two public talks for now. The first talk was held during the virtual HannoverMesse 2021, on April 12th, 2021 and the second talk was held during a virtual conference organized by Wirtschaftsförderung Bonn, one of the three core partners of the German CMDF.

We plan to use more local promoters. We have already started related activities with the city of Bonn. The German CMDF member ZENIT GmbH also performed a directed search within their SME database, to identify companies with similar profiles to BWI. We plan to contact them individually to

present our service proposal. We believe that the success story is a great tool to point out to the built-up advantages and unique selling points of MakerSpaces and to make them known in the industry.

4.3. Preparation of first sessions with companies

This section presents the plan on how to set up the first sessions of the live-prototyping service with companies, where we will try out the service to receive feedback so that we can refine it.

4.3.1. Whom do we address?

Companies that are located within the radius of the MakerSpace Bonn (up to 70 km distance) and are (possibly producing) industrial companies. The industry domain does not matter. Ideally, the company already has a concrete challenge in mind that they want to solve.

4.3.2. What can I expect as a company if I participate?

As a company team, we will be guided by FIT employees to define our challenge in concrete terms and to generate solution ideas based on this. In the next step, we will be supported in selecting the best ideas, concretizing them and developing prototypes from them. Employees of the MakerSpace Bonn help us to implement the prototypes. Techniques such as 3D printing, software programming or sensor technology can be used. Employees of the Maker Space Bonn explain the different techniques and for which prototypes they are suitable. They give us guidance so that we can work independently. The construction of a 3D model can also be done virtually. Step by step, we will be supported to refine and improve our prototypes.

4.3.3. What is the benefit of participation for the company?

At the end of the workshop, a challenge has been concretely defined and a solution idea has been prototyped. All participating employees learn relevant methodologies of the design thinking process and take this knowledge back to their daily work. Furthermore, the workshop participants acquire knowledge in the development of prototypes. A concrete result of the workshop is a product prototype, which they can also have sent to the makerspace after the workshop. The workshop offers the opportunity for an exchange between the employees.

4.3.4. What should the company bring along?

To achieve good results, it is an advantage if the company already has challenges in mind for which they would like to find solutions. An example could be the brief: "We make shutters and want to network them over the Internet."

4.3.5. How does the "live prototyping workshop" work?

There is a preliminary meeting/pre-workshop with the client so that FIT and the MakerSpace Bonn can work together to develop an agenda in response to the client company's challenges. This would last about half an hour to explore what is at stake. The workshop has a duration of minimum 2 days. The duration will be defined based on the complexity of the challenge. Due to the Corona pandemic, the workshop might be virtual. We will use the first day to detail the challenge and get some initial ideas. Two FIT institute staff members will methodically guide through this day. On the second day, we will concretize the ideas into prototypes and produce them together with the MakerSpace Bonn. There will

be employees of different disciplines in the MakerSpace Bonn, who will support in an advisory capacity and implement the prototype for the client. If the MakerSpace cannot receive guests, the prototype can also be sent by mail.

4.3.6. How can FIT and MSB support the client beyond the workshop?

We are happy to support the client in detailing the product beyond the workshop. For example, FIT staff can assist them with further training and consulting on user-centered product design and usability. Maker Space Bonn employees will support the client by providing suitable premises for the further development of the prototypes and by advising them on manufacturing processes and materials.

4.3.7. How will the sessions be evaluated?

We give workshop participants a questionnaire at the end of the workshop. In addition, there should be an observer from the team who is not a workshop facilitator to provide additional feedback.

5. CMDF Service "Nerd Testing"

In addition to the Live-Prototyping service, an additional service was outlined, focussing not on prototyping new artifacts, but testing existing ones. This service was appropriately named "Nerd Testing" to reflect the particular user group that makers constitute. This service is an idea that came up during a brainstorming session, concluding that this could be something of interest to certain companies. The service will be only outline briefly here as the development phase is not yet concluded.

