

Lena Tørresdal

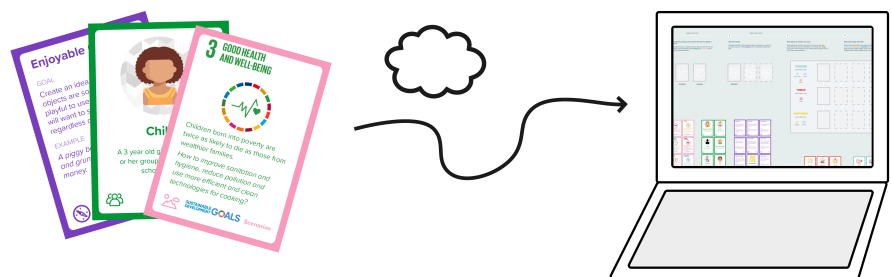
Digitiles: A Digital Transformation of a Card-Based Design Toolkit

Master's thesis in Informatics

Supervisor: Monica Divitini

Co-supervisor: Francesco Valerio Gianni

June 2021



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Department of Computer Science



NTNU

Kunnskap for en bedre verden

Abstract

Tiles is a card-based design toolkit supporting non-experts in idea generation. As remote teams and digital collaboration are becoming more common, it is important to enable idea generation and brainstorming activities in the digital environment, such as through digital card-based design tools.

This thesis focuses on creating a digital version of Tiles to allow people to work together in creative co-design workshops, regardless of where they are located. The digital toolkit aims to support creativity and cooperation in idea generation workshops. An initial review served to identify a gap in the research of digital card-based design tools, and this thesis focuses on contributing to filling this gap by researching and evaluating the digital transformation of a physical card-based design toolkit.

The research is grounded in design science research methodology. A literature review was performed to examine card-based design tools characteristics, and to identify design requirements of digital card-based design tools. Interviews were conducted with participants having expert knowledge of Tiles and other card-based tools, to identify characteristics of Tiles, and to investigate how these characteristics could be transferred to a digital toolkit.

Data from the literature review and the interviews resulted in requirements and suggested functionalities for the design of a digital prototype, named Digitiles. Digitiles became a fully functional prototype of a card-based design toolkit that was implemented using an existing platform. The prototype went through three design iterations and was evaluated by performing usability tests and online co-design workshops. The digital toolkit can be accessed from web browsers on any computer.

The results contribute to increased knowledge of the transformation of card-based design tools from the physical to the digital environment. The findings from the evaluation of Digitiles suggested that it was fun to use, and that the prototype supported creativity and cooperation in digital idea generation workshops. The results of the evaluation are mostly specific to Digitiles. However, the requirements and implemented functionalities can be reused when digitally transforming other card-based design tools, or when developing new digital card-based design tools.

Sammendrag

Tiles er et kortbasert designverktøy som støtter ikke-eksperter innen idémyldring. Ettersom eksterne team og digitalt samarbeid blir stadig vanligere, er det viktig å muliggjøre digitale idémyldringsaktiviteter, for eksempel gjennom digitale kortbaserte designverktøy.

Denne oppgaven fokuserer på å lage en digital versjon av Tiles, slik at folk kan jobbe i kreative samarbeidsdesignøkter, uavhengig av hvor de befinner seg. Det digitale verktøyet har som mål å støtte kreativitet og samarbeid i idémyldringsøkter. Et behov for mer forskning av digitale kortbaserte verktøy ble oppdaget, og denne oppgaven forsøker å bidra til økt kunnskap innenfor dette området, ved å undersøke og evaluere den digitale overføringen av et fysisk kortbasert designverktøy.

Forskningen er forankret i design science research-metodikken. En litteraturgjennomgang ble utført for å undersøke kortbaserte designverktøy og deres egenskaper, og for å identifisere designkrav til digitale kortbaserte designverktøy. Intervjuer ble gjennomført med deltakere som hadde god kunnskap om Tiles og andre kortbaserte designverktøy, for å identifisere egenskapene ved Tiles, og for å undersøke hvordan disse egenskapene kunne overføres til et digitalt verktøy.

Litteraturgjennomgangen og intervjuene resulterte i krav og foreslåtte funksjonaliteter for utformingen av en digital prototype, kalt Digitiles. Digitiles ble en full funksjonell prototype av et kortbasert designverktøy som ble implementert ved bruk av en eksisterende plattform. Prototypen gjennomgikk tre designiterasjoner, og ble evaluert ved å utføre brukbarhetstester og digitale idémyldringsøkter med flere brukere. Det digitale verktøyet kan brukes gjennom nettlesere på hvilken som helst datamaskin.

Resultatene bidrar til økt kunnskap om overføringen av kortbaserte designverktøy fra fysisk til digital versjon. Funnene fra evalueringen av Digitiles avslører at det var morsomt å bruke verktøyet, og at prototypen støtter kreativitet og samarbeid i digitale idémyldringsøkter. Resultatene av evalueringene er stort sett spesifikke for Digitiles, selv om det er mulig å gjenbruke kravene og de implementerte funksjonalitetene i den digitale overføringen av andre kortbaserte designverktøy, eller når man utvikler et nytt digitalt kortbasert designverktøy.

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Acronyms

COVID-19 Coronavirus disease of 2019.

DSR Design science research.

FR Functional requirement.

HCI Human-Computer Interaction.

IoT Internet of Things.

NSD Norwegian Centre for Research Data.

NTNU Norwegian University of Science and Technology.

PR Platform requirement.

RQ Research question.

WS Workshop.

Chapter 1

Introduction

1.1 Motivation

Card-based design tools have been valuable assets for designers and other stakeholders for many years (Roy & Warren, 2019). The goal of card-based design tools is to inspire people to think creatively and to facilitate collaboration (Aarts et al., 2020). Research has also suggested that tangible user interfaces have great effect on learning processes (Antle, Droumeva & Ha, 2009), which is the intent of many card-based design tools. Tiles is an example of such a design tool, which has been tested in multiple workshops, and has been shown to promote creativity and collaboration amongst the participants (Mora, Gianni & Divitini, 2017).

Remotely run teams and digital cooperation has become more widespread since the Coronavirus disease of 2019 (COVID-19) outbreak, and may continue to increase in the future. As technology is such an important part of everyday life, it is important to offer digital tools that facilitate creativity and cooperation in design workshops, such as card-based design tools.

The uncertainty and restrictions followed by COVID-19 has also made it more difficult for groups of people to gather physically. Physical design workshops using card-based tools are some of the affected activities, since it requires the participants to be co-located. Such design tools are most often used in academic situations, and at the time of writing, governments are still trying to limit any physical gatherings that are not strictly necessary, meaning these kinds of activities are just not feasible.

This thesis will focus on transforming the physical Tiles toolkit into a digital toolkit. The aim is to develop a digital toolkit that is both enjoyable and supports creativity and cooperation in digital idea generation workshops. This way, Tiles can continue to promote creativity and cooperation in both online and offline design workshops.

At the same time, there seems to be a gap in the research of digital card-based design tools and the transformation of such tools, from the physical to the digital environment. This thesis will focus on contributing to filling this gap. Creators of card-based design tools and researchers of the Human-Computer Interaction (HCI) field may benefit from the results of this thesis, which can be used in future work and research. Designers and other stakeholders will also be able to benefit from the result, as a digital version of Tiles allows for performing digital co-design workshops without the participants having to be physically co-located.

1.2 Context

This research has been done as part of a master's thesis at the Department of Computer Science at the Norwegian University of Science and Technology (NTNU). The thesis completes the Master of Science programme in Informatics.

Tiles IoT Inventor Toolkit¹, a toolkit developed for a research project at NTNU, was used as a basis for this project. The research in this thesis focuses on developing a digital version of this toolkit.

1.3 Research Questions

This research aims to find out how to best transform the physical Tiles toolkit into a digital toolkit supporting creativity and cooperation in idea generation workshops. To support creativity, the toolkit should facilitate brainstorming of new ideas. Cooperation in idea generation workshops can be supported by creating a workspace where the participants are able to communicate, exchange ideas and work together towards a common goal. The main research question (RQ) is:

RQ1: How can Tiles be transformed into a digital toolkit supporting creativity and cooperation in idea generation workshops?

Identifying characteristics of physical card-based design tools could help create requirements that could be embedded in the digital prototype. Although physical and digital environments are different, some characteristics are considered to be important in both. Thus, a sub-question is defined as follows:

RQ1.1: What are the characteristics of card-based design tools concerning artifacts, process and cooperation in idea generation workshops, that should be considered in the digital transformation?

At the same time, in order to research how to best transform Tiles into a digital toolkit supporting creativity and cooperation in idea generation workshops, it would be useful to look at the characteristics of the physical Tiles toolkit. By

¹<https://www.tilestoolkit.io/>

investigating the use of Tiles in idea generation workshops, important characteristics concerning creativity and cooperation can be identified. This leads to a second sub-question:

RQ1.2: What are the characteristics of the physical Tiles toolkit supporting creativity and cooperation in idea generation workshops that should be considered in the digital transformation?

Once these characteristics have been identified, requirements should be created to support these characteristics in the digital toolkit, named Digitiles. A study on how these requirements can be embedded into the design of Digitiles, leads to a third sub-question:

RQ1.3: How can the identified requirements supporting creativity and cooperation in idea generation workshops be embedded in the design of Digitiles?

As the transformation of the toolkit to the digital environment would result in a new toolkit with unknown characteristics, it would be interesting to see how Digitiles is being used in digital idea generation workshops with multiple participants. This could give insightful information of the strengths and weaknesses of the digital toolkit in use. The fourth sub-question is:

RQ1.4: What are the strengths and weaknesses of Digitiles used in idea generation workshops?

1.4 Research Methods

Design science research (DSR) was chosen for this study, as the methodology provides useful guidelines for evaluating the research project (Hevner & Chatterjee, 2010). DSR focuses on developing new artifacts that solve identified problems (Hevner & Chatterjee, 2010). Figure 1.1 illustrates the work of this study in the context of the three cycles of DSR.

For the relevance cycle, the goal is to identify problems that can improve the environment. The relevance cycle also comprises the development of requirements through feedback and testing. The design cycle is about developing and testing the design solution, which could be based on results from the other cycles. The rigor cycle provides a knowledge base to the research project. It implies researching existing knowledge to guarantee that the produced design is a contribution to research (Hevner & Chatterjee, 2010).

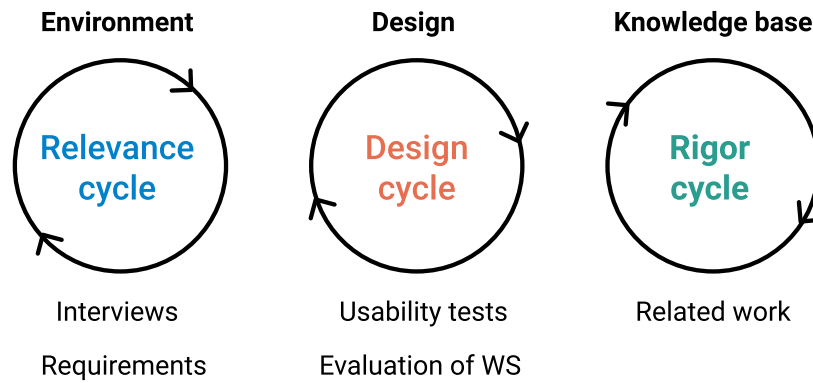


Figure 1.1: Design science research cycles.
Adapted from figure by Hevner and Chatterjee (2010).

Design science is an iterative process, and there is no detailed description on how it should be performed. Although, understanding and identifying the three cycles from figure 1.1 would be useful when performing DSR.

The research process started with comparing and analysing literature of card-based design tools. A gap in the research of digital card-based design tools was discovered during this review. The literature review helped identify characteristics of physical card-based design tools, answering RQ1.1. A set of requirements were identified from the literature review, which can be placed in the relevance cycle. The work of the literature review and related work can be placed in the rigor cycle of DSR, where the knowledge base is used for researching existing systems.

Parallel to the literature review, interviews were conducted with people who had expert knowledge of Tiles and other card-based design tools. This was done in order to gain information about different processes around card-based design tools, such as performing workshops and creating tools. The interviewees also helped identify the characteristics of the original Tiles toolkit, and how the characteristics of creativity and cooperation in idea generation workshops can be transferred from the physical to the digital environment, answering RQ1.2. From the interviews, it became clear that the research on this subject was highly relevant, and that there was indeed a demand for a digital solution of a card-based design tool. The interviews are part of the relevance cycle of DSR.

Moving to design, the outcome of the two other cycles became the starting point in designing a prototype and developing a digital solution. In the design cycle, a prototype was implemented based on the identified requirements and functionalities from the previous cycles, which was the study of RQ1.3.

The prototype was evaluated by performing usability tests and digital co-design

workshops, and went through three design iterations where it was adjusted based on the feedback from the participants. The evaluations helped identify strengths and weaknesses of the prototype, answering RQ1.4.

Several data generation methods were used during this research to collect data: interviews, group discussions, observations, questionnaires and artifact analysis. The data was analysed using both quantitative and qualitative data analysis approaches.

1.5 Results

The outcome of this study contributes to the field of card-based design tools in several ways. The findings from the literature review and the interviews suggests that there is a need for research on digital card-based design tools, the digital transformation process and evaluation of digital card-based design tools. Some of the interviewees also expressed a need for digital card-based design tools to support educational activities.

A set of functional requirements was identified from analysing card-based design tool characteristics, which can apply to other card-based design tools going through a digital transformation. From the interviews, important characteristics of Tiles were identified. In addition, the interviewees shared experiences from designing card-based design tools, performing workshops and also suggested functionalities for designing the digital prototype.

The outcome of the literature review and the interviews resulted in a fully functional digital prototype of Tiles, named Digitiles. The prototype went through multiple design iterations and was adjusted based on feedback from several users. The prototype was tested by performing usability tests and digital co-design workshops. Additional functionality that was not part of the physical toolkit was also implemented in the digital prototype, yielding good results.

The findings from the evaluation of the co-design workshops suggested that Digitiles supports creativity by facilitating generation of new ideas. It was also found that Digitiles supported cooperation in the digital idea generation workshops, by providing a digital workspace where multiple participants could exchange ideas and work together towards a common goal. The participants of the evaluation also stated that using Digitiles was fun.

1.6 Outline

- Chapter 2 presents an overview of the research problem, background information on card-based design tools, the design process and Tiles.
- Chapter 3 includes an analysis of related work, including different card-based design tools used in idea generation workshops.
- Chapter 4 describes the interviews conducted as part of the research.
- Chapter 5 presents the identified design requirements and functionalities from the previous chapters.
- Chapter 6 presents an overview of the design choices that were made to create the first version of Digitiles.
- Chapter 7 offers a description of the usability tests of Digitiles.
- Chapter 8 includes the description of the evaluation of Digitiles used in digital idea generation workshops.
- Chapter 9 summarises the research and presents a conclusion of the work.

Chapter 2

Problem Definition

Tiles has been frequently used by researchers and in academia for the past few years, however, because of the pandemic situation it has been put on hold. This thesis will contribute to making a digital version of the toolkit, so that Tiles can continue to promote collaboration and ideation processes in digital workshops, when physical attendance is difficult.

A digital transformation could also permit additional features and functionalities that would not be possible in a physical version of the toolkit. Taking advantage of existing technology might help create a customised toolkit, which can be adjusted to support multiple needs. Other possible benefits include accessing more users and production cost reduction.

At the same time, transforming the physical toolkit into a digital toolkit cannot be seen as a straightforward process. A digital version of the toolkit would be considered to be different than the original, regardless of how the toolkit is digitally transformed. It requires research to find out how to transfer the original toolkit into something that is still enjoyable, and promotes creativity and cooperation in digital idea generation workshops. It would also be interesting to add additional functionalities, and to look at how to best take advantage of going digital.

In this thesis, *card-based design tool* is used to describe both *tool* and *toolkit*. They are used interchangeably, and often in consistency with the terminology used in the papers. *Card-based tool* is also sometimes used as a shorter version of *card-based design tool*.

Section 2.1 starts with a short introduction to the history of cards used in design processes. Section 2.2 introduces Tiles.

2.1 Using Card-Based Tools in Design Processes

Using cards as part of design processes is not a new phenomenon. One of the earliest version of card-based design tools was created in 1952 (Roy & Warren, 2019). Since then, countless new card-based design tools have been created with the aim to stimulate creativity in different ways. Some tools focus on specific domains, while others can be used for general purposes for brainstorming and generating ideas (Roy & Warren, 2019). The tool could either provide strict rules and clear steps in the design process, or be more playful and free. Research has shown that cards-based tools can be used as a way of communicating ideas and making the design process less abstract (Wölfel & Merritt, 2013). Cards are simple tangible artifacts that are easy to manipulate, which makes them suitable for multiple purposes.

2.1.1 The Ideation Stage of Design Thinking

Card-based design tools can help facilitate creative combinations and information on ideas (Roy & Warren, 2019). For this reason, they are especially considered to be useful tools for the ideation stage of a design process.

Ideation or *ideate* is one of the five stages in the Design Thinking methodology (see figure 2.1). Ideation involves generating new ideas that are based on the previous stages of the Design Thinking methodology, namely *empathize* and *define* (Thoring & Müller, 2011). Once you have researched the needs of a selected user, and defined the users needs and problems, you can start generating ideas for a solution to the defined needs and problems.

An ideation phase usually involves some sort of brainstorming activities, where many ideas are produced in a short amount of time. The ideas can later be reflected on, and the participants can discuss and vote to reduce the number of ideas (Thoring & Müller, 2011). In the end, the selected idea(s) goes through the next two stages of Design Thinking, namely *prototype* and *test*. Design Thinking is an iterative process, meaning the different stages can be revisited multiple times before the idea is complete.

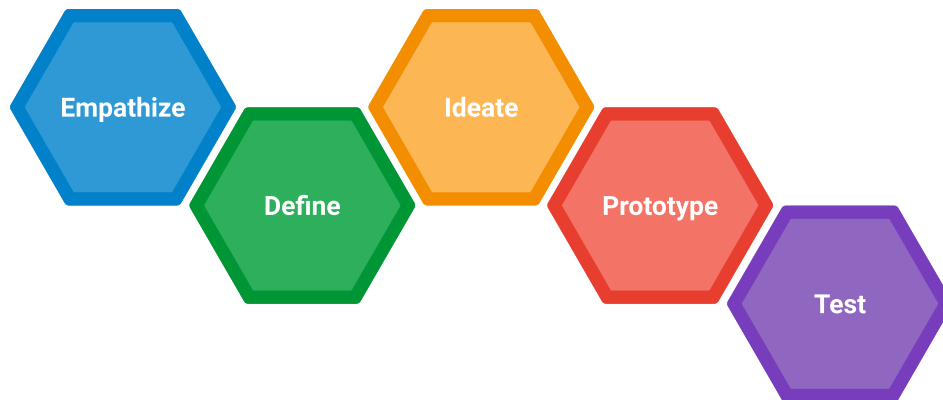


Figure 2.1: The five stages of Design Thinking.

2.2 Tiles Ideation Toolkit

Tiles is a card-based ideation toolkit with the purpose of engaging non-experts in idea generation and creativity (Mora et al., 2017). In addition to trigger brainstorming and creative collaboration, one of the focuses of this tool is to teach the users about IoT and the possibilities of building their own solutions in accordance with the UN sustainable development goals¹. Tiles has been tested in different workshops, both in primary school, secondary school, and universities (Gennari, Melonio, Rizvi & Bonani, 2017), (Mavroudi, Divitini, Gianni, Mora & Kvittem, 2018), (Mora, Gianni, Nichele & Divitini, 2018).

The Tiles IoT Inventor Toolkit consists of 126 cards and a board. Some examples of Tiles cards are shown in figure 2.2. The cards are divided into nine categories:

- Scenarios
- Personas
- Missions
- Things
- Human actions
- Sensors
- Services
- Feedback
- Criteria

¹<https://sdgs.un.org/goals>

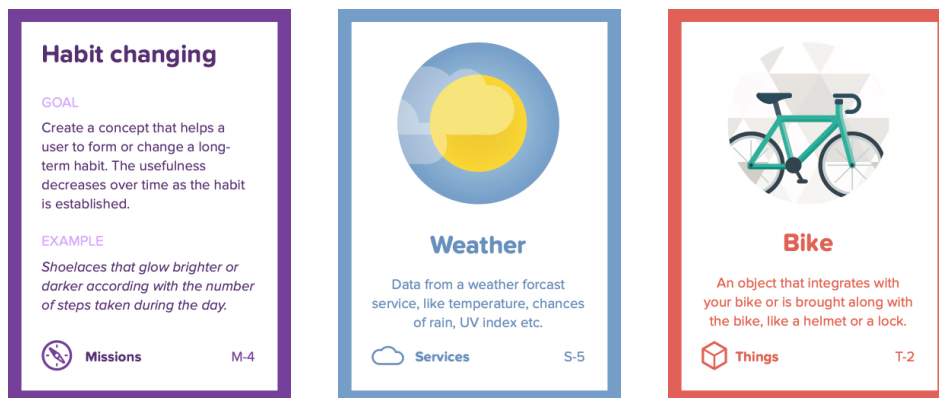


Figure 2.2: Examples of cards from the Tiles toolkit: Missions, Services and Things.

The board consists of placeholders for the cards, a section for sketching a storyboard and lines for writing down an elevator pitch. At the bottom of the board there is a playbook section with seven design steps, containing detailed information on how to use the toolkit to generate new ideas. For each design step, different categories of cards are used. The headline of the seven steps are listed below:

1. Select a persona and a scenario that you have agreed to focus on.
2. Refine the mission.
3. What objects are central to your user?
4. What actions trigger the "thing"?
5. How does the object respond when it is triggered?
6. Flesh out the idea.
7. Reflect and improve.

The participants are to follow these steps within a limited amount of time. The toolkit including the provided artifacts should give the participants enough information to use the toolkit on their own, without any need for additional information or knowledge on the subject. Figure 2.3 displays the Tiles toolkit board.

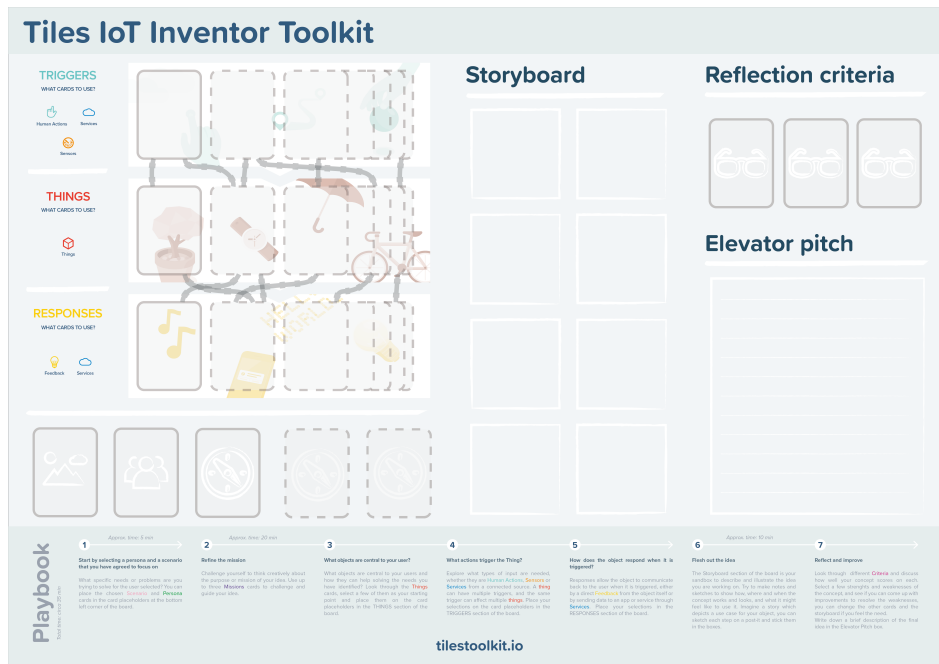


Figure 2.3: The board from the Tiles toolkit.

Chapter 3

Related Work

To develop a deeper understanding of card-based design tools and to identify important characteristics of physical card-based design tools in idea generation workshops, a literature review of existing tools was performed.

It would also have been valuable to analyse and compare digital card-based design tools, as there are different approaches to designing a digital versus a physical tool. Unfortunately, it was difficult to find enough digital public card-based design tools to do an analysis. As a consequence, it can be argued that there is a need for a digital card-based design tool, which makes this thesis a useful contribution to research, as part of transforming a card-based design tool from the physical to the digital environment.

The method used to analyse the card-based tools are described in section 3.1. Section 3.2 introduces the three physical card-based tools: Tango Cards, PLEX Cards and Toolkit to Game Design. In section 3.3 the three tools are further discussed, analysed and compared with the Tiles toolkit. Section 3.4 includes a table with the identified characteristics of card-based design tools concerning artifacts, process and cooperation.

3.1 Method

When searching for relevant articles on card-based design tools, the following search string was used:

card AND design AND (tool OR toolkit)

The databases ACM Digital Library¹ and IEEE Xplore² were used for the article search.

¹<https://dl.acm.org/>

²<https://ieeexplore.ieee.org/>

On ACM Digital Library database, 154 results were generated with the use of the search string on title and abstracts of the articles. The criteria for the articles, was that the involved card-based design tool supported cooperation between at least two participants, and that it had been tested and evaluated in idea generation workshops. After reading through all titles and around 30 abstracts, three of the articles were selected based on those criteria. Additional research and studies on cards and card-based tools were also included as part of the discussion in section 3.3.

When analysing the articles on card-based design tools, the analysis framework presented in section 3.1.1 was used.

3.1.1 Analysis Framework

Some high-level concepts were identified from the Tiles toolkit:

- Artifacts
 - Types of provided artifacts in the tool
 - The purpose of the artifacts
- Process
 - Main goal of the tool
 - Information provided about the process
 - The structure of the process
 - How the artifacts are used in the process
- Cooperation
 - Cooperation techniques
 - Roles in the process
 - Workspace awareness

These concepts were used to create an analysis framework, to provide a structure in analysing different card-based tools. By using these concepts to analyse card-based design tools, characteristics concerning artifacts, process and cooperation in idea generation workshops could be identified and compared with other card-based design tools.

A framework analysis of Tiles using these concepts is presented next.

Artifacts

Tiles consists of a set of artifacts, where each artifact has a specific purpose. Cards are considered the main artifacts of the toolkit, with the purpose of promoting creativity and learning through the use of the cards (Mora et al., 2017). Other Tiles artifacts include the board with the playbook, elevator pitch and the storyboard.

During workshops with Tiles, paper to draw on and post-it notes are also often available.

Process

The main goal of using Tiles is to generate IoT solutions to solve defined problems for specific users.

The process of Tiles is described in the playbook section on the board. The process of a Tiles workshop can sometimes be different in the way that the participants are given other design instructions. However, the standard process is usually followed.

The users follow the seven steps provided by the playbook. For each step, the users discuss and decide on which cards to choose. In the end, they sketch their final idea in a storyboard. The storyboard is usually based on the selection of cards from all the previous steps. Finally, the selected idea is reflected upon and presented as an elevator pitch. The users can also go back and forth to make changes in the previous steps.

Cooperation

Tiles is created to support cooperation between multiple users. Tiles does not provide any specific roles for the users, meaning the users have freedom to choose how they want to cooperate.

Workspace awareness can also be seen in relation to cooperation, as it is required to be able to cooperate with others using the same design tool. Workspace awareness has been defined by Gutwin and Greenberg as "the up-to-the-moment understanding of another person's interaction with the shared workspace" (Gutwin & Greenberg, 2002). In physical co-design workshops, workspace awareness comes more natural, as people can gather available information from the environment and the other users.

3.2 Card-Based Design Tools

3.2.1 Tango Cards

Tango Cards is a card-based design tool that aims to inform designers on how to create tangible learning games (Deng, Antle & Neustaedter, 2014). The tool was designed to be used in different activities throughout the design process, and to inspire the work of designers. In a study done by Deng et al. (2014), Tango Cards was reviewed by experts, revised and tested in 12 design sessions.