The idea of the Nerd Testing is as follows: Potential clients (start-ups, companies, etc.) of the MSB have a product or prototype that they need to test or perhaps conduct a proof of concept. Obviously, for this, they need to test with unbiased users - people without any preconceptions and foreknowledge who can try out using the product for carrying out a typical task with it. The client would then ask the MSB for available "nerd testers". These would simply be members of the MakerSpace who constitute, in this way, a particular user group that is 'tech-savvy' and unbiased as they did not yet take part in the development of the soft- or hardware. Obviously, the tested products or prototypes would fall into a certain category of rather technical tools – those that the nerd testers would be the typical user group. The main benefit for the client would be freely available and highly motivated test users who are technophile and can thus provide helpful insights into and tips for the suitability and further improvements of the prototype. Note that typically, test users are *not* to be tech-savvy as normally, end users, contrary to the developers, have rather little technical knowledge and are used to usable interfaces. In contrast, here, nerd testers cannot only provide feedback regarding the usability (and do perhaps less so) but rather focus on technical feasibility. Therefore, the prototypes would tend to be – albeit not necessarily – in a rather early stage of development when not the interface itself but rather the technical arrangement is crucial.

The Nerd Testing service will be accompanied by the necessary skills for conducting effective and unbiased user tests. The expertise for this is provided by the German CMDF. So, companies could commission the German CMDF to conduct the user testing. Then, the German CMDF would plan and apply the tests, taking care that excellent testing principles are applied. They would also document the test results in an appropriate manner so that they can be used by the customer to devise next steps for improving the current product prototype.

The Nerd Testing Service is further developed at the moment. It will be advertised via the ZENIT network in order to find customers for trying it out – equal to what is planned with the Live-Prototyping Service. The elaborated service and the insights from the application workshops will be described in D5.12 – Collaborative Testing and Training Sessions 2.

6. Conclusions

The works described in this Deliverable aim at defining collaborative services and training offered by CMDFs, which could be of interest for companies, especially SMEs.

The Deliverable presented a collaborative online workshop series, exploratory studies and the resulting findings and Service-Ideas of the German CMDF. We present activities run with the German CMDF as general examples, to keep this report concise and short. From our perspective, it leads the path towards the activities ran by the other iPRODUCE CMDFs. The German CMDF has a dedicated focus on Training and Service-Innovation and therefore, other partners of T5.6 contributed to our research findings, during WP5 related meetings, by giving valuable feedback and inputs during informal discussions and joining dedicated interviews and focus group meetings.

As we consider D5.11 being a preliminary version of D5.12, we plan to report on dedicated CMDF Testing and Training related activities and workshops organized and run by other CMDFs in this second version.

Our summarized conclusions are the following:

The online workshop series that was conducted by the German CMDF over the course of 2020 helped to get a feeling about what companies might find interesting when looking at a CMDF in general. It was confirmed that the CMDF is expected to be a place of innovation where up-to-date knowledge about recent technologies and developments can be learned. For instance, the topic of how to organize the changed remote work during COVID-19 lockdown times and which tools to use gained some interest. However, the workshop series format as such is not suited as a potential commercial service.

The interviews with instructors/start-ups revealed the weak points of start-ups in innovation processes. In particular, they struggle to show that an idea really works, i.e., whether the product does what it is supposed to do and whether it suits its users' needs. The focus group workshop showed the strengths of CMDFs. These lay mainly in the phases *prototype* and *evaluate* of the design thinking process.

The collaboration services that are described so far address these identified characteristics. First, there is the service for testing especially those products that are of interest for tech savvy people. This is accompanied by providing knowledge and consultancy about prototyping and evaluation processes. Second, there is the Live-Prototyping service, which extends the well-known concept of rapid prototyping by saying: We create prototypes even more rapidly; we do it live during the customers' innovation workshops. This exploits the huge expertise of a CMDF to create prototypes of different kinds and to do this fast and efficiently.

As next steps, we will apply these services with companies from the network of the German CMDF for getting experience and for refining them further. In addition to this, we might come up with more collaboration services.

Next to this, we also plan to highlight related activities of other CMDFs in the second half of the project. Some other CMDFs are working towards own testing and training services. Deliverable D5.12 should therefore shed light on their offerings and focus on further replicating and exploiting those. Thus exchanging ideas within iPRODUCE CMDFs.

PRODUCE

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