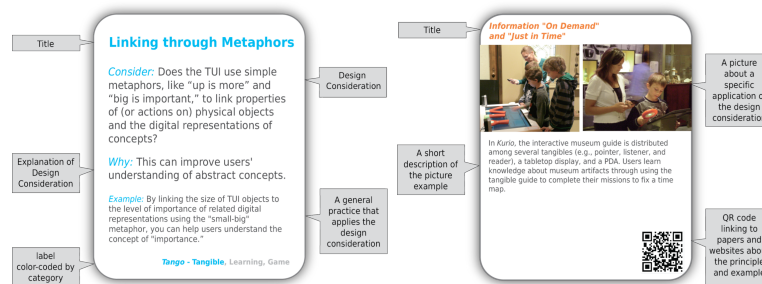


Figure 3.1: Example of a Tango Card, front and back.
Retrieved from Deng, Antle and Neustaedter (2014).

Artifacts

There are a total of 25 Tango Cards, divided into two different categories: tangible learning cards (11) and game cards (14). The cards contain a lot of information about each design concept. The information on the learning card contains a title, information about design considerations, explanation of the design consideration, and a general example on how the design consideration can be applied.

The game card contains a title, a photo of a specific application of the design consideration and under the photo, a short description of the picture example. The game card also initially contained a QR code which was unimplemented. The purpose of the cards is to inform designers of the different concepts. During the user study, sticky notes and a whiteboard were also available for use. An example of a Tango card is displayed in figure 3.1.

Process

The tool itself does not contain a strict process on how and when the card should be used. Tango cards aim to be an inspiration for designers, and support different uses. The cards have been tested during a user study with design students, where each team consisted of two students. There were two design cases, the first was to redesign a web-based game into a tangible learning game. The second case was a concept development of a tangible learning game for children. Each session lasted for 40 minutes, and in the end the participants presented their design concept and rationale.

Before the session started, the participants were given a short introduction to tangible user interfaces. Furthermore, they were introduced to the cards and got to explore the card deck for five minutes before they were given the task.

During the session, the participants used the cards as a conversation medium. The cards were used as a way to help the participants reach a common understanding and also reminded the participants of perspectives they would not have thought of otherwise. When evaluating the content of the cards, the study showed that the

picture was not used as much as the text side of the card. Some of the participants reported that the pictures of games were difficult to understand. Three of the groups also said that the cards contained too much information, and one of them pointed out that the title would have been sufficient.

There were also observed many instances of sorting and grouping of the cards. One of the twelve groups used post-it notes to group and outline design rational and analysis. One of the participants used the guidelines of the cards as formative evaluation of their ideas.

Cooperation

During the user study by Deng et al. (2014), the participants were able to cooperate any way they wanted to get the task done. There were no roles or specific approaches on how to solve the tasks. This led to different approaches in solving the task, and also different cooperation mechanisms, some of them mentioned in the process above. As mentioned, the cards were used as a conversation medium, and the cards contributed to discussion and idea generation. All the participants had access to the same cards at all times, which gave the participants the opportunity to discuss and elaborate on the concepts together.

3.2.2 PLEX Cards

PLEX Cards was developed to communicate an existing framework called Playful Experiences framework (PLEX). The PLEX framework was developed for designers and other stakeholders who wanted to design for playfulness. In a study done by Lucero and Arrasvuori (2010), PLEX Cards was evaluated in three iterations. A fourth version has also been developed, and is available for download online³. In addition to the cards, two idea generation techniques were also designed and evaluated, PLEX Brainstorming and PLEX Scenario.



Figure 3.2: Example of a PLEX card, fourth version.
Retrieved from Lucero and Arrasvuori (2010).

³<http://www.funkydesignspaces.com/plex>

Artifacts

The card-based design tool consists of 22 cards, where each card represents a PLEX framework category. The purpose of the cards are to inspire to create something that is in line with the Playful Experience framework. Figure 3.2 displays an example of a PLEX card from the last version.

Process

PLEX Cards can be used in different settings, and the tool is not restricted to a specific stage of the design process. One can argue that they would be most valuable in an early phase of the design process, specifically the ideation phase, where ideas are being produced. PLEX Card have been tested during ideation workshops, where the goal was to generate as many ideas as possible, drawing cards one by one. The participants of these workshops were paired, so each group consisted of two participants. While drawing cards they would discuss each category and come up with possible ideas based on the information on the cards. The drawing of cards and idea generation would repeat until they could not come up with any new ideas. Participants mainly found the cards useful for supporting idea generation and concept creation. Some stated that they came up with ideas that they otherwise would not have thought of. Others stated that the cards helped them focus on the playfulness, which was the intention of the framework.

In the same study by Lucero and Arrasvuori (2010) two idea generation techniques were also introduced and tested. The first technique, PLEX Brainstorming, was created with the intention of generating a lot of ideas in a short amount of time. Each pair of participants received a deck of PLEX Cards. One PLEX Card was drawn and placed on the table so both participants could see the card, hereby referenced as the *seed card*. Afterwards, each participant drew three additional cards, which would be kept a secret from the other participant. The first participant would start explaining an idea based on the *seed card*, and the second participant would then in turn place a card from his/her hand on the table when they felt they could further elaborate on the idea. The first participant would then place a card from their hand if they were able to continue with the idea based on that card. When three cards were placed on the table, the two participants discussed and agreed on one idea. The final idea was described in writing, before shuffling the cards and starting a new idea generation process.

The second idea generation technique, PLEX Scenario, was aiming to generate more "fully" and quality-based ideas in a short amount of time, instead of a large amount of ideas, which was the case with PLEX Brainstorming. A template was introduced as an additional artifact to the PLEX Cards in this session. The template contained a placeholder for each of the three cards with additional questions for creating a scenario under the placeholder. There was also room for writing down notes for the scenario under each card on the template. The participants were again divided into pairs of two, where each pair drew three PLEX Cards from a card

deck. Their task was to create a scenario using the three cards. They could place a card where they thought it would best fit to find a combination that helped them build a scenario. The scenario was then documented by writing on the provided template or sketched. Another version of the technique with seven cards drawn from the deck was also tested. In this version, the participants chose three out of seven cards to form their scenario.

In the evaluation of the PLEX techniques, mixed feedback was given. Some participants stated that turn-taking in PLEX Brainstorming blocked their creativity, while others found the structured approach useful when generating ideas. Another issue that arose from the brainstorming technique, was that the idea was dramatically changed when new cards were laid on the table. The idea was often not completed until all of the three cards had been placed on the table, although good ideas might have been generated earlier in the design session. However, most participants considered their outcome of the processes of high quality.

Cooperation

PLEX Cards supports cooperation by introducing different idea generation methods, such as the methods mentioned above. The participants can cooperate in different manners, either by drawing in turn and discussing each card, or by using a template to structure the process a bit more. It is possible to introduce roles, as they did in the PLEX Brainstorming technique, or cooperate more freely. During some of the workshops, the process was a bit strict. Hence, the participants were limited to cooperate and share information in a certain way, and everyone did not have access to the same information at the same time.

3.2.3 The Toolkit to Game Design

The Toolkit to Game Design was developed to motivate younger audience in game creation, while aiming to promote environmental preservation and biodiversity conservation (Beça et al., 2020). An article by Beça et al. (2020) presents the outcome of two game creation design sessions with upper-secondary students where the toolkit is put into use. The toolkit is available for download on Gamers4Nature homepage ⁴.

⁴<http://www.gamers4nature.pt>

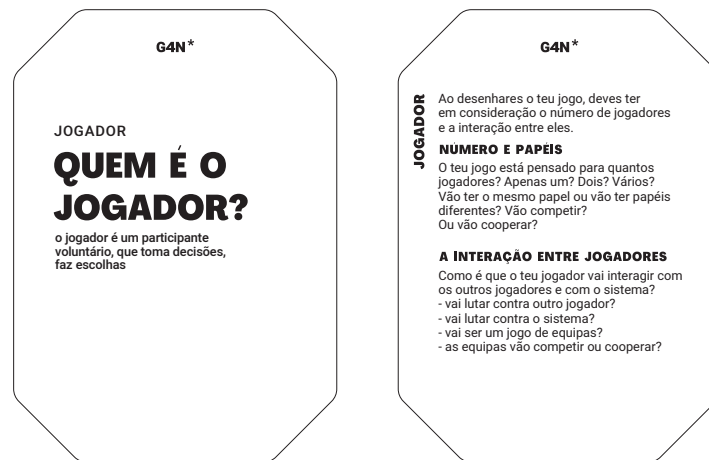


Figure 3.3: Example of a card from the Toolkit to Game Design, front and back.
Retrieved 28.01.21 from <http://www.gamers4nature.pt>

Artifacts

The toolkit consists of the following artifacts: Game Construction Card Set, Rapid Game Design Document and thematic cards. An example of a card from the toolkit in Portuguese can be found in figure 3.3. The Game Construction Card set consists of 12 cards, where each card present a game element. The Rapid Game Design Document explains how to use the cards in designing a game narrative. Lastly, the 20 thematic cards presents issues with environmental and biodiversity preservation. The artifacts of the toolkit were developed with the help of experts and potential users.

Process

The process on how to use the toolkit is explained in the downloadable Rapid Game Design Document. The first part of the process is to establish a history of the game, selecting a *premise*, *history* and a *character* card. The next part of the process is to select *player* cards and think about how to keep the player interested in playing the game, and what type of actions he/she can do. Furthermore, game objectives should be defined, meaning what the game character is able to do. Objects and resources are also defined in this step. The next step is to define which moves that are needed, and then which rules to introduce. The last step includes defining how and when the game should end. During the different steps, the provided cards in the toolkit are to be used as an inspiration to decide each of these steps, which in the end should provide enough information to sketch and create a game.

In the study done by Beça et al. (2020), each design session was divided into two parts, the first part involved using the toolkit to develop a game narrative. The second part was the implementation of the game, using a programming language. The groups consisted of 2-3 participants. In the end, each group had come up with functional prototypes to be presented to the rest of the groups. At the end of each session, participants were asked to answer a questionnaire, indicating how much they agreed with statements involving the use of the toolkit in the game design process, and how useful the the different artifacts were.

All but one participants totally agreed that the Toolkit to Game Design was helpful in organising the group's ideas. Most participants thought that the toolkit was useful when it came to drawing attention to important aspects of building a game, and that the toolkit increased the game's narrative construction process. 16 out of 26 participants said that the toolkit limited their creative process. This was linked to the fact that they had a predefined theme they needed to implement. When it came to the different artifacts, the majority thought the information was clear, and that the artifacts helped their design process. Around 50% of the participants stated that the resources contained too much information, and that it required previous knowledge to understand the information.

Cooperation

The toolkit does not provide any roles, and the participants are free to cooperate in any way. The most prominent part of the cooperation seem to involve discussion and agreeing on which cards to select and which ideas to go on with. The information on the design document and the cards are available to all participants. In the study done by Beça et al. (2020) they did not say anything about which cooperation mechanisms arose in the design session.

3.3 Discussion

The three design tools in section 3.2 have the common goal to guide participants through design processes, and to inspire them to think creatively. This is also the purpose of Tiles, which aims to facilitate creativity and idea generation, in addition to teach the users about IoT (Mora et al., 2017). Similar processes, artifacts and cooperation techniques can also be seen in different tools, which will be further discussed.

Table 3.1 displays some of the properties of the analysed tools.

Design tool	Artifacts	Card decks/categories	Guided process
Tango	cards	multiple	no
PLEX	cards	single	no
TTGD	cards, game design document	multiple	yes
Tiles	cards, board	multiple	yes

Table 3.1: Properties of the analysed card-based design tools.

3.3.1 Artifacts

Tango Cards, PLEX Cards and Toolkit to Game Design provides cards for different uses. Toolkit to Game Design also introduces additional artifacts, such as a game design document explaining the process. This is also true for Tiles. For Tango Cards and PLEX Cards, the cards contain all the information that is needed to use the tool. Post-it notes, blank sheets and whiteboards were also introduced as optional artifacts during the design sessions using the tools.

The cards in all of the mentioned tools contained information about different concepts, which were used for generating new ideas in co-design workshops. It has been researched that card decks used as design tools can overload users with information (Roy & Warren, 2019). At the same time, cards can also be oversimplified, meaning there are limitations to how much information that can be communicated on the cards (Roy & Warren, 2019). The information provided on the cards can be considered crucial for the result of a design process using the cards. As a consequence, it is important that the information on the cards are informative, but at the same time easy to understand. As seen in the study by Beça et al. (2020) using the Toolkit to Game Design, 50% of the participants reported that the cards contained too much information. This was also the case in the evaluation of Tango Cards in the study by Deng et al. (2014), where some of the participating groups meant that the title of the cards would have been sufficient.

When transforming the provided artifacts to an online version, it may be considered important to display the artifacts in a way that does not seem overwhelming for the users. Many physical artifacts in a tool have the property that they can be easily picked up and moved around. Cards can be structured and categorised, so that the cards are displayed in a more favourable way. It may be necessary to create a way of structuring the same information digitally, and facilitate interaction of the different artifacts in the tool, in a way that is not too complex for the

user.

Post-it notes can be used as a way of organising the different cards, as seen during one of the design sessions with Tango Cards in section 3.2.1. An easy tangible piece of paper is also something that is often considered a useful artifact in design processes. Finding a way to transfer some of the beneficial physical properties of a post-it note could also be useful when moving online.

3.3.2 Process

PLEX and Tango Cards did not provide any strict guidelines on how to use the tools, and the process of the design sessions varied. The creators of both of these tools argued that they could be used in different parts of the design process, although it seemed that they had been mostly tested and used in early stages of the design process. Similar to Tiles, Toolkit to Game Design had predefined process steps that one could follow while using the tool.

The participants of the design sessions using these tools were provided with some information about the tool, process or the task before they started working. For Tango Cards, the participants were firstly given a short introduction to the theme, and then they got to explore the cards. With PLEX Cards, the process varied in the study by Lucero and Arrasvuori (2010), and so the participants were told how to use the cards beforehand in the different design sessions. Toolkit to Game Design did not explicitly state what type of information the participants were given other than the tasks, although information about the process could also be found in the documentation of the toolkit. In all of these studies, facilitators were present so that questions about the process or the tool could easily be answered. When using the tools without arranged design sessions with facilitators, the experience may be different.

Findings from a systematic literature study on design card sets shows that there is often a lack of documentation regarding how different design cards should be used (Aarts et al., 2020). The same study concludes that one should focus on designing the design process, not just the cards so to fully take advantage of the card sets as a way of communicating design knowledge. This would be essential if people who are unfamiliar with the tool are using it for the first time, or do not have any facilitators to consult with. When moving a toolkit to a digital environment, this is also something to bear in mind. The digital toolkit should provide enough documentation on how to use it, otherwise it might not be used in the right way, or not at all. This is also supported by an observation from a study showing that too much freedom can lead to difficulties in knowing what to do with the cards, and as a consequence, they will not be used (Aarts et al., 2020). Especially, this might be considered important for a toolkit with lots of different artifacts which can easily lead to confusion if the approach is not documented well enough.

It can also be considered important not to restrict the participants too much in

their creative process. As the card-based design tools are meant to be used in creative design session, it is important that the users have space to be creative. A turn-taking approach, which was used in a study with PLEX Cards led to participants reporting that their creativity was getting blocked (Lucero & Arrasvuori, 2010). On the other hand, other participants reported that turn-taking was useful in generating ideas. It may be a fine line between providing too much information and strictness, and giving the users enough freedom to explore and be creative.

3.3.3 Cooperation

In all three studies of design tools in section 3.2, participants were divided into teams, and they had a common goal they should reach. They were also provided with different tasks which they could solve using the card-based tool. The cards seemed to be the basis of the communication, and therefore also the basis of the cooperation.

Cards can often act as a common basis for understanding and communication in teams (Roy & Warren, 2019). This is also something that is supported by the tools in section 3.2. In all three cases, the cards provided some piece of information that was used in the discussion to generate ideas. In the design sessions with Tango Cards and Toolkit to Game Design, all of the participants had access to the same information, and they were free to discuss and point to the cards to generate a common understanding and brainstorm ideas from the information on the cards. In the design sessions with PLEX Brainstorming and PLEX Scenario, the cards were divided amongst the two participants, and so they would only have access to parts of the resources. They would display cards based on the discussion with each other, and also based on which cards the other participant displayed.

In the above scenarios, awareness is very important. The participants need to pay attention to what has been done, and what others are doing, and then act accordingly (Gutwin & Greenberg, 2002). In physical design workshops the participants can point to any cards, and discuss the information on that card as everyone knows which card is targeted. They can select cards that they want to take on to the next part of the task. One example is in the Toolkit to Game Design, where the participants select *player* cards and define actions and moves based on which cards they selected as the player. This is also similar to Tiles, where the team have selected some cards in the previous stages of the process, which they are to build on in the next stages of the process. They have a common template that is available to everyone, so everyone in the team knows which cards have been selected, and they all know how far in the process they are. In digital co-design sessions this should be facilitated, so that the participants can see what has been done. It could also be useful to see where the other participants are working and what they are doing at the time, to coordinate tasks and plan ahead. In addition, the participants need a way to communicate the ideas to each other.

3.4 Identified Characteristics of Card-Based Design Tools

From the literature review and analysis, some important characteristics of card-based design tools concerning artifacts, process and cooperation in idea generation workshops have been identified, thereby answering RQ1.1. Table 3.2 displays an overview of the identified characteristics. The identified characteristics will be used to develop functional requirements for the design of the digital toolkit.

Artifacts	
Facilitate interaction with the different artifacts (cards, board, post-it notes etc.).	Facilitate the possibility of grouping different cards to provide structure.
Information on the cards should be readable and clear.	
Process	
Provide enough information about the process/tasks so that the participants know what to do at all times.	It should be clear which part of the process stages the participants are working on.
Facilitate space to be creative in the different parts of the process, without giving the participants too much freedom.	
Cooperation	
Facilitate pointing interaction to point at a specific card where everyone can see which card is pointed at.	Facilitate communication between participants.
Everyone should have access to the same information (cards, board etc.).	Facilitate a way of seeing where other participants are working or what they are working on.
Facilitate the ability to select cards, and let everyone know which card(s) are selected. Could be placed on a template or a board.	

Table 3.2: Identified characteristics of card-based design tools used in idea generation workshops.

Chapter 4

Interviews

Interviews were conducted as part of this study to gather information about the participants' knowledge of card-based design tools, and gain insight into what experiences they have with facilitating both physical and online workshops using card-based design tools. Identifying characteristics of Tiles supporting creativity and cooperation in idea generation workshops, and investigate ways of transforming these characteristics to the digital environment, would also be helpful when designing the digital toolkit.

People with knowledge of Tiles, creators of card-based tools and people who had experience with online workshops using card-based tools were selected as the main participation group.

This chapter starts with describing the method in section 4.1, before presenting the results in section 4.2. Lastly, a discussion of the interview results can be found in section 4.3.

4.1 Method

4.1.1 Semi-Structured Interview

Semi-structured interviews was chosen in this study, as this allowed for some flexibility in what questions to ask. A set of predefined questions were made, but there was also room for asking additional questions if that came up naturally in the interview. Semi-structured interviews also allow the interviewees to "speak their minds", and they also might introduce issues of their own, if relevant (Oates, 2006).

4.1.2 Procedure

As the participants were located in different parts of the world, the interviews were conducted digitally via Zoom¹, a digital communication tool. The server on Zoom was hosted by a NTNU server maintained by Uninett². For the participants that resided in Trondheim, the interviews were also conducted digitally as a COVID-19 infection control measure. The interviews were conducted with one participant per interview, and the duration of the interviews varied from 20-50 minutes. Audio tape recording was done to capture the discussion during the interviews. The audio recorder that was used during the interviews was external and had no internet connection. This was done to securely store the data from the interviews.

Each interview started with a short introduction to the project, and an explanation of the intention of the interview. The participants were told that there would be some predefined questions, but they were also welcome to talk about things that were not specified in the interview guide. The intention behind this, was to avoid potential valuable information that would get lost, in case the interview guide did not cover all important aspects. This is also in line with the semi-structured interview method (Oates, 2006).

4.1.3 Participants

The participants in the study were chosen based on their experience with Tiles and other card-based tools. The participants were suggested by the Tiles team, as they already had an overview of people who had used Tiles in the past. Some of the participants were suggested by other participants, based on their knowledge on card-based design tools.

The participants received information about the study and a consent form they could sign before the interview took place. The participation was voluntary.

In total there were nine participants. All of the participants had facilitated at least one workshop using a card-based tool, while seven of them had facilitated workshops using Tiles. Another participants had only participated in a workshop using Tiles. The participants from the interviews who had experience with Tiles, had either used the full toolkit, or an adapted version of the toolkit.

Seven of the participants were researchers in different fields, mostly related to HCI, and their knowledge on the subject were considered to be very high. Five out of nine participants did also have experience with the creation of their own toolkit. Two of them had experience with facilitating online workshops using card-based tools.

¹<https://zoom.us>

²<https://www.uninett.no>

Table 4.1 displays an overview of the participants and their experiences with card-based tools and workshops.

Participant no.	Facilitated Tiles WS	Participated in Tiles WS	Created card-based tool	Facilitated online ideation WS
P01	X		X	X
P02	X		X	
P03	X			
P04	X		X	
P05	X			
P06	X			
P07		X	X	X
P08	X			
P09			X	

Table 4.1: Interview participants and their experiences.

4.1.4 Interview Guide

A general interview guide was prepared before the interviews were conducted. The purpose of the interviews was to gather information about the following topics:

- Co-design workshops using Tiles and other card-based tools
 - Purpose of design workshops
 - Pre-session information
 - Artifacts of card-based tool
 - Cooperation in design workshops
 - Creativity in design workshops
- Digital co-design workshops
 - Cooperation in digital design workshops
 - Creativity in digital design workshops
 - Benefits of digitising card-based tools
 - Challenges with digitising card-based tools
- Creation of card-based tools
 - Main focus
 - Challenges
 - Lessons learned

The questions were created with the intention of letting the participant share their thoughts and experiences with card-based design tools, and to get their opinion on aspects of a digital transformation of a physical card-based design tool. Therefore,

it was also important that the question was perceived to be open, so that the participants would be able to speak their mind rather than answer yes or no. The general interview guide with the questions are attached in appendix A.1, and the rationale of the questions can be found in appendix A.2.

As the participants had different experiences with card-based design tools and design workshops, the general interview guide was adapted based the following experiences:

- Experience with facilitating co-design workshops using Tiles
- Experience with facilitating co-design workshops using other card-based design tools
- Experience with online co-design workshops
- Experience with creation of card-based design tools

The latter two experiences were considered especially valuable for finding out what the focus should be when creating a digital card-based design tool, and important lessons learned from performing online co-design workshops. As some of the participants had experience with several of these points (see table 4.1), a combination of questions from all related categories were asked.

In preparation for the main interviews, two practise interviews were performed to ensure that the quality of the questions were good, and that the questions were understandable. One of the practise interviews was performed with someone who fit the profile as a potential participant, while the other was performed with a person who had no experience with card-based design tools. After the practise interviews, some of the questions were adjusted, and a couple of new questions were added to the interview guide.

4.1.5 Ethics and NSD

To ensure that the project was according to ethical guidelines and that the personal data would be processed in a good manner, the project was notified to the Norwegian Centre for Research Data (NSD) in advance. An assessment was done, and the interviews could then be carried out. The participants received a copy of the information sheet regarding how their personal data would be processed. The participants were free to either accept or decline the approach written in the information sheet, and they could at any time request that their data would be deleted. A copy of the information sheet with the consent form is attached in appendix A.3. All of the participants signed the consent form beforehand.

4.1.6 Data Analysis

The data from the interviews were analysed using thematic analysis (Maguire & Delahunt, 2017). The data from the audio tape were first transcribed and anonymised, giving each participant a code instead of using their names. The tran-

scribing of the data was done by listening to the audio on the recorder while writing down every sentence in a document on the computer. The aim was to capture every word as closely as possible, only leaving out filler words, such as "uh", "ah", "um" from the document. Words that were hard to understand, or got lost because of noise or bad audio quality, were marked in brackets with the time of the statement inside of the brackets. Conversation that was not relevant for the interview data was also left out of the transcribed document. After each transcribed interview, the audio would be played once more, while proofreading the transcribed data to get the transcribed results as accurate as possible.

Once the transcribing was done, the data were assigned *codes* to describe the content of the data (Maguire & Delahunt, 2017). Two people were coding the data separately to ensure quality and reliability of the presented data. The author of this thesis, hereinafter referred to as the researcher, used a qualitative data analysis software called NVivo³. The co-supervisor coded the data using Miro⁴, an online whiteboard tool, to visually display a summary of the statements in different groups. The codes were made based on the related topic of the different statements from the interview, and from the question categories. The coding results were later discussed and modified between the researcher and the co-supervisor. The codes used by the co-supervisor and the researcher can be seen in figure 4.1.

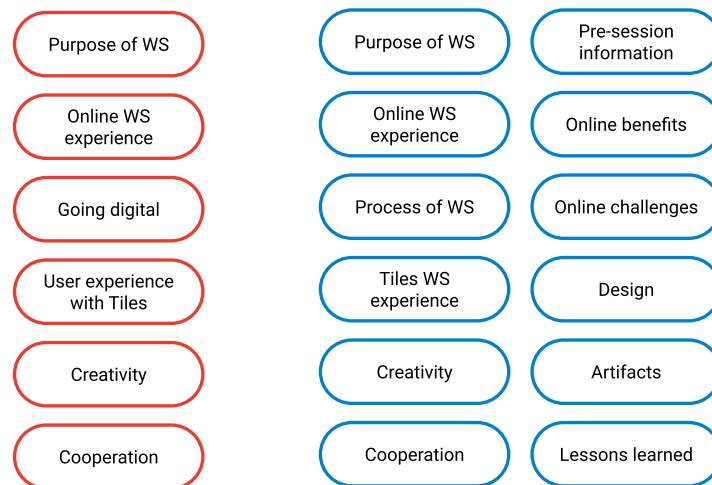


Figure 4.1: Data analysis codes created by co-supervisor (red) and researcher (blue).

Both code assignments were done in similar matters, so it was easy to merge them together in the end. Once all the data were reviewed and categorised once more,

³<https://www.qsrinternational.com/nvivo-qualitative-data-analysis-software/home>

⁴<https://miro.com/>

the researcher created themes based on the two coding results as seen in figure 4.2. The identified themes were used to organise and present the results in section 4.2.

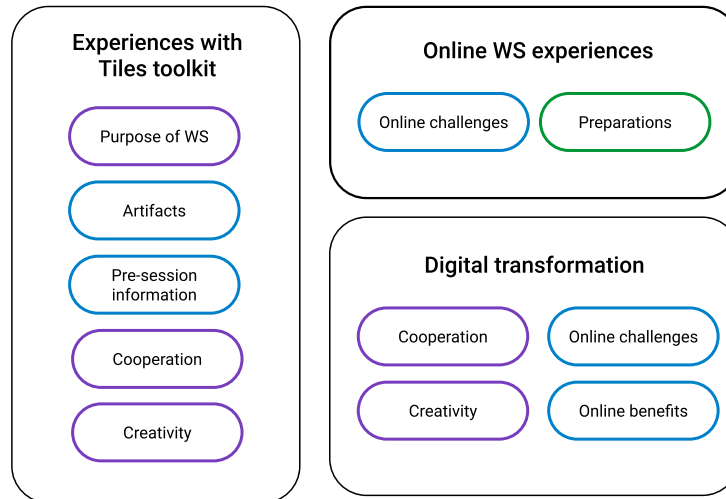


Figure 4.2: Themes used to organise the results of the interviews.

Colour codes: blue = researcher, purple = merged from both code results, green = new.

4.2 Results

4.2.1 Experiences With the Tiles Toolkit

All but one interviewee had experience with either facilitating or participating in one or more Tiles workshops, and so these interviewees shared their experiences with the toolkit in general and how the workshops were structured.

Purpose of Workshop

The interviewees stated that they had used Tiles for different purposes, mainly to familiarise people with the technology and to generate new ideas, but also for team building:

I think it changes slightly from workshop to workshop, depending on the audience. I think in most cases, we're doing workshops with people that are not familiar, either with the technology at all or internet of things technology. So, I think the first purpose, and what is common in all workshops and for all participants, is to make them familiar with the technology. And the second purpose is to do some team building (...) Usually teams are formed with people that do not know each other from

before. And I think that the third goal, which might be more evident in certain workshops than others, is to have them develop an idea. (P04)

Tiles was also frequently used to support product design, and five interviewees stated that they had used Tiles for this purpose. One of those interviewees who used Tiles as part of a product design phase for university students, stated that one student group won an award for generating the best idea:

The entrepreneur part of this school and computer science wanted to do something together; and I said "yeah OK, let's do a six-weeks intense IoT smart home participatory thing". And what I did, I asked students to first do interviews with older adults and then ask what they found interesting in smart objects, what could help them in the future (...) And then with the students, I did a Tiles workshops. And it was a group of 4-5 students with one Tiles set on their table. They had, I think a day, to come up with proper ideas. (...) One group, they won the entrepreneur award of the school, with a small idea that came out of the workshop. (P02)

One of the interviewees stated that they had been adapting the tool, using it for quick ideation and brainstorming with students who were doing an IoT master's degree:

They did an Internet of Things course, and I wanted them to generate ideas and practice creativity with scenario development for their project's scenarios using Tiles, not in exactly a strict form that you would describe the use of Tiles. So not the board, just the cards (...) I moderated it. I was trying to give them cards that were related to the previous cards that I had given them. So, I gave them the "things" cards, and I kind of associated it loosely with the missions that they had received before. (P05)

Another interviewee had been using Tiles cards with university students of Computer Science as a way to reflect upon their design ideas before they started to implement their solution:

First they got some inspiration activities where they got to know about the material they would be working on (...) And after that they did the inspiration stage, we had some sort of hackathon with them. We did also use Google design sprint techniques in order to enable them to come up with, hopefully a vision of ideas. And then we used the sample criteria cards to help them reflect over their design. And then they went on to develop their solution. (P03)

Pre-Session Information

Before the workshop started, a facilitator would usually give a short presentation, going over what the participants of the workshop would be working on. One of

the interviewees explained the process like this:

Usually, we only do a very brief introduction, like five minutes, just to go over the process and basically give them some recommendation. (P04)

The presentation and the information that is given in the beginning of a workshop was usually tailored according to the participants of the workshop, depending on their age, knowledge and interests. This was stated by one of the interviewees:

In advance if there was any need to adapt to the audience depending on their age or their interests, some things were changed. (P06)

The same interviewee who had facilitated a number of Tiles workshops with children, emphasised the importance of giving a good presentation as a way to motivate them to finish the process:

I really think that giving a good presentation in the beginning with a couple of examples helps participants to see the goal. Because we saw in some sessions that participants don't see the goal there. Like "I need to be here for an hour, an hour and a half, and what's the goal? Is it to present something as an elevator pitch, and then we go home?" So, giving a good presentation to tell them that this is a good opportunity to see the possibilities in the world, to spark their creative process, to get their ideas to the point where they seem alive, where they seem viable, helps them to be motivated to do it. Because I think, that might sometimes be the problem, that people lose motivation because they don't see what they will get out of this. (P06)

The playbook section on the board contains information about the different steps, and so in most cases there is no need to elaborate on how participants should use the toolkit before the workshop starts, according to one interviewee:

We don't get in detail regarding the activity, because it's kind of fleshed out in the playbook section of the board, so we don't use our time just to read the information that is already available to the participants. (P04)

Tiles Cards

A big part of the process with Tiles is selecting cards of different categories, and discussing which cards will be best suitable for the idea the participants of a workshop is about to come up with.

Most of the interviewees agreed that the Tiles cards were helpful in the creativity process, and that they had a positive effect on the collaboration. One of the interviewees expressed it like this:

The cards were excellent in getting people started and thinking out of the box and collaborate and laugh. (P05)

One interviewee stated that the information on the cards could help the participant to understand their task better:

In the beginning of the presentation, most participants seemed quite confused about what they were supposed to do now because it sounds very open. But when they for example see the cards, it becomes clearer. And they explore the cards, for example different personas they should design for. So it becomes more clear, like "maybe this person is a good persona for designing certain activities", then certain triggers and so on. (P06)

One interviewee who had been working with children using Tiles, experienced that there could be too many cards to choose from:

Sometimes there were too many cards (...) there were those who just kept browsing as there were way too many alternatives to choose from. (P08)

Another interviewee stated that an attempt was also made to limit the number of cards and make some predefined choices in some of the workshops, yielding good results:

Sometimes we tried not giving a fully open board in the sense that they couldn't use all the cards. So if we say for example: "Maybe you should try designing for this person, for this kind of artifact" and so on, it helps them a bit to relax and maybe then they can think about certain aspects that they want to address, rather than having a full world at their feet, not knowing what they should do." (P06)

The Playbook

The playbook on the Tiles board contains information about what the participants should do in the different stages of the process, and which set of cards to use for each step. Several interviewees stated that they liked the fact that the different process stages are written down on the board, and that this makes the tool easy to use.

Tiles has a very clear way on how you should use it. There are different steps, which are very well defined, which makes it an excellent tool for education for instance. (P07)

Usually when we do physical workshops, we are always surprised that participants don't ask many questions about the process. (P04)

Although one interviewee stated that Tiles is a good tool for educational purposes, the structured process could make experience users feel a bit restricted:

Once you become more experienced, it's sometimes a bit harder as volatile environments make you feel a little bit restricted because you are limited to the predefined steps, for instance. Even though you don't have to do

the steps in order to use the cards, but having the whole template where you place everything on, the whole system is built around that, and if you want to break loose from that, it requires a bit more creativity. (P07)

Another interviewee agreed that a structured process with predefined stages could affect the users and compromise the creativity:

The structure that was given with Tiles, which we didn't follow, was a little bit rigid. And when it comes to brainstorming in creative workshops, you need a bit of freedom to improvise the process. So you have to provide some structure, but the structure also have to be flexible and adaptive. (P05)

Each of the steps defined in the playbook section have a suggested time frame on how long you should spend on each steps. One interviewee emphasised the importance of not using too much time on each of the steps:

If there is one thing you have to be clear on, it's the time frame for each step. If not, it can easily take too much time, and then you will loose some of the drive and spark. (P08)

The last steps in the playbook is about sketching the idea and giving an elevator pitch. According to two interviewees, these are considered to be the most demanding steps in the process. One interviewee expressed it like this:

I think sometimes groups cannot sort of finish the process (...) Especially the last part, the elevator pitch. I think not many groups manage to flesh that out, probably. And we don't know whether this is more like a time issue or if it's more like they don't have the skills to write an elevator pitch. Or for that, I think it's probably the most kind of individual activity. You can play with cards as a team, you can sort of spread them out, exchange, share, so it's more like something that offers collaboration. The elevator pitch is more like, it's probably something that would need a leader, because if you have four participants in a team, there is no point in writing down four elevator pitches. (P04)

Cooperation Within Groups

When performing a workshop using Tiles, the participants of the workshop are usually divided into groups of 3-5 people, depending on the number of participants, and they are cooperating towards a common goal.

The interviewees identified some factors that could affect the cooperation within a certain group. According to two interviewees, the level of collaboration can sometimes be related to how well the group members know each other from before:

I noticed that sometimes it depends how much the participants know each other, how they are familiar with each other. (P06)

I think it was relatively small groups, and they knew each other already, they were on eye level, which kind of helped them to first properly explore. (P02)

Another factor that seems to play a role in cooperation, is the age of the participants. One interviewee expressed it like this:

Age is a bit of a factor in some ways. The older the participants were, the more engaged they were. Usually if they were students at the university, the cooperation was quite obvious and clear, and the ideas as well. (P06)

A third identified factor is about voluntarily participation versus mandatory participation in schools. One interviewee stated that mandatory participation could affect the cooperation level in a group:

It was a bit more efficient when it was a voluntarily activity rather than just a school activity. (P06)

The interviewees did not express any strict "hierarchy" in the decision making process, but it was not unusual that one person from each group took the main lead. One of the interviewee stated it like this:

I would say that in some cases there is sort of a leader that emerges. Probably in most cases, there is someone taking the role of sort of a game master, I would say. And that reads the playbook and then try to arrange the work. (P04)

The cards were often seen as a medium in the conversation, according to the interviewees. One interviewee stated that browsing Tiles cards enabled collaboration:

I think it's the initial activity, which is browsing cards, that enables collaboration, because you see people discussing around the cards (...) I saw some groups breaking the deck of cards in four and then each group member was going over a set of cards. (P04)

Idea Generation and Creativity

In most cases, the goal is to come up with some idea from the workshop using Tiles. Factors of Tiles that promote creativity and idea generation in workshops have been identified by the interviewees.

According to some of the interviewees, the participants of the Tiles workshop liked the fact that in the workshop they were free to develop anything they liked, without having to deal with additional pressure:

They liked the fact that it was a ground where they could cooperate and they could be more relaxed and fun, because they are in a kind of rigid environment, the engineering schools, and people are told to behave and think more strictly and focused. At that point they were asked to think

unfocused and collaborate, so the completely opposite than what they were used to, and they really liked the collaboration part, and meeting the other students and exchanging ideas. (P04)

You get to create something without fixed boundaries, and there is a bit of imagination and creativity in that. (P08)

Several interviewees stated that the artifacts in Tiles promoted creativity in some ways. One interviewee stated that the problems they were solving promoted creativity, because they could have an impact:

I think it has something to do with the problems that we ask them, or that we use a starting point in the design activity, which are very simple to understand. It's something everyone can relate to, like climate change or like food waste reduction. I think this is the first thing that makes people interested, because it seems like they could solve something that could have an impact. And then in general, I think it's a bit of the mix of mission cards, and we ask them to sketch storyboard, so usually that's something that makes people creative. (P04)

Another interviewee stated that the design of the artifacts helps the creativity process:

I think the design itself and the provided artifacts help with the sparking, and initiate the creativity process. (P06)

4.2.2 Experiences With Online Workshops

Two of the interviewees had experience with facilitating online remote workshops using card-based tools. Both interviewees used Miro as a platform for hosting the workshop.

Preparing for the Online Workshop

One of the interviewees stated that it took a lot of planning and preparation of the online workshop, to get it to work as desired:

It's quite a lot of explaining beforehand which I do using email, so I have two instructive emails. One of them is very practical, like "we will be together in this planner room, and after that you will move to a group room, and in that room you will spend that much time, and then we come back to the planner room". There's all this practical stuff to take care of to make sure that people know where they need to be and what will happen. And it works quite well, but it still takes a lot of explaining to have people in the right place. (...) The second instruction is about introducing a case that I've prepared for the tool I use (...) That is done in the session mostly, we start planning the session once everyone finds out

where they need to be, and then I introduce the case we will be working on today. (P07)

In addition to the practical information on where the participants need to be, one would also have to prepare the digital platform where the tool is used. One interviewee expressed it like this:

There are some other preparation which the participants will never see, of course, where I use one Miro board, one big whiteboard, and then I have separate zones for each group on the same whiteboard. And the reason for that is that even though they are working in smaller teams, they can still have the impression that other things are happening. (P07)

The same interviewee stated that the preparation of a digital workshop was more time consuming than a physical workshop:

If you do the digital version, the preparation is a lot more intense, I tend to spend a lot more time on many things (...) getting everything ready and prepared. (P07)

Another interviewee used frames in Miro for navigating over the board and the cards, and stated that it simplified the navigation process for the participants:

I had prepared frames, which is a speciality in Miro for navigating over the boards for each step and for each set of cards, so that it was easy for the participants to navigate over the board and to grab a card and to place a card, etc. (P01)

One interviewee stated that there was a need for a more elaborated explanation on how to use the tool in an online workshop, compared to using the physical tool, and that the interviewee added a script to explain the different parts of the tool in Miro:

One thing I added was the script, saying this is what you can go through. In the physical workshop I would usually explain that (...) Even if you explain it, my experience was that they need a little explanation on screen to make it very clear what they are supposed to do here. That is something I didn't have before, well I had some slides, but never in paragraphs of text, so then I transported that into clear instructions, like "how you should use this, and what you should do". (P07)

For communication between participants in the workshops, both of the interviewees expressed that they used external audio or video chat:

We were audio connected and we had another window open of Miro. (P01)

In the digital version they only had a video chat available. (P07)

Challenges With Online Workshops

One of the challenges of doing an online workshop is that participants also need to learn how to use the digital platform. Both interviewees expressed challenges relating to this in the following ways:

For nearly all the participant it was their first time using Miro, so it was another challenge for me, not only to give an introduction to Tiles, but also to Miro at the same time. (P01)

The groups are usually not familiar with Miro as a system, and then they need to explore all these little buttons and everything that they have on the screen. And sometimes that turns out to be a bit confusing. (P07)

One interviewee stated that another challenge with performing online design workshops, was that it was harder to make changes and be flexible compared to physical design workshops:

It feels more like a hit or miss when you do the actual session, whereas when you are doing it physically you can always bend the rules a little bit or change things on the fly. If you're doing it digitally, it really needs to be right the first time. (P07)

One interviewee stated that sketching was left out of the process, as this was not well supported by the online platform:

No fancy sketches or something like that, because it was too complicated and most people are not very used to draw something very good with a mouse or like some detectors, so it was a mainly text based. (P01)

According to one of the interviewees, pointing at artifacts was one of those interactions that could be hard to facilitate in the digital environment:

One of the biggest difficulties, or differences at least, is that in the digital environment it's a lot harder to indicate stuff, like point to a card, or say that "this little group here, that's what you should be looking at". And they have their little mouse pointers and each person can see each other's mouse cursors on the screen, but it's a lot more difficult on the digital version to point or to indicate, "I am now referring to this element here" or something. You can like drag things around, but then the change is already there, but as maybe in a physical version you would say "maybe if we connect this card with this card", and then you would point to it with your finger. It's a lot harder to have that kind of interaction in a digital platform. (P07)

Another issue that arose for one interviewee, was that the space in the template was limited, and at some point the board got a bit messy as there were a lot of cards on the board. The interviewee expressed it like this:

In the placeholders where you place the different cards on the board, for the “things”, “sensors”, “actuators”, “services” etc., it got for one moment a little bit messy on the board. Because everybody had some cards they wanted to place, and so as you might know, it is not about having a lot of cards, it is about having the right cards. And for this very moment it was a little bit overloaded. (P01)

4.2.3 A Digital Transformation

Promoting Cooperation and Workspace Awareness

As an answer to the question "Do you have any suggestions on how to promote cooperation during a digital design session?", different aspects of digital cooperation and workspace awareness arose.

One interviewee emphasised the importance of building a connection with the other group members, and that this was something that could easily get lost when working remote:

I think online you need to do a very deliberate job in having a shared understanding and a shared feeling (...) I think having a way to have people connect with each other in a personal way. (P02)

The same interviewee suggested a possible solution to this problem by giving the groups of the workshop some tasks where the goal is to get more comfortable with the other group members:

It can be a task to just make everybody comfortable with each other. And I think that's a thing that we have to keep in mind if you want to do online creativity and online collaboration. (P02)

One interviewee suggested having a shared common space where you can see what the other groups are doing:

I think you would need sort of smaller group sessions, and that everybody unite in a sort of conference type of session with some sort of board for everybody to stick things on, and then zoom in and out to see the details of the things that are all the groups'. (P05)

This can also be supported by Miro, and one of the interviewee with online workshop experience tried out a similar method, where each group could see what the other groups were doing. The interviewee stated that this led to cooperation across groups:

We would do a session with maybe 40-50 people. And then each group is about 4-5 people. And there will be 10 zones within the one canvas. And they would really have the feeling that other things are going on, what other people are doing, you can maybe check out how other people are

*approaching it. The groups sometimes started to coach each other (...)
(P07)*

Another interviewee used Google Docs as an example on how awareness can be promoted in the digital environment:

When you work on a Google doc, the fact that you can see what others are doing or you see where there's a pointer in the document. So these are very simple clues so to help you to be creative, and they replace sort of the physical experience of someone going through a set of papers, and you can sort of guess where this person is reading just by looking at the person. (P04)

Promoting Creativity

Promoting creativity in a digital workshop can be considered different than a physical workshop. Suggestions on ways of promoting creativity online was discussed with the interviewees.

One interviewee stated that synchronicity is important for enabling creativity:

Synchronising people in an online creativity session is like a big deal, and I think we could do that better. And that also place into the notion of "I want to share a card with you, I want to only show a card to you, and not to the others". Or "I want to give ten cards to you and ten cards to someone else". And I think the overall notion for that would be that we can seamlessly go back and forth between small rooms and big rooms, you and me could have a secret whispering discussion, while the people next to us don't hear that (...) I think that the ability to connect synchronicity and asynchronicity back more seamlessly, that would be a great thing for creativity online. (P02)

Another interviewee stated that there is no "correct" way of promoting creativity, and that it depends on the context:

Nailing down the secret to enable people to be creative, it's impossible, because it changes so much from the context. Both from like age, education and cultural context. (P04)

The same interviewee stated that creativity techniques should be adapted to the users:

I think the first point is like any sort of technique that you want to design to help people to be creative, to do creative work. Any of these techniques are not universal, so they really need to be tailored, according to the users. (P04)

One interviewee suggested that showing some examples of ideas that could come out of a design workshop could be useful when promoting creativity. The inter-

viewee stated that especially ideas from younger participants of the workshop can appear unrealistic, and that examples could be helpful:

Examples help people understand and see the options. Because for some people, most of what they think about is, let's say, what is also existing now, like smart refrigerators. We've heard that idea many, many times (...) So, having maybe some usual, as well as some very unusual examples, like videos they can see of things working, can maybe help to spark their creativity. Included in, let's say in the presentation or in the promotional video or whatever that might be, of artifacts that are actually working. I think that could help them develop more ideas that are realistic. Because we saw for example with younger participants, they tend to go very, very unrealistic, which makes sense I guess. Their imagination is a bit more open, and they have less constraints in what the cost of something is and what the abilities of somethings are. (P06)

Two interviewees mentioned different ways of bringing cards into the discussion as a way to help the creativity in a team, either by random inspiration, proposing questions or using reflection cards to get the participants to reflect on their ideas:

I'm thinking about some way to randomly inspire people, like to bring something maybe unrelated, like they would have little cards appearing from time to time, "maybe you can use this", and then you get an image of a light or a garden or any random kind of stuff, just to trigger other things. (P07)

Let's say we have a group of students that are in a Zoom room talking, and they are going to struggle for sure, at some point. So, having like reflection questions or those cards right there. "Think about this question when you think about designing." Prompting the questions to them to spark their mind to think, for example, "this is what we are thinking about. Is it good for the user, is it targeting the user, is it realistic whatever the goal might be?" (P06)

Benefits of a Digital Transformation

One of the most stated benefits was related to the current situation with the pandemic, and the fact that you could reach more people, as you would not need to be physically co-located. Some of the interviewees expressed it as follows:

The benefits of the digital version is of course the situation we are in now, we can use it remote, distributed, so I can sit here, my participants can sit spread all over Germany or even across the world. (P01)

A clear benefit for me is that it can be done more. It can be done with more participants. (P06)

A second benefit was related to the fact that it is easy to create multiple copies of the toolkit and its artifacts. One interviewee expressed the following:

It is easy to create a new copy. You can make this copy permanent as it only takes up a little bit of memory somewhere in the cloud. (P01)

Some interviewees also expressed that it is easier to make changes and update a digital toolkit compared to a printed physical toolkit. One interviewee stated it as follows:

It's quite easy to make little changes or adaptations to create new version and to fix errors or something. If you have it here [shows the physical box with the cards], you have to reprint it. (P01)

Another discovered benefit was the use of custom cards. One of the interviewee experienced that the custom cards of the tool were used more frequently during the online workshop than in the physical workshops:

In all the offline workshops I have ran, these cards [custom cards] were not often used, because it is a nice card and you do not want to write on it. You might put a sticky note on it, but they are not very often used. And in the online workshop this card were quite often used with virtual post-it notes to customise it. (P01)

Not having to recycling the cards can also be considered a benefit for facilitators of a workshop. One of the interviewees expressed it as follows:

If I'm thinking of doing an introduction class, with 60-70 students, I would have to print ten canvases, and I would need to have ten sets of cards and then I have to be aware that every card comes back. And that's kind of a really big issue, and a lot of my work as a facilitator would go into making sure that the workshop was properly laid out. (P02)

Some of the interviewees stated that a digital toolkit could also be useful for educational purposes, and that it might be easier to follow the process of a digital version. One interviewee stated the following:

I think it can be also very good, if for example a teacher wants to do it in schools. I think it can be quite easy for them. So if they have troubles with planning, with the crisis and everything, what they need to do, what they should do, I think design workshop in such a fun way can be very helpful for the learning plan as well. And for sparking creativity in their pupils. (P06)

According to one of the interviewees, a possible benefit could be to use the technology as a way of changing the process, so it becomes less tedious:

One thing that's probably interesting to look at, is making it easier in ways you cannot do offline (...) What are the tedious processes in an analogue tool set that I can reduce with an algorithm? (...) You could

for example say you have the benefit of the digital tools, where you can add algorithms that help the people to decide which cards would be best fitting to another one. (P09)

Challenges With Digital Transformation

One of the challenges with a digital transformation of a card-based toolkit can be related to the fact it becomes a different tool, and it is unknown how well it will work in this setting. Two interviewees expressed this in the following ways:

Moving from the physical to the digital, it's very sort of unknown, because again we know that the workshop works well, we don't know why it works well, but at the same time we know that we designed this to be a very sort of physical or in-person activity. (P04)

It's a different paradigm really. You take something from the initial version, and then you have to see how it works in a very different setting. (P05)

Another challenge that was stated by several interviewees, was related to the fact that a digital workshop could possibly compromise the collaboration between the participants that is present in a physical workshop. Some of the interviewees expressed it as follows:

Challenges I think is worth mentioning is collaboration, that's the main one to me. And creativity to me is the results of collaboration, so that's the third factor that can be impacted when moving online. (P03)

Normally you have an analogue tool set with cards, and you want to have a discussion. You want to have people that are discussing certain topics together in a dialogue and in collaboration to create something during discussion and dialogue. The problem is when you have to do it online this is a different story, because interaction is interfering a lot more from my perspective, than helping at the moment. (P09)

You lose the common physical medium. Being able to use this medium to show something without having to explain it in words. (P08)

Some of the interviewees also stated challenges with interaction of cards between participants in the digital environment:

With Tiles we have a lot of "things" cards. So, I can give ten "things" to you and ten "things" to someone else, and everybody is reading ten, and we get a shared understanding. It's really easy to split up and pair and share and point to specific "things". And that's what's getting lost if we would have it on a Miro board (...) Sharing and giving around, would be like the first thing I find myself in need of having. And pointing to one of them. (P02)

I saw some groups breaking the deck of cards in four and then each of the group members going over a set of cards. These are dynamics that are very easy to negotiate when you are face-to-face, but they are very hard to negotiate over sort of digital or over distance. Unless you clearly, sort of, you have a system that supports those activities that this does. (P04)

Communication is also different in the digital environment, and two interviewees stated that it can be harder to express yourself when you are digitally communicating with your team members, compared to having a face-to-face discussion:

In a physical group it might be easier for people to jump in with their own opinion, whereas in a digital room, sometimes you need to very consciously start speaking, or indicate that you want to say something. In a creative process, if you're not that assertive to jump in the conversation, chances are high that you will just stay in the background, whereas you're not really being asked "What do you think about it?". And I think that it's kind of difficult to hear everyone's opinion about something. (P07)

One interviewee suggested that a coordinator can be used to help the participant engage in the discussion:

Maybe people would be shy in the beginning, about contributing, since I guess you have also experienced that in meetings as well, that some people usually don't talk at all in meeting sessions on Zoom. So that can be a problem, and I think that a coordinator or a person to lead the workshop might be a bit more needed, so to reduce the empty silence. (P06)

4.3 Discussion

From the interviews there were identified several characteristics which should be considered when transforming Tiles into a digital toolkit. Gaining insight into how workshops with Tiles promotes creativity and cooperation in idea generation workshops, and examine how these characteristics can be transferred into the digital environment, were one of the main focuses of the interviews, thereby answering RQ1.2. In addition, functionalities and features that could be tried out in a digital version of the toolkit were also suggested by the interviewees. The following section presents a discussion of the results.

4.3.1 Workshops Using Tiles

According to the interviewees, Tiles had been used for different purposes. One of the interviewees expressed that the most prominent use was to familiarise the participants of the workshop with IoT and related technology, and to engage the

participants in idea generation. The workshops with Tiles were often adapted to the participants of the specific workshop, aiming to making it more relevant for the target group. Some of the interviewees had also been using an adapted version of Tiles, either by using only parts of the toolkit or by including existing tools and technology.

The pre-session information that was given before the workshop started, was considered as something that could easily be adjusted depending on the on the participant's age, knowledge or interests. Some of the interviewees suggested that the information and the problems the participants were given in advance, could help engage the participants and facilitate creativity, and thereby affecting the outcome of the workshop.

The Tiles cards were used in a collaborative way, as a medium of discussion. This is also supported by the findings from a study by Roy and Warren (2019), in addition to the analysed card-based tools in section 3.2. Many of the interviewees also agreed that the cards worked as an inspiration for idea generation, and to help the participants of the workshop to come up with useful ideas. Although it was also stated that the large amount of cards could confuse the participants, as it gave the participants too many opportunities. This was mostly true for the younger participants, and that they would in some cases benefit from a less open process, where they were handed a predefined problem to solve.

It was stated almost unanimously that the steps in the playbook were well defined, and that it was easy to follow the suggested approach of Tiles. One interviewee stated that there were hardly any questions from the participants regarding the playbook section. However, one drawback of this approach was mentioned by two interviewees. One of them stated that they did not follow the given structure as they thought it was too rigid, and that it did not provide enough freedom. Another interviewee expressed that this process worked for beginners, but for more experienced participants, this approach could seem to strict. As the main target group is non-experts, a structure such as the one provided with Tiles could be beneficial in a digital version. Although, it should be acceptable to go back and forth between the different steps, rather than strictly following the numbered order of the steps.

The last steps in the playbook, which include sketching and pitching the generated ideas, were considered to be the steps that the participants struggled the most with. According to some of the interviewees, some participants tended to neglect the sketching step, and just present their idea instead. It was stated these steps did not facilitate collaboration as well as the other steps, which include discussion and brainstorming. It usually requires one person from each group to sketch the idea on behalf of the rest of the group, and one person pitching the idea.

It was stated that Tiles promoted collaboration between participants by providing collaborative activities and artifacts that could be used in the discussion and for brainstorming. Participants would often use the cards to discuss and sketch dif-

ferent solutions to problems. The collaboration factor within groups also seemed to depend a bit on how well the participants knew each other from before. This is also supported by Tafliovich, Petersen and Campbell (2016), who researched student development teams, and found that the teams became more effective when they were familiar with the other team members.

One of the interviewees stated that age was also a factor that affected the level of collaboration, and that older participants seemed to have a higher level of collaboration than the younger participants. The facilitators of the Tiles workshops stated that they observed the participants to contribute nearly equally in the decision making process, although there was almost always someone taking the role as a "leader".

The interviewees agreed that the workshop with Tiles promoted creativity, and it was stated that the workshop using Tiles was a free space where the participants could think unfocused and exchange ideas. One of the interviewees expressed that the problems that the participants solved during the workshop with Tiles promoted creativity, as everyone could find something they could relate to. In turn, this could give the participants the motivation to find a creative solution to a problem.

4.3.2 Online Workshops

The two interviewees who had experience with facilitating online co-design workshops using card-based toolkits, used Miro as a platform for hosting the workshop. Both interviewees used the same artifacts that were part of the original toolkit, only a digital representation of the artifacts. One of the interviewees expressed that the preparation was a bit stressful, because everything needed to be in place before the workshop started. There was also little room for error compared to conducting physical workshops, according to the interviewee.

Both interviewees expressed challenges with teaching the participants to use Miro, as almost none of the participants had any prior experience using the platform. One of the interviewees stated that the participants required a more elaborate explanation on how to use the digital version of the toolkit versus the physical toolkit. As a result, one of the interviewees created a script and included this in the platform, where the participants could get more detailed instructions on how to use the tool and the platform. Other challenges was related to the interaction with the artifacts, and that this is different in the digital environment. Pointing to things was one of them. Drawing was also considered an issue, as most people were not familiar with drawing digitally with a computer mouse, according to one of the interviewees.

4.3.3 A Digital Transformation

Cooperation during a digital workshop is different from the physical cooperation face-to-face. One of the interviewees suggested that facilitating the participants getting to know each other before they start, could be a good solution for making the participants feel more comfortable working together. This can also be done online. Another suggestion from a different interviewee was having a shared space where everyone could see what the other participants were doing. This was also supported by another interviewee, who used a shared whiteboard for all the participants in a digital workshop. According to Gutwin and Greenberg (1999), maintaining workspace awareness is important for distributed teams, so that the team members get a better understanding of what is going on.

Online creativity can be promoted in different ways. One of the interviewees stated that it depends a lot on the context and who the participants are, and therefore, it should be tailored according to the participants. Some of the interviewees suggested using the cards as a way to inspire the participants to think more creatively. One of the suggestions involved giving them random and unrelated cards to inspire them to think outside the box. Another suggestion that was made, was to give the participants some random cards they could use, or ask them some questions to get them to reflect upon their idea during the workshop.

Some of the stated benefits of transforming a physical card-based tool into a digital version, were related to reaching more people and the fact that it would be easy to update the tool. One of the interviewees also stated that the custom cards were more commonly used during the digital workshop, and that this led to participants coming up with their own ideas instead of using the predefined cards in the toolkit. One suggestion that was made, was to use the technology to make the decision making process of the toolkit easier, by for example introducing algorithms.

Some of the challenges that were mentioned during the interviews, were related to the fact that creating a digital version of Tiles introduces a new tool with unknown properties. This is just something that needs to be tested, and thereby confirm or reject the possibility of it being a good enough design tool. Other challenges of the digital transformation related to the interaction with the cards, which will become a different interaction than the physical. Communication was also mentioned as a possible challenge, as it might be harder for people to speak up in a digital environment compared to having a discussion face-to-face.

Chapter 5

Implications for Design

Analysing card-based design tools and interviewing people with expert knowledge of Tiles and other card-based design tools, have led to substantial findings, which were used to develop a digital toolkit. The findings are presented in this chapter as requirements and high-level functionalities.

Section 5.1 presents the functional requirements identified from the literature. Section 5.2 displays some high-level functionalities identified from the interviews. Lastly, section 5.3 of this chapter introduces some platform requirements for the digital prototype.

5.1 Functional Requirements

Eight functional requirements (FR) have been identified from analysing existing card-based tools used in idea generation workshops. The requirements were considered to apply for all card-based tools that are to be used in digital workshops, and were not specific to Tiles alone. The requirements were categorised by the different concepts used in the framework analysis of the card-based tools in chapter 3, namely artifacts, process and cooperation. The functional requirements are listed in table 5.1.

5.1.1 Artifacts

Requirements supporting the interaction with artifacts of the card-based tool:

FR1: A user should be able to easily interact with the different artifacts of the card-based tool.

In physical workshops the artifacts are tangible and easy to move around. In a digital workshop, this is something that needs to be facilitated.

FR2: A user should be able to move selected cards around, so that it is possible to group different cards in suitable ways.

Grouping of cards was seen in some of the physical workshops of the analysed tools. This can provide some form of structure for the users of the tool.

FR3: All cards should be easily accessible and visible, so that the users can make a thorough selection.

The cards should be organised in a way that makes it easy to see all cards that are part of a category, so that it is easier for the users to make a thorough selection. In a physical workshop one can easily go through a card deck using the hands, however, in a digital workshop this is not the case.

5.1.2 Process

Requirements supporting the process of the workshop and the tasks provided by the tool:

FR4: Information about the process should be easily accessible and clear, so that the users know what to do at all times.

The card-based tool should provide enough information about the process or the different tasks, so that the users know how to use it. This information needs to be clear and visible to all participants using the tool.

FR5: A user should be able to see the progress at all times of the design workshop, so that it is easy for the users to see what has been done, and what is left to do.

The users of card-based tools should have a clear overview of where in the process they are. This includes having easy access to information about the total process.

5.1.3 Cooperation

Requirements to facilitate cooperation between team members in the digital environment:

FR6: All participants of the same team should be able to communicate with each other to facilitate cooperation between team members.

In online workshops communication needs to be facilitated between the users. This can be done either by implementing communication functionality in the tool, or using external communication tools.

FR7: A user should be able to see where the other team members are working in the tool, to be able to cooperate with the other team members.

To achieve workspace awareness in the digital environment, the users of the tool should be able to coordinate the work, and see what the other team members are up to.

FR8: Changes made by a user should be visible to all other users working on the same tool, so that everyone is informed about the progress and the changes made.

If someone makes a change, selects cards or does something related to the tool, it should be visible to all team members, so that everyone know what is going on in the process.

No	Artifacts
FR1	A user should be able to easily interact with the different artifacts of the card-based tool.
FR2	A user should be able to move selected cards around, so that it is possible to group different cards in suitable ways.
FR3	All cards should be easily accessible and visible, so that the users can make a thorough selection.
Process	
FR4	Information about the process should be easily accessible and clear, so that the users know what to do at all times.
FR5	A user should be able to see the progress at all times of the design workshop, so that it is easy for the users to see what has been done, and what is left to do.
Cooperation	
FR6	All participants of the same team should be able to communicate with each other to facilitate cooperation between team members.
FR7	A user should be able to see where the other team members are working in the tool, to be able to cooperate with the other team members.
FR8	Changes made by a user should be visible to all other users working on the same tool, so that everyone is informed about the progress and the changes made.

Table 5.1: Functional requirements for card-based tools.

5.2 High-Level Functionality

The participants from the interviews suggested multiple functionalities and features that could be useful in a digital version of Tiles. The researcher selected eight of the suggested features and functionalities from the interviews, which are further discussed in this section. These functionalities were selected based on the number of participants from the interviews who suggested similar functionalities, and also to what extent they could promote cooperation and creativity in digital idea generation workshops. The last functionality, gamification, was identified from literature.

The functionalities were later prioritised, and some of them were selected to be part of the first prototype.

“Be keen to use a new version, to try out something (...) Because once you are digital, you are not any longer bound to this, what we have in our world.” (interview participant no. 1)

Custom Cards

One of the participants who had experience with facilitating digital workshops, stated that the custom cards were used more commonly in the digital workshops compared to the physical workshops. Facilitating a way of easily creating custom cards could provide more freedom in the design process, and support creativity.

Random Cards

One of the participants suggested that random cards could be good for inspiring the participants and to let them think outside the box. Being able to draw random cards from a deck is also possible in a physical workshop, although it would be interesting to try out a similar functionality in the digital toolkit.

Supporting Various Workshops

Participants from the interview stated that they had used Tiles for different purposes and in different types of workshops. Examples of different workshops included quick ideation, where the goal was to come up with as many ideas as possible in a short amount of time, hackaton and shorter workshops with predefined problems. In a digital environment it would be possible to implement support for multiple types of workshops.

One example would be using Tiles for quick ideation, which would be possible without using the board. One of the participants who had facilitated a workshop using Tiles, handed out random cards which the students were supposed to use for brainstorming. If a randomly drawn card functionality was implemented, this could possibly be combined with a quick ideation brainstorming session, so as not

to spend much time on deciding which cards to use. A possible solution would be to select a random *persona*, a *scenario* and a *mission* card, then having to come up with an idea for an IoT solution that would match these cards. This would give the participants more time in focusing on quick ideation, rather than coming up with a perfect solution.

To enable facilitators to customise the workshops, it would be useful to provide some guidelines on how this could be done in the digital toolkit.

Countdown Timer

One participant stated that it was very important to follow the time that was given for the tasks in advance. If not, the participants could easily get unfocused. Displaying time on the board, or having some countdown functionality could be a way of making it clear for all participants to stay within the time constraints for each step.

Virtual Pointing

One of the participants who had conducted digital workshops using a card-based tool, stated that it would be nice to be able to point to objects, such as the cards, to show the other participants of the workshop a specific card. Finding a way to facilitate this feature in a digital workshop could be useful for promoting awareness.

Providing Examples of Solutions

Another suggestion involved providing the users some examples of IoT solutions that could be created from the Tiles toolkit in order to motivate the users to finish the process. However, a potential drawback of this, is that the users tend to produce solutions similar to the examples provided, which could potentially reduce the creativity level. On the other hand, examples could help improve the quality of the solutions and ideas (Sio, Kotovsky & Cagan, 2015).

Team Building Activities

One participant suggested giving the users some team building activities or tasks before the workshop starts, so that the users can get to know each other and build a connection. This could have a positive effect on the cooperation level within groups.

Platform Instructions

The two participants who had experience with digital workshops in Miro, stated that the users of the workshops tended to spend some time getting to know the platform before they began with the workshop. They also explained that it could

sometimes be a challenge that the users did not know how to use the functionalities provided by the platform.

As a solution, one of the participants from the interviews added a description on how to use the platform and the tool.

Gamification Elements

Adding gamification elements to the digital toolkit was not discussed in the interviews, however, research has shown that gamification could enrich the design tool and provide a more playful experience (Morschheuser, Hamari, Werder & Abe, 2017).

Gamification has been defined by Huotari and Hamari (2017) as "a process of enhancing a service with affordances for gameful experiences in order to support users' overall value creation". Some common motivational affordances used in gamification have been identified by Hamari, Koivisto and Sarsa (2014) and are listed below:

- Points
- Leaderboards
- Achievements/Badges
- Levels
- Story/Theme
- Clear goals
- Feedback
- Rewards
- Progress
- Challenge

Studies has shown that these motivational affordances produces positive effects (Hamari et al., 2014). However, it is also important to understand the users and the target group when gamification is applied (Morschheuser et al., 2017). Some of the affordances and how they can be applied to a digital version of Tiles are discussed next.

Points could be given for finishing the process step within the time limit or for developing creative ideas. The latter would require a "judge", which could be the facilitator or a leader of the workshop. Checking if a group has finished a process step within a time limit, could be part of an automated process that checked if cards have been placed on the associated card placeholders in time. It would also be possible to track the contribution of the individual member of each group in the activity log. A group could for example be given points for a more or less equal contribution to the workshop. This would perhaps increase the motivation for having everyone in the group participate in the workshop, and to finish the process. Lack of motivation for completing the last steps in the workshop using

Tiles, was also an issue that could sometimes occur, according to one of the participants from the interviews.

If points were given, a global *leaderboard* could be created based on the score of each group. Perhaps this could boost the motivation within a group to create a better ideas than their fellow groups.

Achievements or *badges* may be harder to track, although one could for example be given badges for contributing to certain parts of the workshop. However, points could also cover this part of the process.

Clear goals are already considered to be a part of the Tiles toolkit, as the sub-goals involves completing each of the steps in the playbook section. The end goal is to develop an IoT solution that solves a problem, which is specified in the beginning of the process. It might be useful to make the goals more prominent in some way, indicating that a sub-goal has been completed, and display the next goal of the process on the way to complete the end goal. This could also be displayed as a visual process, for example a progress bar indicating how much is left to do before the workshop is complete. Sound effects could also be used to indicate achievement of goals.

5.2.1 Prioritising Functionalities

The goal of the first digital prototype was that it should be simple and functional. When it has been tested, it would be possible to extend with extra functionality and features to take advantage of the digital environment. The prioritised table can be seen in table 5.2.

The high-level functionalities were priorities based on to what extent they were perceived useful and easy to implement in the first version of the prototype.

One of the most important features was considered to be custom cards, which is already a part of the Tiles toolkit. A way of editing the cards became a high priority in the first version of the digital toolkit. In addition, facilitating a way of pointing to objects was considered to be important, so that a member of the team was able to show a specific card or an object to the other team members. As a result, pointing was also rated high.

Countdown timer and random cards were considered to be very useful, although they are not strictly necessary functionalities. One can assume that both of these functionalities would be easy to implement, and therefore, they were rated medium.

Providing instructions for the use of the platform could also be useful, to inform the participants of what they can do and where to start. However, it would be interesting to test if the participants are able to figure out how use the toolkit and the functionalities before adding any platform instructions. After the test, it

will be possible to adapt the instructions to the needs of the participants. This functionality also received medium priority.

Team building activities was considered to be a low prioritised functionality at first, as it was not considered to be essential for the first version of the digital toolkit. At first it would be useful to test the prototype without such activities, and then introduce team building activities later, to see if they could have a positive effect on the cooperation and creativity level within groups.

Supporting multiple workshops would require the ability to customise the tool, and this implementation could potentially be time consuming. As this was not considered important for the first version of the prototype, this was also rated low in priority.

It would also be possible to implement gamification elements later, when the other more important functionalities were in place. For this reason, gamification elements was also rated low.

Providing examples of IoT solutions in the tool was also considered a low priority. It would be interesting to test this in a later version of the toolkit, and see if such examples helps the creativity level, or if people will copy the provided examples.

When testing the prototype, other functionalities might be suggested and prioritised.

Functionality	Priority
Custom cards	High
Virtual pointing	High
Random cards	Medium
Countdown timer	Medium
Platform instructions	Medium
Team building activities	Low
Supporting various workshops	Low
Providing examples of solutions	Low
Gamification elements	Low

Table 5.2: Functionalities prioritised from high to low.

5.3 Platform Requirements

When designing the digital prototype, two options were considered. The first option was to create a new platform from scratch. The second option was to use an existing platform. Both options had their advantages and disadvantages.

If a platform were to be developed from scratch it would obviously be a lot more time consuming. On the other hand, it would allow for total customisation of the tool. If there already existed a platform that supported the following requirements, it might be a good solution to use an existing platform to save time and effort creating a new platform. The platform requirements (PR) were specified as follows:

- Multiple users working together in the same workspace.
- Synchronous update to support cooperation between users and workspace awareness.
- Uploading custom elements to the system so that artifacts can be reused.
- Interaction with uploaded elements, such as moving and editing of elements.
- Displaying other users through visible mouse pointers, to support workspace awareness in the digital environment.

The platform requirements were summarised in table 5.3, and were used to evaluate existing platforms.

No.	Requirement
PR1	Multiple users
PR2	Synchronous update
PR3	Upload custom elements
PR4	Interaction with uploaded elements
PR5	Visible mouse pointers

Table 5.3: Platform requirements for the digital toolkit.

Chapter 6

Going Digital

This chapter starts with an evaluation of online collaborative whiteboard platforms in section 6.1, in order to decide which platform, if any, would be most relevant for designing a digital toolkit. Section 6.2 presents an overview of the design choices for the digital prototype. This includes the implementation of requirements and functionalities that were presented in the previous chapter.

6.1 Evaluation of Collaborative Whiteboard Platforms

Online collaborative whiteboard platforms were considered to be a good choice for implementing a toolkit, as such platforms had already been proved useful in supporting digital design workshops with multiple users. In addition, most online whiteboard platforms already support synchronous update and multiple users, meeting platform requirements PR1 and PR2 in table 5.3. Participants from the interview had used such platforms for digital design workshops, and the researcher also had previous experience with using some of the online collaborative whiteboard platforms.

An evaluation of four different web-based collaborative whiteboard platforms was done, to investigate if any of these existing platforms were sufficient to support the design of the digital toolkit. As Miro had been used by participants from the interviews for conducting card-based design workshops, and the Tiles team had uploaded the artifacts of the Tiles toolkit to the platform, Miro was considered to be the first choice, unless any of the other platforms seemed to work better for this purpose.

After searching for collaborative online whiteboard platforms, AWW App, Jamboard and Mural were found to be prominent choices in addition to Miro. Table 5.3 of platform requirements was used as a starting point for the evaluation of the platforms.

6.1.1 Miro

Miro¹ is a collaborative whiteboard platform with many different features. The platform has built-in functionality that lets the users of the platform see where the other users are working on the board in real time. It is also easy to follow a specific user through a mouse pointer, and see the changes made by others. One can create new elements by selecting something from the menu, or upload custom images to the board. It is easy to interact with the uploaded elements, moving them around or editing them directly. Miro allows creating new frames, which is a functionality that lets the user organise elements on the platform and navigate between them. One can navigate between the different frames either by selecting the frame from a menu, or manually move between different frames on the board by zooming in and out. Miro also support integration with external applications. It also allows integration with other tools and plug-ins, which allows for more advanced features. Miro provides a free plan, although one would need an upgrade at \$8 a month to be able to support more than one user at the same time.

6.1.2 Mural

Mural² is a digital workspace with lots of functionality, similar to Miro. The platform allows uploading custom content and creating frames which one can navigate between. Similar to Miro, Mural also allows users to see each other through a mouse pointer, and it is easy to see what changes have been made, and who made the changes. Mural also offers a facilitator mode, which allows for extra functionality, such as summoning all users, which could be useful in design sessions. Like Miro, Mural supports integration with external applications. The starter plan cost \$12 a month.

6.1.3 AWW App

AWW App³ is a lightweight online whiteboard tool, with limited functionality. AWW App does not require any login information, and it is fairly easy to use. It supports drawing, creating simple shapes, and adding post-it notes to the whiteboard. It also allows uploading custom photos, which can be resized and moved around. AWW APP also supports seeing the movement of the mouse cursor of other users working in the same document. Although it supports all of the required platform functionalities, the platform lacks a way to create frames one can navigate between. Even though this was not a specified requirement, it makes it harder to organise the different uploaded elements. AWW App is free to use, although there is a premium version that offers a bit more functionality, like managing participants rights and PDF upload.

¹<https://miro.com/>

²<https://www.mural.co/>

³<https://awwapp.com/>

6.1.4 Jamboard

Jamboard⁴ is a simple collaborative whiteboard tool made by Google. It supports drawing, uploading images and a few other additional functionalities, such as creating shapes and sticker notes. However, the platform is not easy customisable, and it does not support external integration or plug-ins. It does not display where the other users are located on the whiteboard when they are moving around, only when they are drawing or selecting something on the board. Similar to AWW APP, Jamboard does not provide frames for navigation. Jamboard is free to use.

6.1.5 Discussion

From the evaluation of online collaborative whiteboard platforms, it seemed that using an existing platforms should be sufficient for developing a digital prototype of a card-based design tool. As seen in table 6.1, Miro, Mural and AWW App support the platform requirements listed in table 5.3.

AWW App and Jamboard were considered the most light-weight collaborative platforms in the evaluation, as they only provide minimal functionality, and not integration with other apps or plug-ins. In addition, AWW App and Jamboard does not support creating frames and easy navigation, and as a consequence, it will be harder to organise the uploaded elements and navigate between them.

Two of the interviewees in chapter 4 had used Miro for transforming physical card-based tools, so that they could arrange digital workshops using the tools. The interviewees stated that they were satisfied with the platform, and that the digital workshops had gone well. Some of the limitations they mentioned, were specifically pointing to an object and sketching. Sketching/drawing is supported in all four platforms, although it is different from drawing physically. Pointing is also supported by mouse pointers, although this was not sufficient according to one of the interviewees, who compared it to physically pointing to one card.

The Tiles team had already uploaded the Tiles toolkit artifacts to a Miro board, so that it could be available to use in the pandemic situation (see Figure 6.1). It would be uncomplicated to reuse some of the artifacts in the implementation of the digital toolkit in Miro. For these reasons, Miro was selected as the preferred platform to implement the digital solution of the toolkit in.

Platform name	PR1	PR2	PR3	PR4	PR5
Miro	X	X	X	X	X
Mural	X	X	X	X	X
AWW App	X	X	X	X	X
Jamboard	X	X	X	X	-

Table 6.1: Platform evaluation results.

⁴<https://jamboard.google.com/>

6.2 Designing Digitiles

When designing Digitiles, the aim was to find a good way of implementing the requirements and suggested functionalities from the literature of card-based design tools and interviews, answering RQ1.3. This section presents the design choices that were made to create the first version of Digitiles.

The uploaded cards of the Tiles IoT Inventor Toolkit were reused when creating Digitiles. A lot of the previous design of the toolkit was also reused, as it had proved to be efficient. To take advantage of going digital, and to improve the toolkit in the digital environment, additional functionalities were also added. The first version of Digitiles focused on meeting the functional requirements of table 5.1. The highest prioritised functionalities in table 5.2, custom cards and virtual pointing, were also implemented in the first version of the toolkit.

6.2.1 Reuse of Virtual Uploaded Cards

Figure 6.1 shows the board and the cards of the Tiles toolkit uploaded to Miro. This became the starting point for the design, as it was possible to reuse parts of this Miro board to create a new and improved version of the toolkit. An enlarged version of the image can be found in appendix B.1.



Figure 6.1: The original Tiles IoT Inventor Toolkit artifacts uploaded to Miro.

The Tiles board, as shown in figure 6.1, was intended for physical workshops with physical Tiles cards. When it became digital, it was no longer bounded by the physical restrictions, such as limited space and having to reuse the same board multiple times. Custom cards and new cards could easily be created, without hav-

ing to worry about writing on physically printed cards, or reprint new versions of cards. Multiple people could work together on the same tasks, for example writing the elevator pitch, because they were no longer restricted by limited writing space. To take advantage of some of the benefits of the digital environment, some adjustments were made.

6.2.2 Redesigning the Toolkit

Figure 6.2 displays the result of the first version of Digitiles. An enlarged version of the image can be found in appendix B.2.

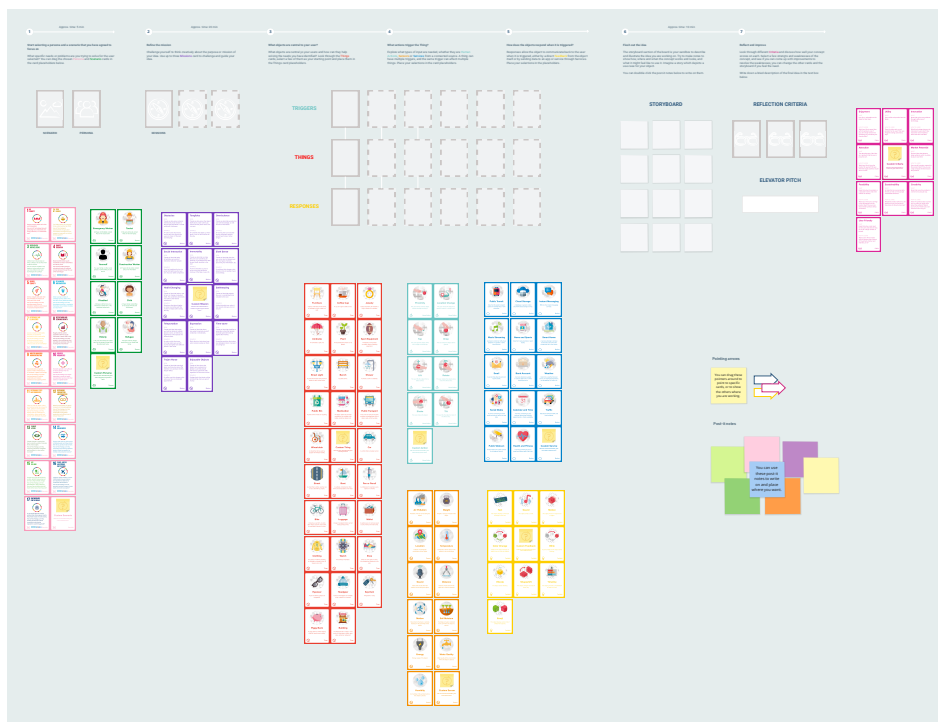


Figure 6.2: The first version of Digitiles.

6.2.3 Artifacts

Functional requirements FR1-FR3 involve interaction with the artifacts of the card-based tool. The main artifacts of the Tiles toolkit consist of nine Tiles card categories, a board with card placeholders, a playbook with the process descriptions, a storyboard and an elevator pitch. The design of these artifacts are described here.

Cards

All cards should be visible for the users, meeting FR3. The cards were organised in different categories, so that the users could view the different cards within each category. As previously mentioned, it is possible to create frames in Miro for different elements which one can navigate between. One frame was created for each card category.

Figure 6.3 displays how frames can be used for navigation in Miro. If you click on a frame, it will zoom in on the selected frame on the Miro board.



Figure 6.3: Card category frames in Miro.

For each category of cards there is a custom card, which allows the user to create a custom description of cards that do not exist in the toolkit. As custom cards was highly prioritised as a functionality, the custom cards were modified so that the description of the custom cards was replaced by a text-box. This allowed the user to double click and write a custom description on the card. Figure 6.4 displays a custom card with an editable description.

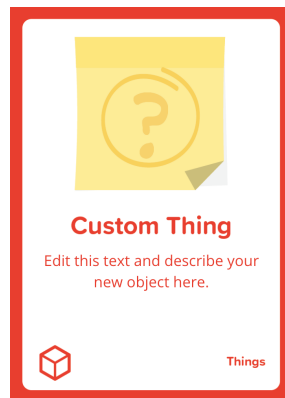


Figure 6.4: Example of a custom card from the *things* category.

As Miro provides functionality for interaction with uploaded elements, moving them around on the board, FR1 and FR2 is considered to be fulfilled.

Post-it Notes

Post-it notes have also been a part of previous Tiles workshops as additional artifacts. In Miro it is possible to create virtual post-it notes and customise the size and colour. To make this feature more visible, a set of empty virtual post-it notes was added to the board.

Card Placeholders

The placeholders were also reused, although they were moved closer to the associated step description, to avoid having to navigate around to find the correct card placeholder. This is also some form of natural mapping, which means that elements that belong together, or have some relationship, should be grouped together (Norman, 2013). Figure 6.5 displays an example of this layout from the prototype.

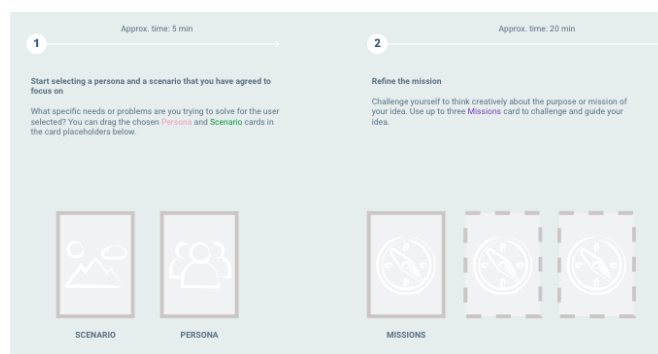


Figure 6.5: The first two steps in the process and the associated card placeholders.

Storyboard

The storyboard section of Tiles consisted of small squares, which were meant for sketching and writing. However, if one was writing or sketching directly in the square, the board could not be reused. Post-it notes were often used instead of writing directly on the squares on the board. A series of empty virtual post-it notes were added to the storyboard (see figure 6.6). The affordance principle by Don Norman (Norman, 2013), is about knowing what you can do with an object by looking at it. By using virtual post-it notes, an association can be made to physical post-it notes which most people have experience with. A virtual post-it note have many of the same properties as a physical post-it note, although it is not entirely the same. As some of the participants from the interviews considered drawing to be challenging in the digital environment, the focus will be on writing instead.



Figure 6.6: The storyboard with a series of post-it notes.

Elevator Pitch

As mentioned, one of the advantages of going digital is that it can be easier to work together on the same parts, such as writing on a digital document. The elevator pitch was one of the things that the interviewees in chapter 4 considered to be an individual activity, because multiple people could not write the elevator pitch at the same time. In the digital prototype, the elevator pitch was created as a text box on the board. Everyone else on the board can see what is written, and change something. This is also in line with FR5 and FR8.

6.2.4 Process

The process steps of Tiles were described in a playbook section on the bottom of the board. Requirement FR4 suggests that the information about the process should be easily accessible and clear. The defined stages of the playbook were one of the main things that the interviewees found useful for non-expert users. The process stages would be more visible by placing it on top of the new board (see figure 6.5).

To meet FR5, the progress of the workshop should be visible for all users so it is easy to see what has been done and what is left to do. Having a shared whiteboard displaying all the elements of the toolkit, including the board with the process steps, enables this requirement.

6.2.5 Cooperation

Communication

To meet FR6, the participants of the same team should be able to communicate with each other. In Miro, there exists an app to support video chat with all team members of the same Miro board. In addition, it is also possible to use an external communication tool to support communication between the participants throughout the workshop.

Overview of the Toolkit and Team Members

As previously mentioned, Miro allows for seeing where the other users are working on the board by having a visible mouse pointer on the screen that display the user's moves. It is also possible to click on the icon of another user to zoom in, and automatically follow this user's movements around the board. These functionalities fulfil requirement FR7.

In Miro one can also zoom in and out to get visual access of the entire board, following the process of the design toolkit and the changes made by other users working on the same board. This is in accordance with requirement FR8.

Virtual Pointing

Virtual arrows were added to the prototype, as this was another highly prioritised functionality to support workspace awareness. The arrows can be moved around and be placed to point at an object or a specific part of the board if needed. The arrows can be seen in figure 6.7).

Pointing arrows

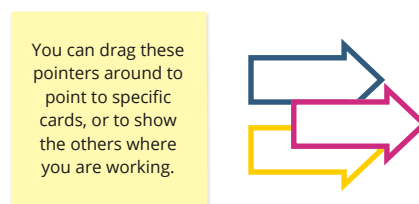


Figure 6.7: Virtual arrows in the prototype.

Activity Log

"Activities" is one of the built in functionalities in Miro. Activities displays a log of all the changes made to the Miro board. The log can be used to re-visit ideas, analyse the progress of the workshop and see what has been done. Even though activity log was not part of the high-level functionalities, it would be interesting to investigate the use of this functionality, as it already exists as part of the platform.

Chapter 7

Usability Testing

Four usability tests were performed to identify potential issues with the first version of Digitiles and its functionalities, and to ensure quality to the prototype. The goal was to be able to improve the usability of Digitiles before it was to be tested in digital co-design workshops.

This chapter begins with a description of the method used in the usability tests in section 7.1. Section 7.2 and 7.3 displays the results of the usability tests. Section 7.4 includes a discussion of the results, and lastly, section 7.5 introduces some of the changes made to the prototype after the usability evaluation.

7.1 Method

7.1.1 Procedure

The usability tests were performed with one participant at the time. Firstly, the participants were given information on how the test would be performed and what the purpose of the test was. This information was closely inspired from the "Ten Steps to Usability Testing" by Hansen (1991), and can be found in appendix C.2.

The usability tests were performed digitally, using Zoom. The participants were given the tasks, both in oral and written format to ensure that they had understood the tasks. A total of ten tasks were handed out, one at the time. Once the participants believed that they were done with a task, they were to say this out loud before they were given the next task. This was done in order to confirm that the participants were actually done with the task, before giving them a new task. After completing all tasks, the participants were free to state their opinions of the toolkit and the tasks, if they had anything they wanted to share.

The researcher took on a passive role during the usability tests, and tried not to help the participants solve the tasks. If any questions came up, the researcher

would repeat the task related to the question, and try to give minimal advice, so that the test results would not be affected.

7.1.2 Participant Observation

Participant observation was used as a data generation method, observing and analysing the participants interaction with the prototype throughout the tasks (Oates, 2006). The participants were sharing their screen in Zoom while interacting with the digital prototype in Miro. The participant's screen in Zoom was recorded, so to allow for the tests to be analysed more thoroughly in retrospect. Screen and audio recordings allowed for gathering more accurate results than one would be able observe alone during the conduction of the tests.

The data from the recordings were carefully observed, to ensure that all the information about the interaction with the prototype and the statements from the participants were covered in detail. The data formed the results of the usability tests. The original statements were rephrased when included them in the results. The results were used to evaluate the first version of Digitiles, and to further improve the prototype.

7.1.3 Usability Tasks

The tasks were created to test the support for cooperation and workspace awareness, interaction with the artifacts and some of the built-in functionalities in Miro. The complete task description of the ten tasks can be found in appendix C.4. A brief description of the actions to be performed in the different tasks are listed below:

1. Locate and move cards.
2. Locate and move cards.
3. Use and edit the custom card description.
4. See changes made on the board (activity log).
5. Re-select a card from the card placeholder.
6. Use virtual arrows to point.
7. Write on virtual post-it notes (storyboard).
8. Navigate between frames in Miro.
9. Locate mouse cursor of another user.
10. Give an overview of the process, what has been done and what is left to do.

Scenarios were created to describe the tasks. This was done in order to make the test feel more realistic (Dumas & Redish, 1999). The scenarios were short and directly linked to the tasks and concerns. The scenario introduction can be found in appendix C.3.

As one of the purposes of the toolkit is to support cooperation between multiple users, some tasks were created to test some aspects of cooperation using the toolkit

(tasks no. 4, 5, 6 and 9). In these tasks, the researcher played the role as a colleague of the participant, and performed some actions on the same board as the participant was using during the test.

Some tasks were created with the intention of testing the interaction with the artifacts that the digital toolkit consisted of (tasks no. 1, 2, 3, 5, 6 and 7). The digital objects were cards, virtual post-it notes, arrows and a board.

Two of the tasks were created with the intention of seeing how well the users were able to locate some of the built-in functionalities in Miro (tasks no. 4 and 8). Another task was created to see if the participants understood the overall process of the tool, what had been done and what was left to do (task no. 10).

7.1.4 Ethics and NSD

A new NSD form was submitted to the existing project, to ensure that the collected data in reference to user testing of the prototype would be processed according to ethical guidelines. All participants received a copy of an information sheet with a consent form, with information on how their data would be processed in advance. The information sheet with the consent form can be found in appendix C.1.

7.1.5 Participants

Research has shown that four to five subjects can detect around 80% of the usability issues, and that the most severe usability issues are likely to be discovered with the first few subjects (Virzi, 1992). As a result, four participants were considered enough in this case, with one of them performing a pilot test to identify the most severe usability problems in the prototype.

It was decided that at least one person who had experience using the physical Tiles toolkit should be recruited as a participant. This was done in order to identify some of the strengths and weaknesses with the digital version compared to the physical version. It might also be that someone who has used Tiles before is able to provide useful feedback on the new functionalities that were not part of the original Tiles toolkit, and reflect on whether this improves the toolkit or not. In addition, it was considered useful to have someone who did not have any knowledge of Tiles test the new digital toolkit. This would enable seeing the toolkit from a new perspective.

As a result, two people who had experience using Tiles in the past and two people with no knowledge of Tiles were recruited for the usability tests. Three of the participants were acquaintances of the researcher, while one participant with knowledge of Tiles was suggested by the supervisor.

As seen in table 7.1, the pilot participant (P01) had been using Tiles once before as a participant. Participant P02 and P03 had no knowledge of Tiles from before. P04 had been using Tiles multiple times, and had experience with facilitating

workshop using the physical toolkit. P02 and P03 had some experience with Miro in the past, and were familiar with some of the built-in functionalities provided by Miro.

Participant no.	Experience with Miro	Experience with Tiles
P01		X
P02	X	
P03	X	
P04		X

Table 7.1: Usability test participants and their experiences.

7.1.6 Pilot Test

One pilot test was performed to detect the most severe usability issues and to ensure that the tasks were understandable. The pilot test was kept in the same format as the other tests, although the pilot participant was told that he/she was free to comment on the given tasks at any time, as well as the structure of the test. After the participant was done with the provided tasks, the researcher went over the different tasks one more time with the participant, discussing the format of the test and the approach taken by the participant during the test. The result of the pilot test can be found in section 7.2. Based on the feedback from the pilot participant, some adjustments were made to the prototype and the tasks.

7.2 Pilot Test Results

According to the pilot test participant, the scenarios and the tasks were quite clear and easy to understand, although some of the tasks were harder to execute than others. In the end, the participant was able to complete all ten tasks. Table 7.2 displays the changes that were made to Digitiles based on the feedback from the participant of the pilot test. The changes are justified from the pilot test results, which are presented in this section.

Edit a Custom Card

The goal of task number 3 was to edit a custom card. When trying to edit the card, P01 clicked on the editable text and pressed the "delete" button on the keyboard, so that the placeholder text would disappear. The result was that the entire text box was deleted, and it took a few tries to get the wanted result. To edit the text, the text box needed to be double clicked twice. This was not very intuitive according to P01. As this was a Miro feature, it was not something that would be easy to change. To make it more clear, the text placeholder description was changed to a more fitting description on how to edit the custom card placeholder text.

P01 also tried to edit the headline of the card that said "Custom Thing", which was part of the image object, so consequently, the text was not editable. Based on the feedback from the pilot participant, the headline of the custom cards were transformed to an editable text box to give the users freedom to change both the headline and the description of the cards.

Activity Log

One of the tasks that P01 struggled with was task number 4, which was about finding a way to see all the changes that had been made on the Miro board. A part of this task was to see if the participants could locate the activity log in Miro.

The activity button was located in a minimised menu on the bottom of the screen. After reviewing almost all of the buttons in the two menus in Miro, P01 found it in the end. When reviewing the activity log, P01 stated that the log did not display a lot of relevant information for the task. The activity log contained a complete log of all the activities performed on the board from start to finish, although some of the activities were not described correctly. One example was the activity of moving a card from the card category frame to the card placeholder, which Miro interpreted as editing a card.

Although it might not be useful for the task, it might be useful for finding out who made the changes, or to redo an action. Therefore, it was decided to keep the task without any modifications for the rest of the usability tests. As the participant struggled with locating the activity log, a description on how to locate the log was made as part of an introduction frame (see figure 7.1). The introduction frame was also one of the suggested functionalities in table 5.2, which was to be implemented and adapted based on the needs of the participants.

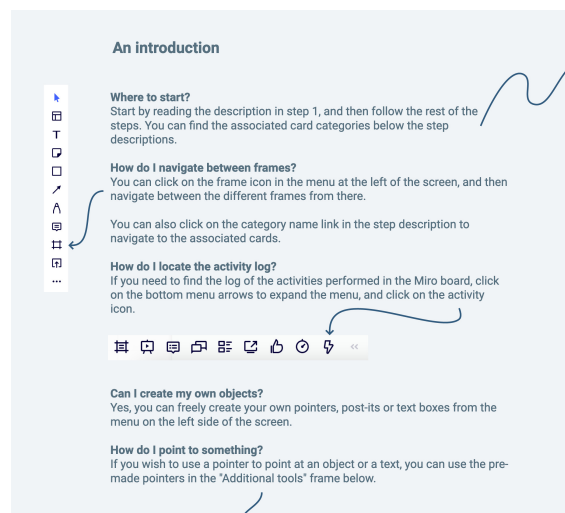


Figure 7.1: Introduction frame explaining built-in functionalities in Miro.

Re-Select a Card

Task number 5 was about changing a card that was added to the *responses* card placeholder by the researcher. The card that was placed was a yellow *feedback* card, and it was supposed to be changed to a blue *service* card, a different category of cards that could also be used as *responses*. P01 was only given the description of the card, not the card category, and as a result, confusion arose. P01 looked thoroughly for the given description of the card in the *feedback* category. It took some time before P01 found the correct card in the *service* category. The tasks description was changed, so that the *feedback* card should be switched with a different *feedback* card. The change did not impact the scope of the task.

To avoid any confusion on which card category types could be used in the different card placeholders, an additional adjustment was made. The possible card category names were placed beside the three card placeholders: *triggers*, *things* and *responses*. This was also something that was done on the board of the original Tiles toolkit. The changes can be seen in figure 7.2.

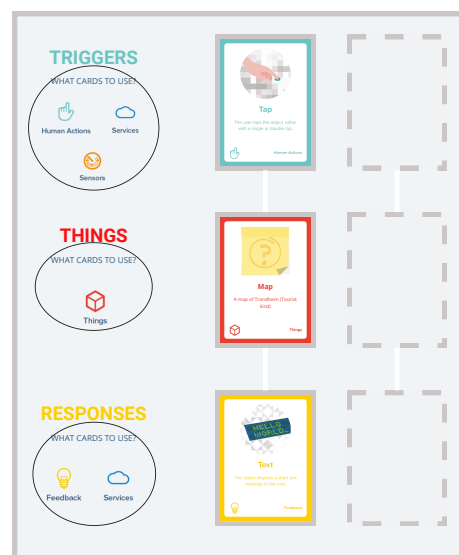


Figure 7.2: New descriptions for card placeholders.
The circles indicate where the changes were made.

Virtual Pointing

The purpose of task number 6 was to test the use of the pre-made virtual pointers, which were located in the bottom right corner of the Miro board. The pilot participant created a custom pointer from the menu, and used this instead. P01 explained that the pre-made pointers were hard to locate, and the participant only noticed them in the end of the test. As P01 was able to create and use a custom

pointer, this seemed like an equal solution to the task. However, as the pre-made pointers were hard to locate, a description on where to find them could also be useful, and was added to the introduction frame. The additional tools section, such as post-it notes and pointers, was also moved below the introduction frame, so that they would be easier to locate.

Navigating Between Frames

Navigation between the different frames was one of the activities of task number 8. To be able to see all frames and click on them, the "frames" button needed to be located from the menu on the left side of the screen. As P01 was not familiar with the Miro features, this was also a time consuming task. P01 stated that he/she would not have used this functionality, if it was not a part of the task. However, the participant expressed that it was a useful feature, although it was not easy to locate. Based on this feedback, a description on where to locate the "frames" button was also added to the introduction frame.

The participant also suggested that it would have been useful to be able to click on the name of the card categories, in order to move directly to the associated frame. This suggestion was also realised in the second version of Digitiles.

Title	Description
Custom cards description	Change description of card placeholder text to a more accurate explanation on how to edit the text.
Custom card headline	Make the custom card headline editable.
Category placeholders	Display possible card category names for the placeholders <i>triggers</i> , <i>things</i> and <i>responses</i> .
Linking frames	Link card category text with card category frames for navigation.
Introduction frame	Create a new introduction frame describing useful features, and where to locate additional tools.

Table 7.2: Changes made to Digitiles after the pilot usability test.

An image of the second version of Digitiles can be found in appendix B.3.

7.3 Usability Test Results

This section presents the results of the usability tests performed by three participants after changes were made to the prototype from the pilot test.

Getting Familiar With the Board

After receiving the first task of the usability test, all of the participants spent some time getting familiar with the toolkit in Miro. The participant who used Miro for the first time, spent some time getting used to zooming in and out of the board and dragging objects around.

P02 navigated to the top left corner of the board, and stated that this would be a natural place to start. P02 began reading the first part of the introduction frame, thereby navigating to the first step in the process description.

P03 located the circle with the number one, which was the first step, and navigated directly to this step. Skimming through the description, P03 started to perform the actions to solve the first task.

P04 zoomed in and out on the board without reading any descriptions. P04 located the card category frames immediately, and started performing the first task, as P04 was already familiar with the process of Tiles.

Locating and Moving Cards

All three participants managed to locate the different cards from under the description of each step, and drag the selected cards to the correct card placeholder on the board. P02 found and used the link that was added since the pilot test to navigate directly to the associated card category frame. The other two participants zoomed in and out of the board, and navigated around the board using the computer mouse to locate the correct card categories.

Edit a Custom Card

The goal of task number three was to use a custom card from the *things* category, and edit the description on the card. The participants were asked to find a suitable card describing a "map".

P02 and P03 used a lot of time looking for a "map" card, because they both expressed that they were looking for a specific card named "map". P03 mentioned after some time that one could have used the custom card, but decided to go for a different card instead. P03 selected the "bicycle" card from the *things* category, and explained that the card could be used as a map over bicycle routes in the city. P02 used 3 minutes and 15 seconds on the task, only noticing that there was a custom card after the task was read aloud once more. After locating the custom card, P02 moved the custom card to the card placeholder and edited the custom

description text as expected. P04 looked briefly through all the *things* cards before deciding on using a custom card.

Activity Log

All three participants struggled with finding the activity log in Miro. The bottom menu bar, where the activity log button was located, needed to be expanded in order to see the button. Both P02 and P03 stated that it was hard to locate. P02 and P03 found the correct button after reading the introduction frame, which was added after the pilot test. However, both participants spent a lot of time looking for it before reading the information provided in the information frame. P03 skimmed through the description in the beginning before starting on the first task. However, P03 did not remember having read this information when performing the task to locate the activity log. When P02 and P03 located the activity log in the end, both participants stated that the information in the log was not very useful. A similar statement was also given by P01 during the pilot test. P02 explained that it would be easier to just explain what had been done using the board, not the activity log.

After some time, P04 carefully read the instructions on where to find the activity log, and then located the menu bar in the bottom of the screen. However, the activity log button was hidden for this participant. The task was cancelled once the researcher noticed this. Unable to know why it had been visible for the other participants, the researcher continued with the rest of the tasks instead. A brief description of the activity log was given to P04. P04 stated that it would have been nice to have this kind of information available, as the log could be used for retrospective reflections of the completed design session using the toolkit.

Re-Select a Card

When being asked to change a card that was added by the researcher on the *responses* card placeholder, all participants managed to complete the task easily. P02 deleted the card to be replaced and dragged the new card to the placeholder. P03 right clicked the card that was to be replaced, and clicked on a button saying "replace image". When clicking on the new card, the change was made. P04 moved the old card back to the card category frame, and dragged the new card to the placeholder. Although different methods were used, all three participants completed the task.

Virtual Pointing

As the pilot test participant did not use the pre-made pointers, a description was added on where to find them and for what purposes they could be used. However, none of the other three participants used the pre-made pointers for the task either. The other three participants found alternative ways of showing the users where they were going to work next, which was the storyboard section.

P02 suggested using the "bring everyone to me" functionality to show the other user where they were going to work on the board. In addition, P02 stated that the cursor pointer should be enough to see where other users were working on the board. P04 also stated something similar, and explained that it was possible to zoom in on the storyboard and place the mouse cursor on it. P04 also stated that if extra attention was needed, one could use the chat to explain where they should be working. P03 tried searching for "pointer" in the search bar without any luck, before looking at the connection lines in the introduction frame. Then, P03 made a connection line from the previous step in the playbook to the storyboard, to show where they were going to work next.

P04 located the "additional tools" frame when starting on the next task of writing on the storyboard. When seeing the pre-made pointers, P04 stated that they were a bit hard to locate. Furthermore, P04 said that it would probably have been a good idea to read the introduction beforehand, as it explained how to use the additional tools.

Write on Storyboard

All of the participants managed to write something using the post-it notes on the storyboard section of the board, without any obstacles. P02 and P03 used the pre-made post-it notes in the storyboard section of the board, while P04 used a yellow post-it notes from the additional tools frame. P04 stated that it was nice with a bit more colour to the storyboard, as this was an important part of the design tool. P04 also explained that the post-it notes with different colours stood out a bit more than the pre-made post-it notes, which had a similar colour to the rest of the board.

Navigating Between Frames

P02 and P03 spent a lot of time looking for a navigation feature in Miro. P03 found the introduction description saying how to navigate between frames after some time, although the "frames" button was not available to the user in that menu. It became clear during the usability test that the "frames" button needed to be added manually by the user before it became visible in the menu to the left. The "frames" button was however, also visible in the bottom menu, and P03 tried using the "presentation mode" that was next to the "frames" button first. This also allowed for navigating between frames, although in a different format. After testing out the presentation mode, P03 located the "frames" button next to it. P02 managed to locate the button after about two minutes, without reading the description on where to find the button.

As the "frames" button was not visible for P02 and P03 in the left menu bar, an updated description on where to find the button in the bottom bar was added to the introduction description before the usability test with P04. However, P04 did not read this description. P04 searched around the board before eventually

zooming out so that all card categories were visible on the screen. P04 stated that this could work as a way of locating all card categories. Furthermore, searching in the bottom menu, P04 located the "frames" button in the end, and stated that this was a better way of seeing all card categories, and that it was nice being able to navigate between them.

Locating Other Users

All three participants were able to easily locate the mouse cursor of another logged in user, thereby locating where the other user was pointing on the board. All three participants clicked on the user icon of the second user on the top right screen, and found that they were able to follow this specific user around on the board.

Understanding the Process

All of the participants managed to give an overview of what had been done and what was left to do. P02 and P03 used the description of the steps when explaining the process. P04 was already familiar with the content of Tiles, and gave a more elaborate explanation of the different steps in the process, and the tasks that were completed.

After Test Reflections

After the participants were done with the usability tasks, the participants were able to briefly discuss and share their experiences using the toolkit.

P02 did not take much notice of what was on the left part of the screen, meaning the introduction frame and the additional tools. P02 explained that this was mostly due to wanting to complete the tasks, and that there were a lot of information around the board that did not seem relevant for the task at the moment. P02 also stated that it might have been easier if one knew more about the toolkit before starting the usability test, and information about what it could be used for. Although being able to complete all tasks, P02 stated that a lot of the content of the toolkit was still unknown after the usability test.

Similar to P03, P02 stated that it might be helpful to know more about the toolkit before starting to use it, although solving the given tasks gave some feeling of comprehension. In addition, P03 stated that the test was kind of an unnatural way of using the toolkit, as one would normally be working in groups and discussing the cards and the content of the toolkit together. If spending as much time as was recommended for each step, P03 stated that it would probably be easier to understand more about the purpose of the tool. Furthermore, P03 said that the toolkit was easy to use, and that it was easy to navigate around the board.

As P04 had experience using the physical Tiles toolkit, P04 was able to compare the two versions. P04 stated that the digital toolkit was very easy to use. Activity

log was one of the functionalities that P04 really thought would be useful, and also something that was missing from the physical toolkit. P04 stated that being able to take ownership of the different actions would be very nice, and also knowing who contributed to the different parts of the workshop. This could lead to follow up discussions and reflections on why a person performed that specific action and so on.

Furthermore, P04 stated that it was easy to neglect both the introduction frame and the additional tools frame, as the attention was drawn to the other parts of the board with fun colourful cards etc. Making it more prominent and more visible somehow, could maybe help draw attention to this part. P04 also stated that the introduction frame contained very useful information, and that it made everything more clear.

7.4 Discussion

From the usability test results, there seemed to be a strong agreement on which tasks that were considered the most difficult, and which tasks were easy to perform. Task 1 and 2 were considered some of the easiest tasks, involving locating the different card categories and moving the cards to the correct placeholders. All four participants managed to complete this task without any issues. All but one participant used the custom card in task 3, although some of the participants spent some time trying to find a suitable *things* card before deciding on using the custom card.

All four participants were also able to complete tasks no. 5, 7, 9 and 10 without any major problems. Although the approaches were not completely as expected, they managed to complete the tasks using various methods.

Task no. 4 and task no. 8 seemed to be the most difficult tasks, which involved locating the activity log and the "frames" button, respectively. Both of these Miro functionalities were to be found in the menu on the bottom of the screen, after expanding the menu arrow symbol. Three of the participants managed to locate the activity log in the end, although not finding the information in the log very useful. One of the participants did not have access to the activity log in the bottom menu, which led to the task being cancelled.

Task no. 6, which involved locating the pre-made pointers and use them in the storyboard section, was also considered to be a difficult task. Alternative methods were used to solve the task. The task instruction might not have been very descriptive, as a "pointer" could be interpreted in different ways. However, the goal of the task was to show the other user where they were going to work on the board, and this was possible without having to use the pre-made pointers.

Even though an introduction frame was created after the pilot test, none of the participants paid enough, if any, attention to this information. The description of

the introduction was also misleading for the "frame" button in the second and third test, which was stated by P03. P02 did not use the description to find this button. Both P02 and P04 stated after the test that they should probably have read the introduction frame more carefully to get all necessary information before performing the tasks. However, P04 stated that the attention was drawn to other parts of the board instead. P02 stated that the introduction did not seem necessary at first, and wanted to go ahead and try solving the task without reading it.

There also seemed to be a clear connection between having used Tiles in the past, and giving a description of what had been done, and what was left to do in the different steps of the process, which was the goal of task no. 10. The two participants who had used Tiles in the past were able to more freely explain what had been done, and why, without reading the description of the steps. They were more easily able to connect the different parts together than the two participants who had not used Tiles previously. The two participants who did not have any experience with Tiles in the past, described only what they had done as part of the task, and what was left to do, based on the description of the steps on the board.

The previous experience level of Tiles also became clear during the process, as the two participants who were familiar with the steps in the process, spent less time reading the step instructions than the other two. P01 and P04 mainly focused on solving the tasks, and the newly added functionalities, which were not part of the Tiles toolkit. On the other hand, P02 and P03 spent some time making sure they had understood the steps before completing the task, or going back to the description after they had performed an action.

7.5 Changes Made to the Prototype

Although some design changes were made after the pilot test, the three other participants also provided useful feedback that was used to make additional changes to the prototype. Additional prioritised functionalities from table 5.2 were also implemented in the new version of Digitiles.

This section describes the changes made to the prototype after the usability tests. An enlarged image of Digitiles after these changes were made can be found in appendix B.4.

7.5.1 Proposed Changes From the Usability Tests

Introduction and Additional Tools

One of the main issues during the usability test involved locating the "frames" button and the activity log in Miro. This seemed to be related to the fact that the introduction frame was not read carefully, as instructions on where to find these

features were specified there. One participant suggested making the introduction frame more visible.

To make the introduction and additional tools more visible, both of them were added as part of the board frame, instead of using additional frames that might be overlooked. A blue border was also added around the introduction, to make it stand out more from the rest of the board. In addition, the introduction description and additional tools, such as the arrows and post-it notes, could be introduced by the facilitator before the workshop, so that people know they are there if needed.

Storyboard

As pointed out by one of the participants, the storyboard is an important part of the toolkit. In the first version of the toolkit, the colours of the post-it notes blended with the colours of the board. The colour on the post-it notes was changed to yellow instead of light blue, to make them stand out more. The users also have the possibility of changing the colour of the post-it notes themselves in Miro.

7.5.2 New Functionalities

Random cards and countdown timer were two functionalities that were rated "medium" in the table of priorities functionalities (table 5.2). These functionalities were also implemented in the updated version of Digitiles.

Random Cards

Giving the users the possibility of drawing a random card from a deck instead of having to choose one on their own, could help the participants in the decision making process by limiting the selection of possible cards.

At the time of writing, it did not exist a built-in functionality in Miro for shuffling or drawing random cards from a deck. It was however, possible to mock a solution that was similar to the experience of drawing a random card from a deck of cards.

One possible way of displaying random cards was to place some cards in a deck, one image on top of the other, and then place a box over them so the cards were not visible to the users before they were drawn. This solution is displayed in figure 7.3.



Figure 7.3: Random card method.

The image on the left shows the deck of cards under the description box. On the right, a card has been dragged from the deck of cards.

This solution was clearly not perfect, as the cards or images needed to be placed under the box with the description, one by one. As a consequence, the order was static unless one would manually rearrange the order of the cards the between workshops.

As a solution to this problem, a plug-in was tested out. The plug-in was called "Totally Random", and had been created by one of the people from the Miro Community¹. The plug-in was not public at the time, as it takes some time to make a plug-in available for everyone using Miro. After contacting the person who created it, access to the plug-in was given. "Totally Random" allowed for grouping different objects together, and shuffling the objects in a random order. The plug-in turned out to be very useful for this purpose, and so it was possible to shuffle the cards between each workshop to get a new random deck of cards.

As the "Totally Random" plug-in was not public at the time, it also had some shortcomings. In order to use it, one would have to install it manually and look for it in the "Apps" search bar. Then one would have to mark all objects that needed to be

¹<https://community.miro.com/>

shuffled, and then hit the shuffle button. This would possibly be time consuming for the users of the toolkit. For this reason, it would probably be easiest to let the facilitator of a workshop handle the use of the plug-in, and add a description on how to use it.

Three card decks of randomly shuffled cards were added to the bottom of the following card categories: *scenarios*, *personas* and *missions*.

Countdown Timer

As there already existed a countdown timer plug-in in Miro, it was easy to implement. The timer could be controlled by a facilitator and be visible to all users on the same Miro board. The timer is located in the bottom of the screen. It is also possible to add additional time if needed. As the steps in the toolkit have suggested time limits, one solution would be to count down the time for each step. This would allow the users to see how much time is left in the process steps, and staying within the time limit of the workshop.

Chapter 8

Evaluation of Digitiles: the Digital Workshops

As discussed in the previous chapter, Digitiles was tested by performing usability tests, and had been adjusted according to feedback from the participants. Additional functionality had also been implemented. At this point, the prototype was ready to be tested in a more realistic setup as it was intended, meaning people working together digitally using the toolkit in idea generation workshops.

The primary goal of conducting idea generation workshops using Digitiles, was to investigate the strengths and weaknesses of the toolkit in use, and how well the toolkit supported creativity and cooperation in the digital environment. It was also important to find out if the prototype was usable with multiple participants using it at the same time, and if it was fun to use.

A total of five digital co-design workshops were performed using Digitiles. This chapter describes the evaluation of the digital workshops, starting with the method in section 8.1, the results in section 8.2 and finally, a discussion of the results in section 8.3.

8.1 Method

8.1.1 Procedure

The workshops were performed digitally using Zoom as a communication tool, and Miro which was the platform the prototype was embedded in. Each workshop consisted of three or four participants that were using Digitiles for idea generation. The aim was to come up with an IoT solution for a chosen *persona* and *scenario* within 40 minutes.



Figure 8.1: The process of the digital workshops.

Before the idea generation workshop started, a brief presentation was given to the participants by the researcher. The presentation contained information about Digitiles and the process, the transformation to the digital environment and a short description of Internet of Things. The participants were also given a couple of examples of common IoT solutions. An introduction to the toolkit was also requested by some of the participants in the usability test in chapter 7. All groups were given the same introduction, regardless of their background and previous knowledge.

After the presentation, the participants were given an introduction to the digital prototype in Miro. The participants were given information about the process steps, what they were supposed to do, and an overview of the different parts of the toolkit. The participants also received a brief introduction to the introduction frame and additional tools, which had been overlooked in the usability tests. The duration of the presentation and introduction was approximately ten minutes. Moreover, the participants were given a link to the prototype in Miro, where they got five minutes to explore the online whiteboard tool. Thereafter, the countdown timer was set, and the idea generation workshop began. The participants used Zoom for video and audio communication throughout the workshop.

After completing the idea generation workshop using Digitiles, a debriefing with a group discussion was held. During the group discussion the participants were able to reflect on their experience with the workshop they just had, and give oral feedback to the researcher. Lastly, they were to fill out an online questionnaire.

An overview of the process of the digital workshops can be seen in figure 8.1.

8.1.2 Data Generation Methods

Using multiple data generation methods was considered useful for producing a lot of relevant data from different aspects of the workshop. It is also likely that this can improve the quality of the evaluations (Oates, 2006). The following data generation methods were used during this evaluation: participant observation, artifact analysis, group discussion and questionnaire.

Participant Observation

During the idea generation workshop, participant observation was used to study how the digital prototype was being used (Oates, 2006). Observing the participant's interaction with the prototype provided information about the usability

of the prototype, in addition to the quality and structure of the design. The researcher acted as a facilitator during the idea generation workshop.

The researcher only got involved to answer questions or to guide the participants if they seemed to be stuck. If this happened, the researcher referred to the description of the step they were currently working on, and tried getting the participants to read it once more without giving any specific answers. This was done in order to avoid guiding the participants to perform actions in certain ways. It was also a way to identify different uses of the toolkit, that the researcher had not foreseen.

Screen and voice recording was done through Zoom to allow going back and analyse the data more carefully.

Debriefing: Group Discussion

After the idea generation workshops, group discussions were held with the intention of letting the participants share and compare experiences. The participants were able to collaboratively reflect over their experience of the workshop and to give oral feedback. Three questions were asked by the researcher during the debrief:

1. What did you think about the workshop?
2. How do you think it would be different to use the toolkit in a physical workshop?
3. What other functionalities could be useful or nice to have?

Additional topics were also discussed if they came up. The group discussions were also recorded using Zoom, so that it was possible to transcribe and analyse the data afterwards.

Questionnaire

A questionnaire was used to gather individual information about the participants' background and their overall experience on using Digitiles. Nettskjema¹ was used to create the questionnaire and gather the data anonymously.

The questionnaire contained a total of 26 questions divided into seven categories:

1. Background, previous experience and knowledge
2. Creativity using the cards
3. The board and the process
4. Navigation and interaction
5. Communication and cooperation
6. Enjoyment and learning
7. General impression

¹<https://nettskjema.no/>

The first question in the first category was text-based, and the other six questions in this category had two or three predefined options. The questions in this category were created to gather information about the participants' study background, previous experience with whiteboard tools and card-based design tools, and their perceived digital competencies. This information was used to compare the results of the workshops with participants having similar or different experiences, backgrounds and knowledge.

The questions in category 2-7 included questions about the participants' experience using Digitiles, covering several aspects of the toolkit. For the 16 questions in category 2-6, the participants were asked to rate a statement using a 10-scale Likert. This allowed the participants to select an option in a wider scale, that most likely matched their opinions (Oates, 2006).

The second category contained questions on how the cards promoted creativity during the workshop. The third category included questions about the process steps and the board. Category four contained questions about navigation around the board, as well as locating and moving cards.

Category five contained questions about how well they perceived the communication between the participants of the same group, and how well they were able to cooperate and coordinate tasks between the team members. It also contained questions about workspace awareness, and to what extent they were able to see the other users working on the board and knowing how far in the process they were as a team. The questions in category six were related to perceived enjoyment and learning using Digitiles.

The questions in the last category, general impression, were text-based. This allowed the participants to describe their experiences and give feedback using their own words.

All of the questions were made mandatory, to avoid getting unanswered questions from any of the participants. Some of the questions were adapted from a questionnaire that was previously used in a physical Tiles workshop by the Tiles creators (Mora et al., 2017). All of the 26 questions from the questionnaire can be seen in appendix D.1.

Artifact Analysis

After the workshops were completed, an artifact analysis of the final board was done. The artifact analysis was performed in order to gather information about the use of the provided artifacts, such as the use of the cards and the result of the storyboard and elevator pitch. The artifact analysis could also provide information on how the ideas came to be.

8.1.3 Ethics and NSD

The NSD notification form from the usability test was updated to contain additional data generation methods, such as group discussion and questionnaire. The changes were approved, and the information sheet was updated and adapted to fit the description of the workshops. All participants received the information sheet and consent for before the workshops were held. The updated information sheet with the consent form can be found in appendix D.2.

8.1.4 Participants

The target group was considered to be non-experts in IoT. In addition, it was important that the participants were comfortable using a computer, as the workshop would be held digitally. Students of NTNU and acquaintances of the researcher were considered easily accessible participants that fit the target group.

University students from two different technical classes were recruited to participate in the workshop. As there were only three people from the two classes who volunteered, additional participants needed to be recruited in order to get enough participants to hold multiple workshops. The supervisor recruited one additional university student with knowledge of Tiles. The researcher recruited three additional university students from NTNU, and nine acquaintances. From the group of acquaintances, only one was a student at the time, and the other eight had completed a degree of higher education.

This resulted in a total of 16 participants (see table 8.1) which were divided into five groups. Four groups of three participants, and one group of four participants. The participants were able to choose who they wanted to attend the workshop with, and as a consequence, all groups had at least two participants who knew each other from before.

Participant no.	Used Tiles previously	Online whiteboard tool experience	Technical study background	Digital competencies
P01	no	none	no	average
P02	no	none	no	average
P03	no	none	no	average
P04	no	none	no	average
P05	no	none	no	average
P06	no	some	yes	above average
P07	no	none	yes	above average
P08	yes	a lot	yes	above average
P09	no	some	yes	above average
P10	no	some	yes	above average
P11	yes	a lot	yes	above average
P12	no	a lot	yes	above average
P13	no	some	yes	above average
P14	no	none	no	average
P15	no	none	no	average
P16	no	none	no	below average

Table 8.1: Information about the participants of the digital workshops.

8.1.5 Data Analysis

The video and voice recordings from the idea generation workshops were not properly analysed due to time constraints. The videos were 40-50 minutes long, containing rich data, and it would require more resources to be able to go through all the videos and voice recording for all groups before evaluating the data. Instead, group discussions, questionnaires and artifact analysis were prioritised in this evaluation.

Group Discussion

The recordings of the group discussions were transcribed and anonymised. The transcribing was done by watching the recordings while writing down everything that was said, using codes for each participant instead of using their names. Conversation that was not related to the workshop was left out of the transcribed document.

After transcribing the data, the transcribed document was analysed and the statements were organised into the following three categories:

1. Statements related to experience with WS
2. Statements related to physical VS digital WS
3. Suggestions on additional functionalities

The categories above were related to the questions asked during the group discussion. Tables were created to get an overview of the different statements in each category, and how many people agreed with the different statements, or said similar statements (see appendix D.3). The statements from the group discussions were rephrased in the results.

Questionnaire

Data from the questionnaires were aggregated and analysed using Microsoft Excel. Bar charts were created to organise and visualise the data from the statements, and to what extent the participants agreed with the different statements.

The questions with text-based answers were analysed separately. The text-based answers contained the participants' own description of their experience and specific feedback. The answers were used to evaluate the participants' experiences with the workshop, and to gather suggestions on further improvement of the prototype.

Artifact Analysis

The final board of the prototype for each group in Miro were used in the data analysis. From the final board it was possible to get an overview of the approach of each group, which cards they used, and how they chose to structure and present their ideas in the end. It was also possible to examine the use of additional features in Miro, such as post-it notes, drawings and shapes. The prototype board result of each workshop were analysed and briefly discussed in the result section of this chapter.

8.2 Results

The results of the artifact analysis and the group discussions are organised by workshops. Some of the data from the first questionnaire category, containing previous knowledge and digital competencies, are also discussed in the first part when describing the individual workshops. Lastly, the data from the questionnaires (Q8-Q26) from all participants are presented, grouped into the categories of the questionnaire.

8.2.1 Workshop 1

The first workshop was held with three participants who knew each other from before. All three participants had non-technical backgrounds, and according to the data from the questionnaire, the participants had a self-rating of average digital competencies. None of the participants had any previous knowledge about Tiles or any other card-based design tools. In addition, these participants had not used any online whiteboard tools in the past.

Artifact Analysis

The first group selected the "gender equality" *scenario* card and a "female construction worker" as the *persona*. The participants of the group completed everything except the last step with the reflection criteria within the time limit. The group spent all their remaining time on writing down the elevator pitch, and chose to ignore the reflection criteria in the end.

14 cards were selected in total, whereas one of these cards were a custom card from the *things* category. Additional post-it notes were used by this group to specify additional information to the selected missions and the solution. The group also re-arranged the post-it notes in the storyboard section. The group came up with the solution of a "work watch" to track the employees' hours and completed tasks, and that automatically generated the salaries for a company. This way, the salaries would be generated fairly without gender discrimination. A selection of the group's board after completing the workshop can be seen in figure 8.2.

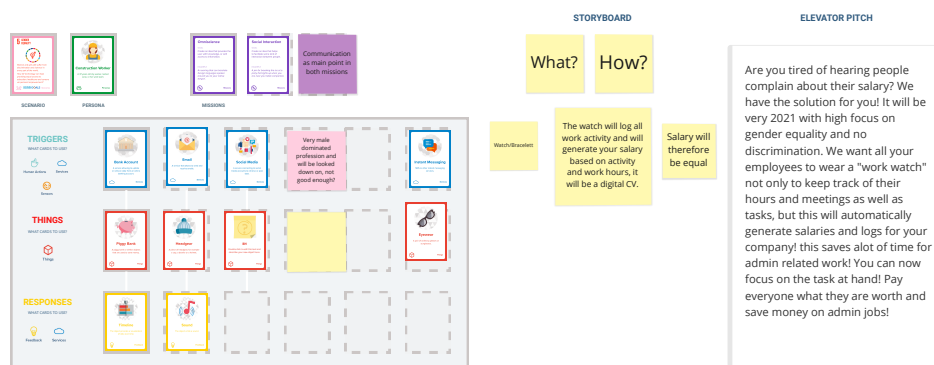


Figure 8.2: Workshop 1 artifacts.

Group Discussion

When being asked what they thought about the workshop, one of the participants stated that it was all a bit confusing at first, but towards the end it was easier to understand what was going on. The other two participants agreed with this statement. Two of the participants stated that it was especially confusing with the large box including *triggers*, *things* and *responses* in step 3-5, and which cards should go where.

One of the participants stated that it was hard in the beginning to understand what you should do with the selected *persona*, *scenario* and *mission* cards, although once you got a bit further into ideation and thinking it made more sense. The participant said that the workshop enabled some creativity, and that he/she was not imagining solving these kinds of problems on a regular Tuesday afternoon.

Another participant said that because he/she was using a small laptop it was a bit

hard to get an overview of everything. To read the text on the cards one would have to zoom in a lot, which made it easy to lose track of what was happening on the other parts of the board. The participant also stated that it might have been easier if he/she had access to a larger screen.

When being asked how they thought it would be different using the toolkit in a physical workshop, one of the participant stated that it would probably have been easier to come up with more ideas. Because the toolkit is so big, it might be easier to focus when having the toolkit with the cards in front of you.

When the researcher asked if the participants thought it would have been easier to cooperate when sitting around a physical table with the toolkit, two of the participants answered "no" instantly. One of the participants said that the reason for this was that they were so used to working remotely.

8.2.2 Workshop 2

Similar to the first workshop, the three participants of the second workshop also knew each other from before. One of the three participants had a technical background, and had a self-rating of above average in digital competencies. This participant was also the only one who had any previous experience with online white-board tools. The other two participants had rated themselves in having average digital competencies. None of the participants had any knowledge of Tiles or had used any other card-based design tools in the past.

Artifact Analysis

The second group selected the "gender equality" *scenario* card and "yourself" as the *persona* card. The group completed all seven steps within the time limit.

A total of 13 cards were selected by the participants of this group, whereas one of the selected cards were a custom card of the *feedback* category. This group did only use the predefined template on the Miro board, and did not use any of the additional built-in functionalities in Miro, such as additional post-it notes, arrows or drawings. The end idea involved automatic heating in the workplace and in the office chairs. The temperature was to be adapted based on the needs of individual employees. The idea was justified by that the temperature in a workplace is usually adapted to men. Some of the artifacts used in this workshop by the second group can be seen in figure 8.3.

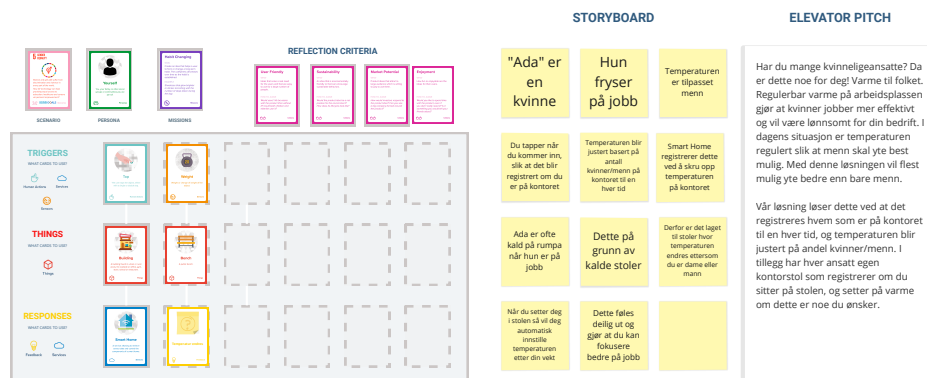


Figure 8.3: Workshop 2 artifacts.

Group Discussion

When being asked what they thought about the workshop, one of the participants stated that it was more fun than anticipated. The other two participants agreed with this statement, although one of them added that it was a bit stressful because of the time constraints. One of the other participants agreed with this.

When being asked how they thought it would be different to use the toolkit in a physical workshop, one of the participants said that it might be easier to get an overview of everything, because they only had a single screen. The participant added that it might also be more difficult to undo actions and having to use an eraser every time you would like to correct something in a physical version.

The participant with a technical background stated that he/she thought it was easier to cooperate digitally when working on something like this, because it is easier to get an overview of what everyone is doing. The participant added that when all participants have their own screen, it enables everyone to work at the same time, and no one is blocking you, which is sometimes the case when you are physically co-located.

When being asked if they could think of any other functionalities that would be nice or useful, one of the participants suggested that when placing a card back into the card category frame, it would be good if it aligned nicely with the other cards, instead of being placed on top of another card.

8.2.3 Workshop 3

In this workshop there were four participants. Two of the participants knew each other from before, while the others did not. All four participants were students of different technical fields.

Two of the participants had used Tiles in a digital workshop previously. The facil-

iator of that workshop had given the students access to the uploaded artifacts of the original Tiles toolkit in Miro, as seen in appendix B.1. One of the participants had knowledge of Tiles, but had not been using the toolkit in an idea generation workshop. The last participant did not have any knowledge about Tiles. None of the four participants had used any other card-based design tools in the past. The participants of this workshop had rated themselves in having above average digital competencies. Only one of the participants had not been using any online whiteboard tools in the past.

Artifact Analysis

The group selected "no poverty" as the *scenario* card, and a "child" as the *persona*. The participants of this group were able to complete all seven steps within the time limit.

The group selected a total of 21 cards during the idea generation workshop. None of the custom cards were used. Similarly to the previous group, this group did also just use the pre-made template, and did not use any additional Miro built-in functionalities. The idea that the group came up with in the end, involved a small device for children, designed to fit the child's interests. The intention of the device was to teach the child about the importance of education, and to motivate the child to wake up and get to class on time. Some of the artifacts used by this group can be seen in figure 8.4.

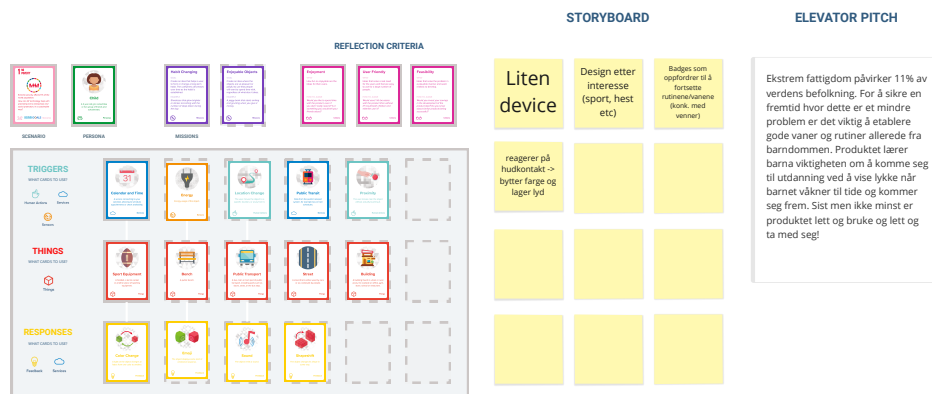


Figure 8.4: Workshop 3 artifacts.

Group Discussion

On the question "What did you think about the workshop?", one of the participants immediately answered that it was a bit intensive. One other participant agreed with this, and added that it was stressful due to the time constraints.

A third participant said that he/she wished there were more cards to choose from,

as it felt like some things were missing. When being asked if there were any specific card categories that should have more cards, the participant mentioned the *service* category. Another participant stated that there should also be more *persona* cards, as the description of the personas in the *persona* card categories was a bit limited.

The two participants who had been using Tiles before, stated that they thought this setup was better than last time. One of them added that last time they only had access to view the cards online, although not being able to move them around. This meant they had to discuss the cards within groups, without having a way of organising the selected cards.

When being asked how they thought it would be different to use the toolkit in a physical workshop, one of the participants stated that it would probably be more chaotic, because one would not be able to see all cards at the same time and navigate around all parts when needed. Another participants agreed with this, and added that it would probably be really challenging to go through all cards in a card deck and remember all of them. One of the other participants added that in a physical workshop everyone cannot work at the same time, and one would have to exchange the cards. One participant stated that it might be easier to brainstorm ideas when you are together physically.

Suggestions on additional functionalities were also given by the participants of this workshop. One participant stated that it might have been useful to have specific roles, because one can easily become passive in a discussion. Another participant agreed with this, and added that if someone had the main responsibility of moving the cards around, it would have been more practical. Because it is hard to take initiative, and you often end up discussing the cards rather than moving the selected cards.

8.2.4 Workshop 4

Workshop no. 4 was done with three participants who all knew each other from before. All the participants in this group were students of technical studies and they had rated themselves with above average digital competencies. None of them had used Tiles or any other card-based design tool previously. Two of the participants had a lot of experience using online whiteboard tools, while the third participant had some experience.

Artifact Analysis

This group selected a random *scenario* card from the random deck, which resulted in the "sustainable cities and communities" *scenario*. In addition, the group selected the "child" *persona* card. The group was able to complete all steps within the time limit.

A total of 18 cards were used by this group. None of the selected cards were custom cards. The group created arrows which were used in the storyboard section

together with the post-it notes. Drawing was also done by one of the participants in this group to highlight the problem/solution in the storyboard. This group presented the solution of a device which tracks the child, and help the parents to find the child if it goes missing. The child can press an emergency button if the child gets lost, to alert the parents of its whereabouts.

A selection of the artifacts used by this group can be seen in figure 8.5.

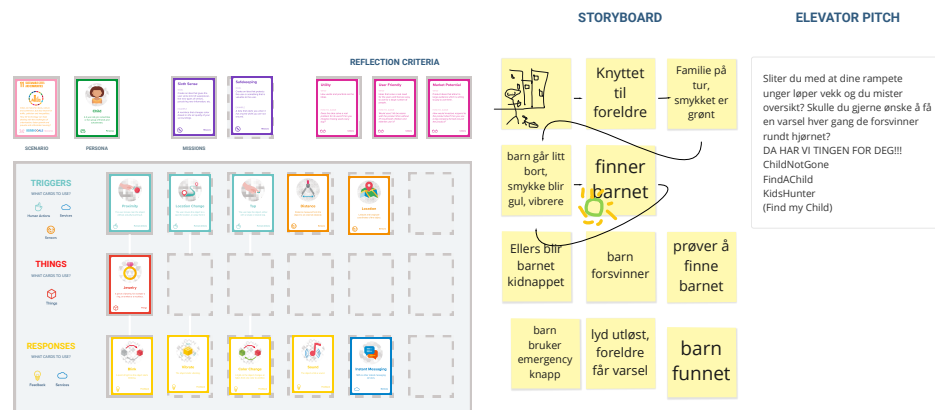


Figure 8.5: Workshop 4 artifacts.

Group Discussion

When being asked what they thought about the workshop, one participant said it was really fun, and because this participant had a lot of experience using Miro, the participant was surprised over how well it went using the platform for this purpose. Another participant stated that he/she was a bit worried that one would need to have a lot of prior knowledge before attending the workshop, but that was not the case. The participant added that it felt like a game.

One participant stated that when using Zoom, there are sometimes hesitation compared to when you are physically co-located in the same room. The participant added that if the group worked together physically using one screen, it would not be an issue. Another participant stated that it might have been different if they did not know each other from before, because knowing the others makes it easier to talk. The participant added that it also makes it is easier to take the initiative to select cards, instead of asking the others beforehand.

One of the participants added that they had come up with a better idea in this brief workshop than they had done previously in a school course working on a project with the duration of several weeks.

When being asked how they thought it would be different to use the toolkit in a physical workshop, one of the participants said that it might be very different,

as you do not see all the cards and the different steps at once, as in the digital version. The participant added that one of the other group members looked at the next steps so that they could get ideas for what cards to choose in the current step, and that this might not be as easy in a physical workshop.

For additional functionalities, one participant suggested using "Crazy 8", which is an ideation technique where one is supposed to sketch eight ideas in eight minutes, and then vote for the best idea. Another participant suggested moving the *things* card placeholder on top of *triggers* and *responses*, as the cards in the *things* category are used first in the process steps.

8.2.5 Workshop 5

The last workshop consisted of three people who knew each other from before. The participants of this group had non-technical backgrounds. Two participants had rated themselves having average digital competencies, while the third had a self-rating of below average digital competencies. None of the participants had any previous knowledge of Tiles or any other card-based design tools. In addition, none of the three participants had any experience using online whiteboard tools.

Artifact Analysis

The group selected "life below water" as a *scenario*, and a "disabled" man in a wheelchair as the *persona* card. This group was able to complete all seven steps within the time limit. A total of 25 cards were selected by this group, whereas 23 of the cards were unique. The group created copies of some of the cards and re-used them to display the solutions in the *triggers*, *things* and *responses* frame. In addition, the group created two custom cards, one from the *things* category and one card from the *sensors* category.

As seen in figure 8.6, the group used multiple additional built-in functionalities in Miro to express creativity. Post-it notes and shapes in different colours were used in both the storyboard and elevator pitch. The solution presented by this group was a multi purpose watch that gives useful information to the fisherman when at sea. The idea was justified by that if a person is in a wheelchair, the person would most likely experience additional challenges when being at sea. Information about the location of the person wearing the watch, the water quality and the location of the fish, were some of the functionalities of the invented device.

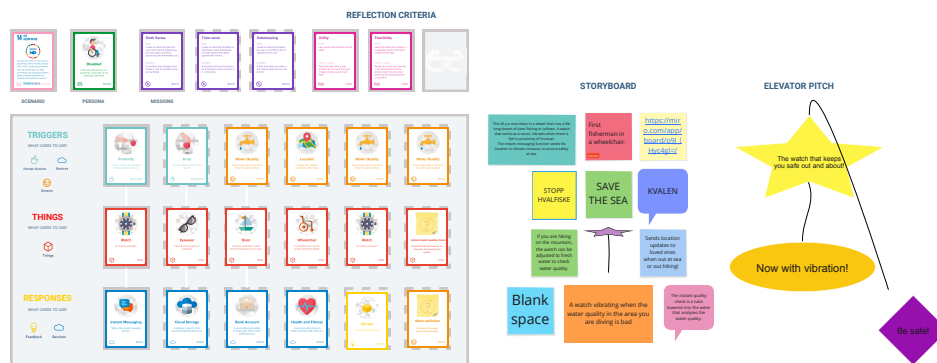


Figure 8.6: Workshop 5 artifacts.

Group Discussion

When being asked what they thought about the workshop, one participant stated that it was fun, more fun than first anticipated. The other two participants agreed with this statement. One of the participants added that it was fun to figure things out as you go.

The researcher asked if they thought the toolkit was difficult to use, and one participant answered no, because one was able to know what to do by reading the steps. One of the participants said it was a good way of cooperating. Another participant agreed with this statement, and that for instance, this would have been a fun way to solve problems in high school, and that it would have made it more motivating for the students.

When being asked how they thought it would have been different to use the toolkit in a physical workshop, one of the participants said they thought it would have been more time consuming. The participant stated that the reason for this was that in a digital workshop, one is able to see all cards and everyone can read what they want, instead of having to show cards to everyone. One of the other participants agreed with this. One participant added that he/she would might not be able to engage that easily in a physical workshop, because it would probably be easy to lose track of what was going on.

One of the participants stated that they would not have been able to create these cool shapes with different colours in a physical workshop. However, the participant added that it would be easier to draw shapes on a physical paper.

When being asked what other functionalities would be nice to have, one of the participants said more shapes. Another participant stated that it might be easier if the tool was in Norwegian, because it could sometimes be hard to understand all of the technical terms in English. One of the other participants strongly agreed with this.

8.2.6 Questionnaire Results

The result of the post-workshop questionnaires provided insightful information about the participants' experiences with different aspects of the workshop and the prototype. Most of the questions were presented as statements, and the participants were to select a value from 0-10, indicating to what extent they agreed or disagreed with the different statements. It was assumed that a participant agreed with a statement, if the selected value of the statement was 6 or above. If a participant selected a value of 4 or below, it was assumed that the participants disagreed with this statement. The results are presented next.

Creativity Using the Cards

To find out how well the cards promoted creativity in the workshop, some statements regarding creativity using the cards were part of the questionnaire (see table 8.2).

No.	Statement
Q8	I had ideas I would not have had without the cards.
Q9	Using the cards helped me to improve or fine-tuning existing ideas.
Q10	Using the cards helped my team to discuss and to form a clear idea.

Table 8.2: Statements regarding creativity using the cards.

The data in figure 8.7 shows that there is a high level of agreement in that the cards helped the participants in the creativity process in different ways. For Q8 the level of agreement is 100%, while for Q9 and Q10 it is around 75% and 85%.

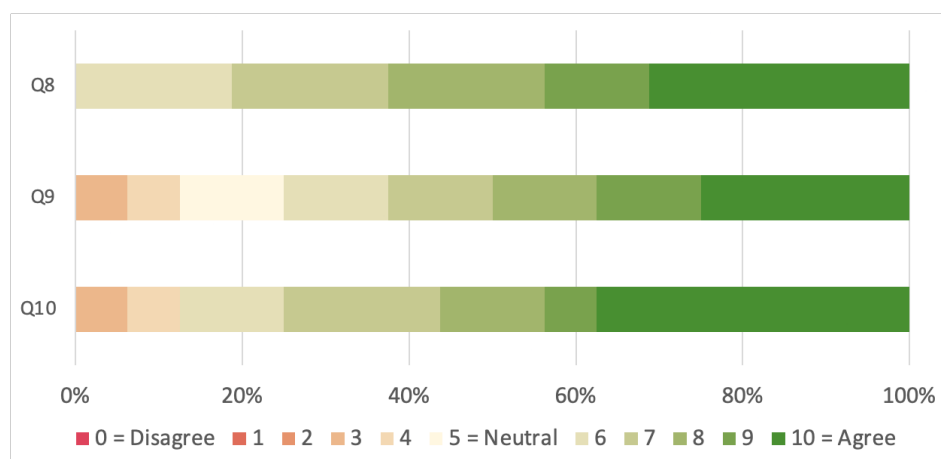


Figure 8.7: Result of statements regarding creativity from table 8.2.

Although the original Tiles cards have proven to support creativity in previous

Tiles workshops, it was nice to see that the digital cards supported creativity in similar ways. In workshops facilitated by the Tiles creators, the questionnaire results from the same statement (Q8): "I had ideas I would not had without the Tiles cards", show that almost 70% of the participants agreed with the statement (Mora et al., 2017). However, as the workshops and questionnaires were organised in different ways, it can not be considered a fully valid comparison between the results of the two evaluations.

The Board and the Process

To find out how well the board helped in structuring ideas, and if the process steps provided enough information, some statements regarding the board and the process of the toolkit were given in the questionnaire (see table 8.3).

No.	Statement
Q11	The process steps on the board provided enough guidance to develop new ideas.
Q12	The board was too complicated.
Q13	The board helped structuring the work and visualising ideas.

Table 8.3: Statements regarding the board and the process.

The results from the questionnaire in figure 8.8 show that around 80% of the participants agreed that the process steps provided enough guidance to develop new ideas. Around 95% disagrees with Q12 about the board being too complicated, and there is a 100% agreement level on Q13 and that the board helped structure the work and visualise ideas.

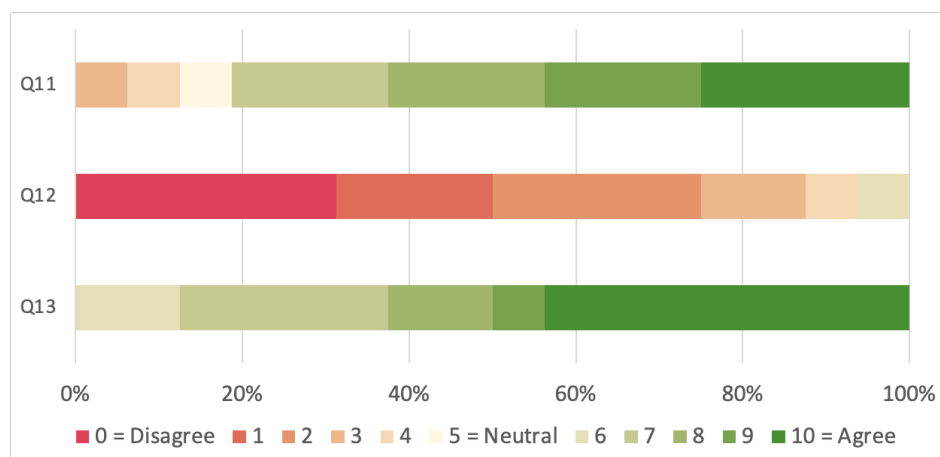


Figure 8.8: Result of statements regarding the board and the process from table 8.3.

Navigation and Interaction

As the toolkit was implemented in an online platform, it was important to evaluate how well the participants were able to navigate around the board and move artifacts, such as the cards, from one place to another. The statements regarding navigation and interaction can be seen in table 8.4.

No.	Statement
Q14	I was able to easily move cards around on the board.
Q15	Locating the correct card categories was easy.
Q16	I was able to navigate between the different parts of the toolkit without any problems.

Table 8.4: Statements regarding interaction with elements and navigation between elements.

The results as displayed in figure 8.9, show a level of agreement from around 75-85% for the statements related to navigation and interaction with elements using Miro. Around 20% of the participants disagreed with Q14, saying that they were easily able to move cards around on the board. Over 20% found it difficult locating the correct card categories, while around 5% had difficulties in navigating between the different parts of the toolkit.

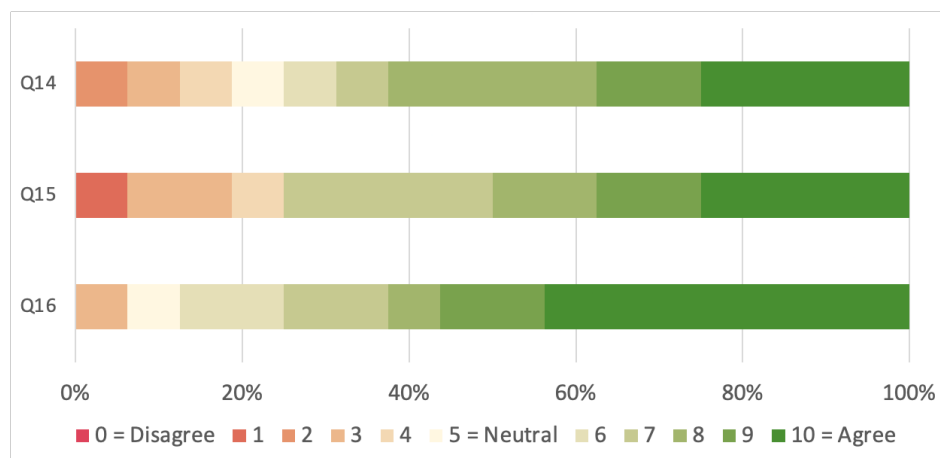


Figure 8.9: Result of statements regarding navigation and interaction with elements in Miro from table 8.4.

Communication and Cooperation

To find out how well the participants were able to communicate and cooperate during the digital workshop, statements regarding these subjects were given as part of the questionnaire (see table 8.5).

No.	Statement
Q17	I found it easy to communicate with the other team members throughout the workshop.
Q18	I found it easy to coordinate the work with the other team members.
Q19	I was aware of what the other team members were doing on the Miro board at all times.
Q20	I had a clear overview of how far in the process the team was at all times.

Table 8.5: Statements regarding the communication and cooperation between the team members.

The results of the questionnaire statements regarding communication and cooperation between team members of the workshops can be seen in figure 8.10. The data shows around 95% agreement levels with Q17 and Q18, around 75% agreement levels with Q19 and around 85% with Q20.

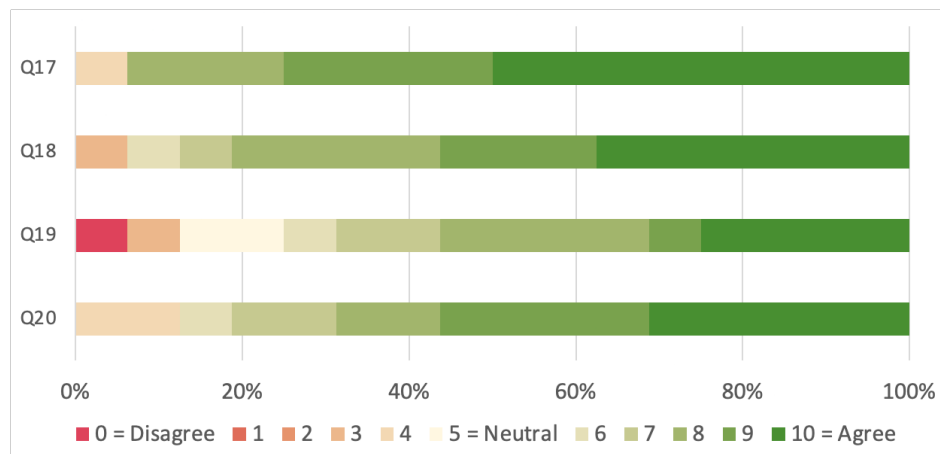


Figure 8.10: Result of statements regarding communication and cooperation from table 8.5.

Out of the four statements, Q19 concerning awareness of team members, seems to be the statement with the lowest agreement levels. Only around 25% fully agrees that they were aware of what the other team members were doing on the Miro board at all times. On the other hand, around 50% fully agrees that the communication between the other team members was easy, and almost 40% fully agrees that it was easy to coordinate the work between team members.

Enjoyment and Learning

Some questions related to enjoyment and learning were also a part of the questionnaire. Table 8.6 displays the statements related these subjects.

No.	Statement
Q21	Using Digitiles was fun.
Q22	I have a better understanding of IoT after using Digitiles.
Q23	I would consider using Digitiles in the future if I have to design an IoT application.

Table 8.6: Statements regarding enjoyment and learning.

From the data in figure 8.11, one can see a 100% level of agreement on Q21, a statement saying that using Digitiles was fun, where over 60% of the participants fully agrees to this statement. For Q22 there is around 70% level of agreement, meaning the majority of the participants agreed with having gained a better understanding of IoT after using Digitiles. Almost 90% agrees with the statement that they would like to use Digitiles again if they are going to develop an IoT application.

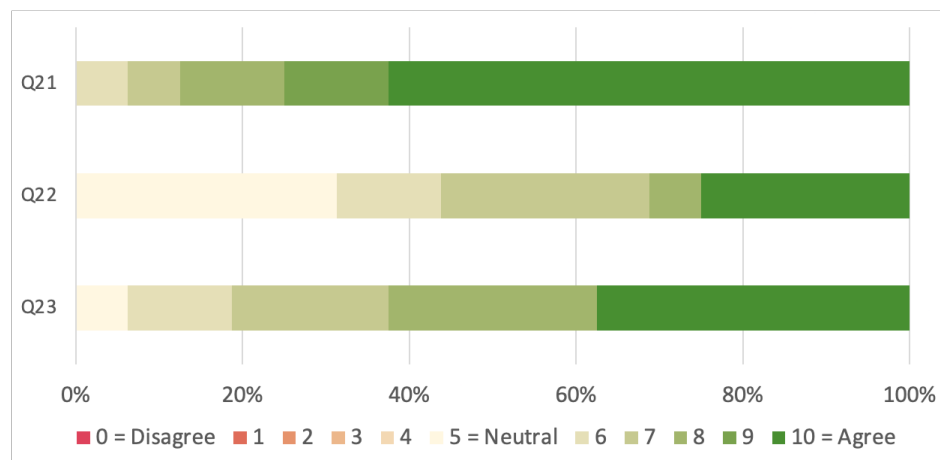


Figure 8.11: Result of statements regarding enjoyment and learning from table 8.6.

In the physical Tiles workshops by Mora et al. (2017), similar results were reported. The data from the questionnaire of the physical workshops shows that over 95% of the participants agreed or somehow agreed with the statements saying it was fun to use.

General Impression

The last category of the questionnaire contained some questions with text-based answers, where the participants were able to give additional feedback on their workshop experience using Digitiles.

The original data from the "general impression" category of the questionnaire can be found in appendix D.4.

Q24: In your own words, what was your experience with using Digitiles?

From the data, it seemed that the majority of the participants had something positive to say about the workshop when using their own words to describe their experience.

One of the participants said that the tool was helpful in coming up with new ideas and develop them further, and that the participant would not have been able to come up with these ideas alone. Other participants expressed similar statements in the questionnaire. One participant stated that Digitiles helped to form and structure ideas, so that one sees the potential to realise the ideas. The participant added that it was a playful way to engage in idea creation, which often can be a tedious and monotonous process.

Another participant suggested that Digitiles could be used for other purposes rather than just creating an IoT solution, and stated that it was nice to be able to have freedom in changing the cards as you go. It was also stated that the toolkit was good for creating simple ideas, however, one participant expressed uncertainty about the tool being strong enough to come up with serious ideas.

Something that came up in the questionnaire, as well as the group discussions, was that there were too few cards to choose from. One of the statements expressed that the group had some difficulties in creating a solution, and stated that there should have been more cards in order to achieve this. From the result of another physical workshop using Tiles, some participants stated the opposite, namely that there were too many cards to choose from and too many possibilities (Mora et al., 2017). At the same time, the participants in the physical workshop had access to 110 cards, while the participants in the digital workshop had access to a total of 126 cards.

Q25: Something I didn't like was...

For the second question, the participants wrote down something they did not like about the workshop.

Some of the participants stated that they sometimes lost the overview of the process and the other participants, and one of them stated that it would have been better using a larger screen. It was stated that it was especially hard when zooming in to read the text on the cards. This was also a subject of the group discussions.

Some of the statements in the questionnaire were also related to negative group dynamics and cooperation. One participant stated that some of the group members quickly became passive in the discussion. Another participant stated that using a communication tool such as Zoom, makes the group dynamics more difficult, and that it requires someone in the group to take the initiative.

One of the statements suggested that the cards could potentially limit the creativity level, as one could easily be obsessed with suggestions on the cards rather than thinking for oneself.

Q26: Something you could improve is...

In the last question of the questionnaire, the participants wrote down suggestions on things that could be improved in the digital toolkit.

Two participants stated that it might have been easier not to have everything on one page/board. One participant suggested having one task per page/board.

Several participants suggested improving the square with the card placeholders for *triggers*, *things* and *responses*. This was also suggested in the group discussion. The statements related to this expressed confusion on where to put the cards, and how the cards were connected.

Another suggestion made by one participant was to create a distinction between card placeholders containing the strengths and weaknesses for the reflection criteria cards.

Two participants wrote that they would have preferred the toolkit to be in Norwegian or supporting multiple languages. One of the participants suggested having a translate button on the board.

8.3 Discussion

This section contains a discussion of the result of the group discussions, questionnaires and artifact analysis from the workshops using Digitiles. By comparing the results of the different data gathering methods, useful information about the perceived experience using Digitiles was provided. The findings of the questionnaire and the group discussions are considered to be tightly coupled, as they provided similar data results. The topics of the group discussions were also prominent in the results of the last questions of the questionnaire.

The discussion focuses on how Digitiles supports creativity and cooperation in idea generation workshops, the digital interaction with the toolkit and the perceived enjoyment and learning using the toolkit. Strengths and weaknesses of Digitiles within these categories are discussed, thereby answering RQ1.4.

Some of the results were also compared with the Tiles toolkit used in physical workshops, and some statements from the participants of the interviews who had

facilitated Tiles workshops. The comparison helped identify additional strengths and weaknesses in the digital versus the physical toolkit.

8.3.1 Supporting Creativity

All five groups were able to come up with one IoT solution for a chosen *persona* and *scenario* in the end. None of the presented ideas were similar, although some of the selected cards were the same for some of the groups. This shows that the toolkit supports creativity in the way that the cards can be used as inspiration to create different solutions. One can assume that the transformation of the physical Tiles toolkit did not affect the ability to generate ideas that are different from other groups.

The result of the groups' storyboard and elevator pitch was also different. Some of the groups used the provided template on the board, while others customised the template by using additional tools in Miro to create new elements and using them as part of the presented solution. Workshop no. 5 and figure 8.6 is one example of a customised creative use of the storyboard and elevator pitch. This shows that the digital toolkit can be used in different ways, and that it allows for space to be creative. Three out of the five groups used the custom cards to create their own cards. Only one group used the random generated card deck for *scenario* cards.

Figure 8.7 also shows that the participants believed the cards were helpful in the creativity process. All 16 participants agreed that they had ideas they would not have without the cards. When comparing digital workshops with physical workshops in the group discussions, it was stated in two different groups that they would have been able to create more or better ideas in a physical workshop.

From the result of the group discussions and questionnaires, some participants requested more cards in order to develop a creative solution. An interesting observation was made by comparing the results of physical workshops done by Mora et al. (2017). The result of the physical workshops show that some participants struggled with selecting cards because there were too many to choose from, even though the participants of the physical workshops had access to less cards than the participants of the digital workshops. A similar statement was also made by one of the interviewees in chapter 4, who had facilitated physical Tiles workshops. This might be related to the fact that when you are using Digitiles, you are able to see all cards at once, compared to having multiple decks of cards on the table. In one of the group discussions there was a general agreement that it would be more chaotic in a physical workshop, because you cannot see all the cards at once.

8.3.2 Supporting Cooperation

From the result in figure 8.10 and the statements Q17 and Q18, it seems that the majority of the participants thought that it was easy to communicate and

coordinate the work with the other team members. The agreement level of the statements related to workspace awareness, *Q19* and *Q20* was a bit lower.

The results of the group discussions and the text-based questions in the questionnaire, show that some participants had a hard time getting an overview of what the other team members were up to when reading the cards. One participant stated that this was because one would have to zoom in to be able to read the text on a card, and then you were not able to see what was going on in the other parts of the toolkit.

In the discussion of physical versus digital workshop, there were split opinions about whether it was easier to get an overview of the toolkit and the other participants in the physical or digital environment.

From the questionnaire result, there were also some statements regarding group dynamics being negatively affected while communicating digitally. In addition, one participant stated that some members of the group quickly became passive, although it is not specified whether this was due to working together in a digital environment. One participant suggested creating specific roles for the participants, so that everyone is responsible for some parts of the toolkit.

8.3.3 Supporting Digital Interaction With the Toolkit

Figure 8.9 shows that most participants were able to easily interact with the different parts of the toolkit in Miro without any issues. From the interviews in chapter 4, two participants stated that it was sometimes a challenge working with Miro as the participants needed to learn how to use it first. In this workshop, seven participants had previous experience using online whiteboard tools, while nine did not have any experience.

From the result of the last category of the questionnaire and the group discussions, it seemed that the participants perceived the digital workshops to go smoothly, and none experienced any major technical issues.

8.3.4 Supporting Enjoyment and Learning

When it comes to enjoyment, this was perhaps the statement that received the highest level of agreement. From *Q21* in figure 8.11, one can see that all 16 participants agreed that using Digitiles was fun. As similar results have been seen in previous workshops using Tiles (Mora et al., 2017), it seemed that the participants were able to enjoy using the toolkit in both physical and digital environments.

The results of the group discussions and the last category of the questionnaire, also show that the majority of the participants had fun while working together in the idea generation workshops. Some participants stated that the time constraints on the different steps lead to stress, and that more time on some of the steps would reduce some of the pressure.

Q22 in figure 8.11 shows that most of the participants had a better understanding of IoT after attending the workshop using Digitiles. Most participant had a non-technical background, and possibly little or no knowledge of IoT to begin with. However, it can be assumed that Digitiles is useful for introducing and informing participants about IoT, which is also in line with the results of physical workshops using Tiles (Mora et al., 2017).

Chapter 9

Conclusion

9.1 Summary of Results

The purpose of this research was to develop a digital version of a physical card-based toolkit, named Tiles. To investigate how to best transform this toolkit into a digital version supporting creativity and cooperation in idea generation workshops, several research strategies and data generation methods were used.

A literature review analysing three different card-based design tools was performed. Nine interviews were conducted with people having expert knowledge of Tiles and other card-based design tools. A fully functional prototype, named Digitiles, was designed and tested throughout four usability tests and five digital co-design workshops with 16 participants. The prototype went through three design iterations.

The result of this research contributes to increased knowledge of digital transformation of card-based design tools. The contributions to this area is the research on how the digital prototype should be designed, comprising the chapters of related work (chapter 3), interviews (chapter 4) and implications for design (chapter 5). A second contribution is the design and evaluation of Digitiles, comprising chapters 6, 7 and 8.

A gap in the literature concerning digital card-based design tools was discovered during this research. As a measure to making this gap smaller, a set of functional requirements were identified, concerning artifacts, process and cooperation in digital idea generation workshops using card-based design tools. The requirements can be applied when transforming card-based design tools from the physical to the digital environment, or when developing a new digital card-based design tool.

9.2 Research Questions

RQ1: How can Tiles be transformed into a digital toolkit supporting creativity and cooperation in idea generation workshops?

This study involves the processes of researching card-based design tools characteristics, interviews and the design and evaluation of Digitiles. The answer to the main research question, RQ1, comprises of the findings of its sub-questions and the research and results throughout this thesis.

RQ1.1: What are the characteristics of card-based design tools concerning artifacts, process and cooperation in idea generation workshops, that should be considered in the digital transformation?

The answer to RQ1.1 rests in chapter 3, where card-based design tools and their characteristics were identified. Table 3.2 displays an overview of the characteristics concerning artifacts, process and cooperation in card-based design tools used in idea generation workshops. From the identified characteristics, eight functional requirements were created (table 5.1). The requirements were considered to apply for all card-based design tools going through this transformation, and were used to create the first version of Digitiles. The requirements could be useful when transforming any physical card-based design tool to the digital environment, or when creating a new digital card-based design tool.

RQ1.2: What are the characteristics of the physical Tiles toolkit supporting creativity and cooperation in idea generation workshops that should be considered in the digital transformation?

In chapter 4 interviews were conducted to gather insights from participants with expert knowledge of Tiles and other card-based design tools, and to further investigate the characteristics of Tiles supporting creativity and cooperation in idea generation workshops. The Tiles cards were considered to be an important factor in promoting both creativity and collaboration, as the cards acted as a conversation medium throughout the idea generation workshops. Co-design workshops using Tiles also enabled creativity and cooperation in the way it was a "free space" where one could relax, discuss and brainstorm ideas with the other team members without having to deal with additional pressure.

Furthermore, ways of transforming the same characteristics supporting creativity and cooperation were discussed. The findings from the interviews resulted in a list of suggested functionalities and features for Digitiles (section 5.2 and table 5.2), that could help support creativity and cooperation in digital idea generation workshops.

RQ1.3: How can the identified requirements supporting creativity and cooperation in idea generation workshops be embedded in the design of Digitiles?

A prototype was designed based on the identified requirements and suggested

functionalities from the information gathering phase. This resulted in a fully functional prototype named Digitiles, which was ready to be tested and evaluated in the digital environment.

RQ1.4: What are the strengths and weaknesses of Digitiles used in idea generation workshops?

This question is answered through the final co-design workshop evaluation of Digitiles in chapter 8. The findings of the group discussions, questionnaires and artifact analysis, provided information about the strengths and weaknesses of Digitiles in use.

The findings from the evaluation suggested that Digitiles was fun to use (100% levels of agreement). It was also found that Digitiles promotes creativity, as the cards helped generate new ideas. The results also show that the ideas generated in all workshops were different. Moreover, Digitiles allowed for space to be creative, as it was possible to customise and design new elements to be used as part of the toolkit.

Digitiles supported cooperation between the participants in the way that they were able to see the other team members, coordinate the work and get an overview of the total process of the workshop. It was also found that the majority of the participants had a better understanding of IoT after using Digitiles.

Some weaknesses were related to workspace awareness, in the way that the participants could not see what was happening at all times, and lost the overview when focusing on reading the cards. Other limitations were also connected to digitally interacting with the different parts of the toolkit. Some participants also stated that the process was a bit stressful due to the time constraints for the tasks.

9.3 Limitations

This research can be also be seen in light of some limitations. Firstly, some of the participants in the evaluation of Digitiles were acquaintances of the researcher. This might impact the validity of the data. However, due to lack of voluntary participants from classes at NTNU, it was necessary to recruit additional participants. As a measure to gather as realistic results as possible, the participants were encouraged to state their honest opinions and not withhold any negative information. The questionnaire was also made anonymous, and so the participants were able to state their honest opinion through the form without being identified.

In addition, the participants in four out of five workshops knew the other participants in the same group from before. Knowing the others on the same team might make it easier to take the lead and perform actions without worrying too much about what the others think. As a consequence, this may affect the outcome of the evaluation in the way that the results of the cooperation within groups mostly reflects groups of people who know each other from before. However, one

can also assume that design workshops using card-based tools are usually performed with people who know each other from before, such as through educational activities in schools, or colleagues in design teams. Therefore, one also can assume that the results of the evaluation reflect a common use of the tool.

Due to time constraints, it was not possible to take advantage of all the data gathered from the idea generation workshops, such as the video and voice recordings. Going over and analysing the conversation and observing the participants throughout the workshop, could help discover detailed information about what the participants actually do instead of what they say they do. This could lead to additional important findings in the evaluation of the prototype. Nevertheless, a lot of rich data were gathered from the artifact analysis, the group discussions and the questionnaire, which should be enough to provide a good overview of the strengths and weaknesses of the digital toolkit.

Using an existing online platform, such as Miro, also has its limitations. By using an existing platform, one is restricted by the functionalities provided by this platform. Creating a solution from scratch would enable more freedom in the development and design. At the same time, it would require a lot more resources and it would be much more time consuming. Not choosing to create a new platform from scratch, allowed for more time to evaluate and test the functional prototype through several design iterations.

9.3.1 Discussion of Data Collection Methods

Digitally Conducted Interviews

Conducting digital interviews with video and voice connection led to some difficulties. In some cases, bad internet connection or audio quality led to words getting lost in the conversation, and the interviewee had to repeat things he or she had said before. All but one interviews were also done in English, even though this was not the native language of any of the participants. This was also a factor that affected the quality of the communication between the researcher and the participants of the interview. Noise from the environment was another factor that affected the quality of the audio, and as a consequence, words could get lost in the conversation.

As a measure to get as accurate results as possible from the participants, the researcher asked the participants to repeat some statements if the researcher did not understand the statement, or if the quality of the audio was bad. The researcher would also carefully go through all voice recordings two times, to ensure that the statements were correctly transcribed before analysing the data.

Using only an audio recorder to record the interviews also had its disadvantages. Audio recording does not capture the non-verbal communication, as one can experience when talking to someone in person. In retrospect, recording video in addition to audio could to some extent have solved this problem.

Group Discussions

Group discussions were held after the idea generation workshops to briefly discuss the participants' collective experience of the workshops. Some of the participants had a lot to say during this debrief, while others did not express much. The researcher could potentially have asked one person a question at the time, so that everyone got the chance to speak their mind.

Questionnaire

Questionnaires were used as an additional data generation method in the evaluation of the workshop to gather a large number of relevant data. It is known that the quality of the data from the questionnaire is directly related to quality of the questionnaire (Oates, 2006). This means that in order to gather quality data it is important to make sure that the quality of the questions are good. It might be that the participant can misunderstand some questions, and put down an answer instead of checking what the question really asks. This might especially be true for Likert scale questions, where it is easy to just select a number without really having read the questions thoroughly.

As the questionnaire was anonymous, it was not possible to go back and ask for an elaborated explanation of the answers to the questions. Individual interviews may lead to more accurate results, but on the other hand, it is also a lot more time consuming than questionnaires.

As a measure to gather as much valid data as possible from the questionnaire, all questions were mandatory. The participants were also asked to answer the questions during the Zoom meeting, which gave the participant the possibility of asking the researcher about the questions in the questionnaire if anything came up. The supervisor also checked the formulation of the questions in the questionnaire before it was submitted.

9.4 Recommendations for Future Work

To further evaluate the strengths and weaknesses of Digitiles, additional evaluations could be done. By using the feedback from the workshop evaluation, it is possible to make design adjustments and changes based on this feedback and perform additional design iterations. The prototype could also be tested on a different group of audience to gather additional data and insights from for example children, teens or elderly people with lower digital competencies.

From the results of the co-design workshops, there are still uncertainties about whether the digital workshops using Digitiles facilitates idea generation as well as physical workshops using Tiles. This is something that could be further investigated by performing both physical workshops using Tiles, and digital workshops

using Digitiles with the same participants, and compare the results of the creativity and cooperation levels in the workshops.

As the prototype is digital, there is also a possibility of adding additional functionalities that could potentially enhance the prototype. Some possible functionalities, which were not implemented due to time constraints, are listed in table 5.2. One example is supporting multiple types of workshops and activities, and adapt the workshop and cards based on the needs and audience of the workshop. Creating a guide for facilitators of Digitiles workshops would allow for customisation of the workshop. Gamification elements could also be implemented to create a more game-based and fun approach to Digitiles.

It is also interesting to investigate platforms other than Miro, and possibly creating a new system which the toolkit could be embedded in. This would provide even more freedom in the development of the prototype.

Moreover, additional research on transforming digital card-based design tools is still beneficial. An elaborated guide on how to approach such a transformation that applies for all card-based design tools could be useful.

The results in this thesis rely on what the participants say, and may not be completely transferable to what the participants actually know and think. Alternative evaluations and data generation methods, such as participant observation, might be useful to further investigate the participants' experiences with Digitiles.

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Appendix A

Interviews

A.1 Interview Guide

1. Have you participated or facilitated in any co-design session or creativity session?
2. Was the session performed physically or digitally?
3. Did you use any specific design tool/ toolkit or framework during the session?
4. What was the purpose of the session?
5. What type of information was provided before the session started?
6. What were the provided artifacts in the session?
7. How did the participants cooperate during the session?
8. How do you think the tool promoted creativity amongst the participants?
9. Did you experience any limitations with the provided artifacts?
10. Can you name some benefits you think can come from digitising a physical design tool (toolkit)?
11. Can you name some challenges you think can come from digitising a physical design tool (toolkit)?
12. Do you have any suggestions on how to promote creativity during a digital design session?
13. Do you have any suggestions on how to promote cooperation during a digital design session?

Precondition: Creator of a design tool:

14. What has been your main focus when designing the tool?
15. Can you think of anything specific that you think has been challenging during the process?
16. Do you have any lessons learned from the experience?

A.2 Rationale of Questions

Question no.	Goal	Keyword
1	Clarify their experiences with co-design sessions or creativity sessions.	participant experience
2	This is crucial when analysing the results from the rest of the questions from the session.	participant experience
3	Be able to compare different tools/toolkits. Evaluate the use of different tools.	tool/toolkit
4	Find out the purpose of the session. Different sessions have different purposes (learning, ideation, implementation of idea).	purpose
5	Find out if the participants required any pre-knowledge to participate in this session. If they used a specific tool - did that in itself provide enough information to be able to use the tool?	pre-session information
6	Get an idea of the complexity of the tool/toolkit used in the design session.	artifacts
7	Identify parts of the cooperation between the participants and cooperation mechanisms during the design session. Can the cooperation mechanisms be transferred into a digital version?	cooperation (mechanisms)
8	Evaluate the level of creativity in the tool. Also depends on the purpose of the tool / session. Can this be transferred to an online version?	creativity
9	Evaluate limitations of different artifacts. Might be something to take into consideration when designing the online version of the tool.	artifacts
10	Evaluate the benefits of digital transition, and identify reasons for doing this.	digital transition, benefits

11	Evaluate challenges of digital transition that I should take into account when designing a solution.	digital transition, challenges
12	Evaluate methods of promoting digital creativity. Might need to find an alternative method from physical creativity promotion.	digital transition, creativity
13	Evaluate methods of promoting cooperation in the tool. Will need to find an alternative method from physical cooperation.	digital transition, cooperation
14	Evaluate different tools/toolkits. What is the area of focus? Why did they focus on this instead of something else? Is this something I should take into consideration when designing a digital solution of a toolkit?	tool/toolkit, focus
15	Gain insights into challenges of designing/ implementing a toolkit (physical or digital).	participant experience
16	Identify lessons that others in the same situation have experienced, so that I can take this into consideration when designing a digital version of the tool.	digital transition, participant experience

A.3 NSD Information Sheet

Are you interested in taking part in the research project "Learning by making: the case of TILES"?

This is an inquiry about participation in a research project where the main purpose is to share experience with card-based design tools and digital collaboration. In this letter we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project

The project is part of a master's thesis in computer science at NTNU, and the duration is one year. The purpose of the project is to develop a digital version of a card-based toolkit named Tiles. The interviews are conducted to gain insight into what experiences the participants have with card-based design tools, and possibly

what experiences they have with digital interaction that can be linked to digital design tools. All sharing of knowledge and experiences is greatly appreciated.

Who is responsible for the research project?

The Department of Computer Science (IDI) at NTNU is responsible for the project.

What does participation involve for you?

If you choose to participate in the project, it means that you take part in an interview. It will take you approx. 40 minutes. The interview will be conducted digitally via Zoom, which will be connected to NTNU's server.

There will be questions about your experiences with design tools, card-based and/or digital version. If you have experience with Tiles, it is desirable that you share your experience with the tool by answering questions about the process. If you have any suggestions on how the tool can be digitized or improved to a digital version, it is also desirable that you answer this. If you have experience in designing a design tool, it is desirable that you answer questions regarding your experience with the design process, and if you have any tips you want to share.

The interview will be audio recorded.

Participation is voluntary

Participation in the project is voluntary. If you choose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you choose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

The audio will be recorded on NTNU's audio recording equipment without network access and will be handled by the student who carries out the project, potentially also by employees at the university who will help with transcribing the interviews. The audio recordings can be uploaded to a computer connected to NTNU network with password protection. All audio recordings will thus be transcribed and anonymised, and each participant will be assigned a unique user code that will help the student to anonymize the data. With the exception of the audio recordings and information necessary to contact the participants, no personal information about the participants will be collected.

The project supervisor will have access to parts of anonymised data. The participants will not be able to be recognized in a possible publication of the thesis. All personal information and audio recordings will be deleted at the end of the project (June 2021).

Your rights

So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
- request that your personal data is deleted
- request that incorrect personal data about you is corrected/rectified
- receive a copy of your personal data (data portability), and
- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?

We will process your personal data based on your consent.

Based on an agreement with NTNU, NSD – The Norwegian Centre for Research Data AS has assessed that the processing of personal data in this project is in accordance with data protection legislation.

Where can I find out more?

If you have questions about the project, or want to exercise your rights, contact:

- Supervisor: Monica Divitini
- Student: Lena Tørresdal
- NSD – The Norwegian Centre for Research Data AS, by email: (person-verntjenester@nsd.no) or by telephone: +47 55 58 21 17.

Yours sincerely,

Project Leader

Student (Researcher/supervisor)

Consent form

I have received and understood information about the project “Learning by making: the case of TILES” and have been given the opportunity to ask questions. I give consent to participate in an interview, and for my personal data to be processed until the end date of the project.

(Signed by participant, date)

Appendix B

Enlarged Images

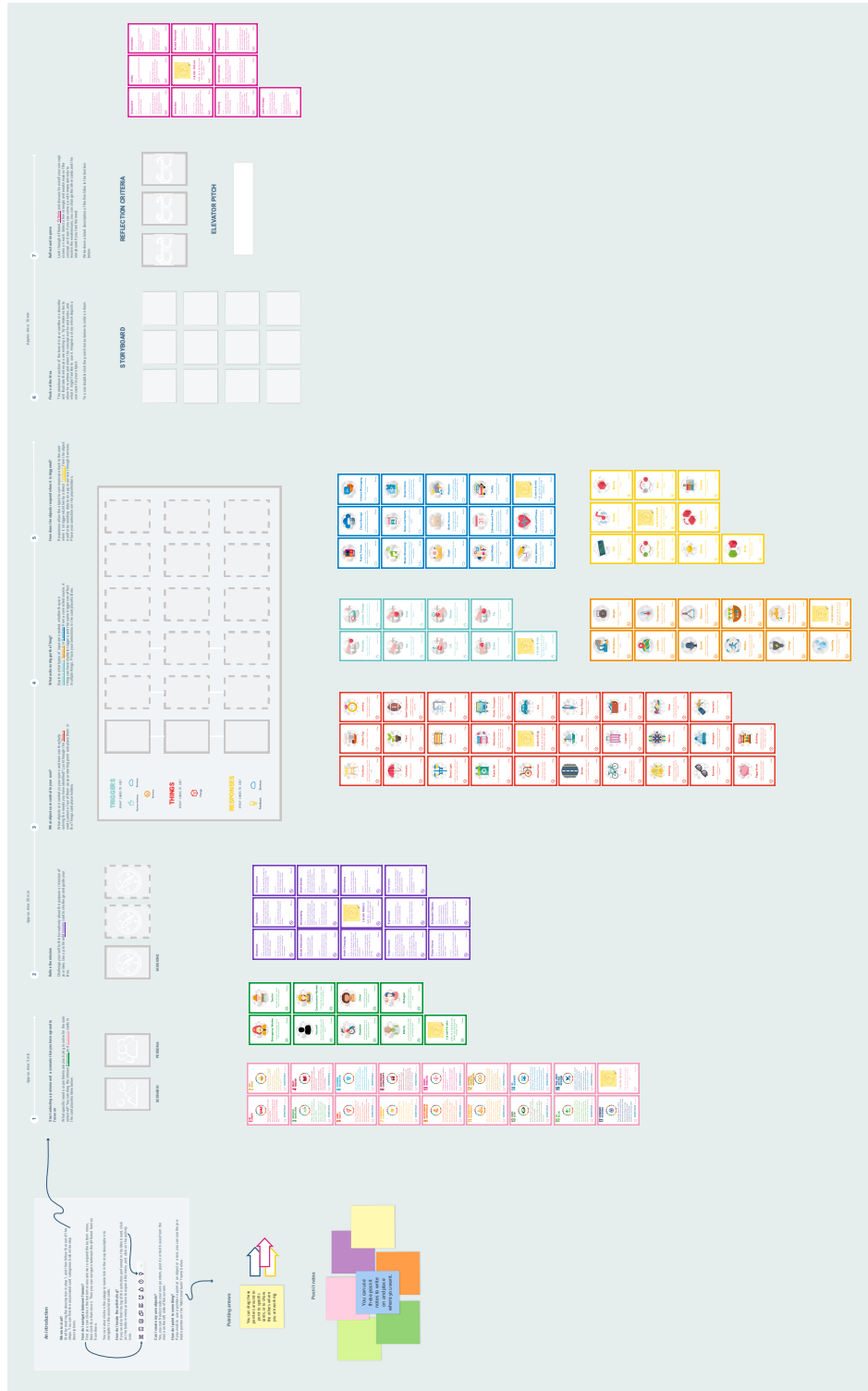
B.1 Tiles IoT Inventor Toolkit Artifacts



B.3 Digitiles: Second Version



B.4 Digitiles: Third Version



Appendix C

Usability Test

C.1 NSD Information Sheet

Are you interested in taking part in the research project "Learning by making: the case of TILES"?

This is an inquiry about participation in a research project where the main purpose is to test a digital prototype of a card-based design tool. In this letter we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project

The project is part of a master's thesis in computer science at NTNU, and the duration is one year. The purpose of the project is to develop a digital version of a card-based toolkit named Tiles. Tests are performed to ensure quality of the user experience of a digital prototype.

Who is responsible for the research project?

The Department of Computer Science (IDI) at NTNU is responsible for the project.

What does participation involve for you?

If you choose to participate in the project, it means that you take part in a usability test. It will take you approx. 40 minutes. The tasks will be given digitally through Zoom, which will be connected to NTNU's server. You will gain access to the prototype on Miro, which is a digital collaboration platform. During the usability test you are to complete ten tasks.

The conversation will be audio recorded. Screen recordings will be taken from the website with the prototype during the usability test.

Participation is voluntary

Participation in the project is voluntary. If you choose to participate, you can with-

draw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you choose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

The audio will be recorded on NTNU's audio recording equipment without network access and will be handled by the student who carries out the project. The audio recordings can be uploaded to a computer connected to NTNU network with password protection. All audio recordings will thus be transcribed and anonymised. The audio recordings will only be used to evaluate the quality of the prototype. With the exception of the audio recordings and information necessary to contact the participants, no personal information about the participants will be collected.

The project supervisor will have access to parts of anonymised data. The participants will not be able to be recognized in a possible publication of the thesis. All personal information and audio recordings will be deleted at the end of the project (June 2021).

Your rights

So long as you can be identified in the collected data, you have the right to:

- access the personal data that is being processed about you
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- send a complaint to the Data Protection Officer or The Norwegian Data Protection Authority regarding the processing of your personal data

What gives us the right to process your personal data?

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Where can I find out more?

If you have questions about the project, or want to exercise your rights, contact:

- Supervisor: Monica Divitini
- Student: Lena Tørresdal

- NSD – The Norwegian Centre for Research Data AS, by email: (person-vern@nsd.no) or by telephone: +47 55 58 21 17.

Yours sincerely,

Project Leader

Student (Researcher/supervisor)

Consent form

I have received and understood information about the project “Learning by making: the case of TILES” and have been given the opportunity to ask questions. I give consent to participate in an interview, and for my personal data to be processed until the end date of the project.

(Signed by participant, date)

C.2 Pre-Test Information

- The purpose of this test is to test a digital prototype of a card-based design toolkit to find out what works, and what does not work so well.
- It is the prototype that is being tested, not your actions.
- I will read a scenario and some tasks you should try to perform, one at the time. I will let you know when you can start with each of the tasks, as there are some preparations that need to be done between the tasks. You can tell me once you think you are done with a task.
- I want you to think out loud while doing the tasks, and tell me what you are thinking about, like for example why you are clicking that button and not another and so on.
- I cannot answer any task related questions during the test, but you can ask as many questions as you want, and we can discuss them after the test.
- You are free to cancel the test at any time.

C.3 Scenario Introduction

You and a colleague on your team got a project where you are to design an IoT solution for a company that wants to reduce the climate footprint for tourists in Trondheim. While waiting for your colleague to join, you decide to get a head start on the workshop.

C.4 Tasks

1. Go to the first step in the design tool, and choose one card from the *scenario* category and one from the *persona* category.
2. The next step is to find some missions from the card category *missions*. Pick two cards from this category.
3. You get an idea of wanting to use a map for the IoT object you are to design. Select a suitable card from the *things* category.
4. Your colleague shows up, and wishes to get an overview of everything you have done so far. See if you can find a log of your activities so far.
5. Your colleague added some cards for *triggers* and *responses* to the map. After some discussion, your team decides that you want to switch the placed *feedback* card with another *feedback* card called “Text”. Perform the switch.
6. Now it is time to work on the storyboard, and you wish to drag a pointer to it to show your colleague where you are going to work. Drag a pointer to the storyboard part.
7. Write a random text on the storyboard.
8. You want to find a way to get an overview of all the card categories, and to be able to navigate between them, so that you can go through all cards one more time.
9. Find out where your colleague is working on the board.
10. You and your colleague reflect on the session you have done so far. Try your best to briefly describe what you have done so far and what remains in the design session.

Appendix D

Digital Workshop

D.1 Questionnaire

Background, previous experience and knowledge

Q1: Educational background/study

Q2: Do you have any experience with design?

- not at all
- some experience / hobbyist
- a lot of experience / professional

Q3: Do you have any experience with software development?

- not at all
- some experience / hobbyist
- a lot of experience / professional

Q4: Before this workshop, did you have any experience with online collaborative whiteboard tools?

- not at all
- some experience
- a lot of experience

Q5: How do you rate your digital competencies?

- below average
- average
- above average

Q6: Have you tried any other card-based tools for design or innovation?

- Name / reference of the tool

Q7: Did you know any of the other participants from the workshop?

- no
- one person
- all team members

Creativity using the cards

Value from 0-10:

0 = I disagree

5 = Neutral

10 = I agree

Q8: I had ideas I would not have had without the cards.

Q9: Using the cards helped me to improve or fine-tuning existing ideas.

Q10: Using the cards helped my team to discuss and to form a clear idea.

The board and the process

Value from 0-10:

0 = I disagree

5 = Neutral

10 = I agree

Q11: The process steps on the board provided enough guidance to develop new ideas.

Q12: The board was too complicated.

Q13: The board helped structuring the work and visualising ideas.

Navigation and interaction

Value from 0-10:

0 = I disagree

5 = Neutral

10 = I agree

Q14: I was able to easily move cards around on the board.

Q15: Locating the correct card categories was easy.

Q16: I was able to navigate between the different parts of the toolkit without any problems.

Communication and cooperation

Value from 0-10:

0 = I disagree

5 = Neutral

10 = I agree

Q17: I found it easy to communicate with the other team members throughout

the workshop.

Q18: I found it easy to coordinate the work with the other team members.

Q19: I was aware of what the other team members were doing on the Miro board at all times.

Q20: I had a clear overview of how far in the process the team was at all times.

Enjoyment and learning

Value from 0-10:

0 = I disagree

5 = Neutral

10 = I agree

Q21: Using Digitiles was fun.

Q22: I have developed a better understanding of IoT after using Digitiles.

Q23: I would consider using Digitiles in the future if I have to design an IoT application.

General impression

Q24: In your own words, what was your experience with using Digitiles?

Q25: Something I didn't like was...

Q26: Something you could improve is...

D.2 NSD Information Sheet

Are you interested in taking part in the research project "Learning by making: the case of TILES"?

This is an inquiry about participation in a research project where the main purpose is to test a digital prototype of a card-based design tool. In this letter we will give you information about the purpose of the project and what your participation will involve.

Purpose of the project

The project is part of a master's thesis in computer science at NTNU, and the duration is one year. The purpose of the project is to develop a digital version of a card-based toolkit named Tiles. Tests are performed to ensure quality of the user experience of a digital prototype.

Who is responsible for the research project?

The Department of Computer Science (IDI) at NTNU is responsible for the project.

What does participation involve for you?

If you choose to participate in the project, it means that you take part in a digital

workshop to test a digital design toolkit. It will take you approx. 90 minutes. The workshop will be held digitally through Zoom, which will be connected to NTNU's server. You will also be given access to the prototype in Miro, an online whiteboard tool.

After using the tool in Miro, a debrief with group discussion will be held where you will answer some questions and give oral feedback on the prototype. After this, you will fill out a questionnaire containing questions about your experience with the workshop.

The screen of the prototype during the workshop will be recorded in addition to the conversation through Zoom.

Participation is voluntary

Participation in the project is voluntary. If you choose to participate, you can withdraw your consent at any time without giving a reason. All information about you will then be made anonymous. There will be no negative consequences for you if you choose not to participate or later decide to withdraw.

Your personal privacy – how we will store and use your personal data

We will only use your personal data for the purpose(s) specified in this information letter. We will process your personal data confidentially and in accordance with data protection legislation (the General Data Protection Regulation and Personal Data Act).

The audio and screen recordings will be handled by the student who carries out the project. The recordings can be uploaded to a computer connected to the NTNU network with password protection. All audio recordings will thus be transcribed and anonymised. The audio and screen recordings will only be used to evaluate the quality of the prototype. With the exception of the audio recordings and information necessary to contact the participants, no personal information about the participants will be collected.

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- Supervisor: Monica Divitini
- Student: Lena Tørresdal
- NSD – The Norwegian Centre for Research Data AS, by email: (person-verntjenester@nsd.no) or by telephone: +47 55 58 21 17.

Yours sincerely,

Project Leader

Student (Researcher/supervisor)

Consent form

I have received and understood information about the project “Learning by making: the case of TILES” and have been given the opportunity to ask questions. I give consent to participate in a workshop, and for my personal data to be processed until the end date of the project.

(Signed by participant, date)

D.3 Group Discussion Statements

Statements related to experience with WS	Agrees
It was fun.	11
Confusing in the beginning because everything went a bit fast and it was at first hard to understand the context.	3
Hard to understand where to put the cards in the box with "triggers", "things" and "responses".	2
Hard to get an overview of everything when using a single small screen on the laptop.	2
More fun than anticipated.	5
A bit stressful/intensive because of the time constraints.	5
Wish there were more cards (services and personas).	2
Liked the flow of the game.	1
Liked that you could go back and make changes in previous steps.	2
Liked that there was no need for prior knowledge.	1
Hesitation using Zoom.	1
Knowing each other makes it easier to talk and you become less critical.	2
Fun using multiple shapes with different colors.	3
Was able to know what to do by reading the steps.	1
A good way to cooperate and solve problems.	2

Table D.1: Statements related to the participants' experiences with the digital workshop.

Statements related to physical VS digital WS	Agrees
More drawing / easier to draw in a physical WS.	2
More ideas in a physical WS.	1
Easier to know what the others are doing in a physical WS.	1
Easier to get an overview of the whole toolkit in a physical WS.	2
Harder to get an overview in a physical WS.	1
Easier to work together in a digital WS.	2
More chaotic in a physical WS because you cannot see all cards at once.	3
Better ideas in a physical WS because it might be easier to brainstorm.	1
More time consuming in physical WS.	2
Not been able to create nice shapes and use different colors in physical WS.	3

Table D.2: Statements related to physical versus digital workshops.

Suggestions on additional functionalities	Agrees
Undo button	1
Auto align of cards when placing them back into the card cateogry frame.	2
Use real name on cursors instead of default anonymous names.	1
Provide roles for all users.	2
Change order of “triggers” and “things” in box.	3
Crazy 8 ideation technique.	1
More shapes and customised objects.	1
Possibility of translating into Norwegian or other languages.	2

Table D.3: Suggestions on additional functionalities.

D.4 Questionnaire Results: General Impression

Med dine egne ord, hva var din erfaring med bruken av Digitiles?

Det var gøy, det føltes ut som en idemyldring i person gjort over nettet.

Verktøyet hjalp med å finne et problem, men at delen hvor man skal sette sammen en løsning ble opplevd vanskelig av gruppen. Her var det litt uklarhet rundt hva vi skulle frem til og hvor mange løsninger vi skulle designe. Synes det manglet litt "kort" for å kunne sette sammen en kreativ løsning

Spennende program. Fikk frem tanker og ideer som ikke hadde kommet frem ellers.

Bra for å være første gang jeg bruker det. Ble bedre og bedre etter hvert som en kom inn i gangen i det.

Synes det var gøy og lærerikt å prøve Digitiles. Det hjalp meg med å komme med ideer jeg ikke hadde kommet på selv og utvikle dem videre.

Veldig oversiktlig og greit verktøy. Enkelt å forstå hvordan ting fungerer, og gode forklaringer over hva som skal gjøres under hvert steg på toppen.

Synes det er en morsom tjeneste.

Synes det var bra, kanskje gøy med enkle ideer hvis man skal komme opp med noe veldig fort. For å få til en seriøs ide tror jeg det er vanskelig uten research og mer betenkningstid.

Det var fint å få inspirasjon til hva man trenger å tenke gjennom før man skal designe nye IoT løsninger.

Veldig god erfaring. Flyten i spillet var bra, og ingenting hakket. Digitiles hjelper å danne ideer, og å strukturere dem slik at man ser potensialet til å realisere dem. En leken måte å drive med ideskapning og konkretisering på. Ofte kan dette bli en kjedelig og ensforming prosess.

Dette var gøy! Kunne gjerne brukt det igjen for å lage noe IoT. Tidsesimatene fungerte bra.

Jeg liker at Digitiles er delt opp i definerte kategorier/steg, som gjør at man bygger på ideen sin. Kortene er visuelt sett fine og selvforklarende. Veldig fint med bilder og ideer. Jeg tror Digitiles kan brukes til andre områder enn bare IoT, og passer bra til brainstorming og idefasen av produktutvikling. Jeg likte også godt at man kunne gå tilbake og legge til flere missions etterhvert som man fikk flere ideer. Bra tidsbruk. Alt i alt veldig bra og gøy WS! Veldig knirkefritt for å være digital.

Morsomt og bra verktøy. Å sitte på zoom trakk opplevelsen litt ned, tro det hadde vært bedre å jobbe sammen fysisk på en skjerm, eller evt i samme rom (med hver sin).

Veldig kjekt og lærerikt. Lærte meg en ny metode for å komme på og utvikle en ide.

Veldig gøy verktøy! Gjør brainstorming i grupper mye enklere. Et nyttig verktøy for både bedrifter og skoler.

Hadde en bra erfaring. Det var gøy og enkelt å bruke.

Noe jeg ikke likte var...

Det var litt for stort for en liten laptop.

At kortene var begrenset, noe som kunne begrense idemuldring og brainstormingen til et nivå.

Når man zoomet inn for å lese tekst på kortet mistet man litt oversikt over hvor de andre i teamet var.

Litt vanskelig på en liten skjerm, sikkert mye bedre med større skjerm eller flere skjermer.

Var av og til vanskelig å skrive kommentarer i boksene.

Vi hadde plutselig litt trøbbel med tekst-feltet på pitchen, men det er nok ikke programmet sin feil ;)

Lett å flytte kortene og man får mange forskjellige perspektiver på ulike temaer.

Noen blir fort passive, få kort, tidspress gjør det mer stressende enn det kanskje trengs.

Alt var bra egt!

Gruppedynamikken er ofte litt vanskelig på zoom, krever at noen på gruppen tar initiativ. At triggers sto over things, ble litt satt ut av dette. Også at triggers hadde samme farge som Human actions, først trodde jeg bare det var dette som skulle inn under dette!

Rekkefølgen på boksene til innfylling av kort på steg 3-5, ble litt forvirret.

Var ikke noe jeg ikke likte. Føler at man fort kan gå for den mest "åpenbare" ideen når man kan velge de første 3 kortene selv, og da heller bare utvide/bygge på den ideen på de siste. Hadde nesten vært kulere om de 3 første kortene var litt random / velge mellom 3 random kombinasjoner, så utvikle noe fra det utgangspunktet. Hadde fremtvunget en mer kreativ ide!

Vanskelig å tegne med datamus. Man ble til tider litt opphengt i forslagene til Digitiles fremfor å tenke selv, men samtidig er de veldig nyttige. Vanskelig balansegang.

At det var på engelsk.

Jeg likte ikke at det var på engelsk.

Noe du kan forbedre er...

Hver oppgave kan være en side.

At det kunne være enklere å visualisere ideen når du var mot slutten av prosessen.

Mer konkret forklaring på hvordan man skulle "angripe" oppgaven med "triggers", "things", og hvordan disse hang sammen.

Dersom en har ombestemt seg og skal ta bort et kort, hadde det vært en ide om du kunne f.eks dobbeltrykke og så gikk det ned/bort.

Lage bokser hvor det skilles mellom fordeler og ulemper. Lage en hurtigtast slik at dersom man skal endre kort så sendes den tilbake.

Når du vil legge et kort tilbake, at det legger seg automatisk fint når du slipper, i stedet for under hverandre osv. At styrker og svakheter i punkt 7 blir skilt tydelig fra hverandre.

Tydeligere seksjoner innenfor de ulike delene. Ha ulik bakgrunnsfarge på de ulike seksjonene.

Gi navn på cursor, vurdere roller på brukere, vurdere å gi mer tid til steg 4 og 5.

Bedre oversikt på en måte, at ikke alt er på én side egt. Men det hadde kanskje vært annerledes hvis det ikke var digitalt.

Kanskje litt med sosialisering og kjennskap i gruppen før prosjektet starter? Kunne dette vært et eget punkt før man velger problemstilling?

Kanskje du kan tydeliggjøre steg 3-5 hva man skal velge til hva, var litt forvirrende at man kunne ha en kategori med kort innenfor flere steg. Kanskje ikonene i den store boksen kunne vært større?

I den delen man skulle sette triggers osv, kunne alle gruppene som skulle flyttes til samme "pool" bli lagt i samme frame, slik at det var tydeligere hvilke grupper som hørte til samme punkt. Evt ha illustrasjoner, så man ikke måtte bruke like mye tid på å lese på den tredje kortgruppen (der det var sixth sense osv). Vet ikke om det er slik nå, men ha random plassering av kortene i hver gruppe, slik at ikke hver gruppe alltid velger de kortene som er plassert nærmest dit man skal flytte opp til. Vi så hvertfall at det skjedde enkelte ganger da vi skulle designe minigames med vårt spill, så kan være en ide for å sikre ulike utfall!

Legge til en mekanisme for å stemme over forslag.

Burde vært flerspråklig.

Du kunne hatt oversett knapp på brettet.

