Global teams - engaging the paradox

Design prototypes as boundary objects for software development in a global team setting.

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Key Words

Boundary objects, Global teams, Pragmatic view of knowledge, Collaboration, Knowledge transfer, Virtual teams

Abstract

In response to the global pandemic of COVID 19 in 2020, countless software developing companies moved their operations entirely to the virtual environment. This research explores how design prototypes as boundary objects change during this transition into the suddenly remote organization and seeks a framework that can accommodate the new reality. Theoretically it draws on the boundary objects and the pragmatic view of knowledge in the organizations. The research is conducted through participatory observations from within a software developing company. Study finds that lack of face-to-face interactions in the early phase of prototyping makes the design prototypes lose their effectiveness as boundary objects in their regular form, and that they lose their central role in the software development process.

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Introduction

Knowledge is difficult to transfer effectively (Carlile, 2002), a challenge experienced by most people in our society everyday Whether it is in school, work, or even in personal communication, we experience information loss or misunderstandings when knowledge needs to be passed on to someone else, and we often feel that '*we know more than we can tell*'. Working with knowledge requires ways of transferring it, and the more efficient the medium the better shared understanding can be built around a specific topic (Carlile, 2002; Star & Griesemer, 1989). People tend to specialize in specific fields, and build knowledge around this topic to become experts. Expertise in a particular field also requires field-specific vocabulary and syntax to store and pass on the knowledge to others specialized in that field. This has led to development of tools for transferring knowledge, such as books, notes, and apps, that support knowledge transfer between two individuals.

Design prototypes in software development

The need to transfer knowledge is no stranger to the software development industry, and has led to development of multiple tools, such as design prototypes. In the way that software developing companies work, many base the collaboration between people from different departments on a design prototype, which begins with a simple sketch to visualise and materialize the idea that will be developed. As the projects go on, design prototypes develop over time to support the teams with a tangible representation of knowledge, yet are simple enough that everyone involved in the project should understand what they represent to continue and finish their work. Naturally working with these design prototypes requires team members or any two individuals to have some knowledge in the field or given project to be useful. Design prototypes are usually developed by product designers, in cooperation together with other team members such as developers who build the software, sales and marketing who sell it to customers, and the managing board that oversees the entire organization and sets the direction for future development. Based on these cooperations the software takes its shape and becomes released to the customers. This study aims to analyse these prototypes, and how they evolve in a major change of the organizational structure, for example mandatory work from home policies among many offices and organizations during the COVID-19 pandemic.

Introducing the analysed organisation

In the early months of 2020, with the global pandemic of COVID-19, governments around the world have implemented strict health and safety measures in order to slow down the spread of the virus. This meant that for many countries and offices a lockdown was put into place. Therefore, for many companies and especially those in the Information Technology branch, mandatory work-from-home policies were implemented to follow the guidelines. It was no different for the analysed organisation that has moved its operations to virtual platforms to continue development and sales of their product. The analysed company is an international software development company specializing in commercial stock keeping software for big enterprises. This study has been made from within the organization and my

role in the company was a product designer, working closely with the development team. This research is also a part of Aalborg University Copenhagen MSc. education in Sustainable Design, as Master Thesis.

When the lockdown was implemented, the team had a project for a new feature half-way done, and continued work as planned from home. The team has set up a virtual space for dialogue in a form of chat room, and has scheduled daily syncs and weekly updates together with the management. Product design and design prototypes have been moved entirely to an online platform that the company has used before for keeping all the designs in one place. Developers were able to access design prototypes at all times, and were able to contact the designer in case of questions via the set up chat room. As the project has been halfway done, design prototypes, usually developed over brainstorming sessions with many team members, were mostly in their final stages, developed before the lockdown together with the developers, and only minor adjustments had to be made to accommodate new changes in the project. If help of a designer was needed, one-to-one meetings have been organized together with the developer, to explain or adjust the design. As the project has already started and has been finished to some extent when all team members of the team were working together in the office, the project has been finished only one week after the planned delivery time.

After a successfully completed project, the team has gained confidence in working remotely with each other, and has been assigned to develop an entirely new feature for the software. To set off with a new project the team had planned brainstorming sessions and started working on the project as they would in an office environment. As the project went on it quickly became frustrating that video conferences and chat rooms are not feasible for a larger group of people and that conferences with more than just a few participants led to an unpleasant and frustrating experiences with interconnections of the microphones, slow internet connection, or low video quality. These inconveniences quickly forced the meetings to get smaller, and usually consisted only of team leads and managers, who had continued with the brainstorming sessions. The design prototypes developed over the meetings had then been shared by the team leads with their teams, as they had started working on the new feature. To update the prototypes, a weekly design sync was created together with different team leads and the temporary issues were discussed and solved in these meetings. As time flies, team leaders' calendars have filled up with meetings, therefore different teams within the organization decided to hold their own syncs in smaller groups. Design prototypes had not been updated as often due to limited communication, and they were not the central point for discussions anymore, as teams had to also prepare other materials such as documentation that was missing on the prototypes. The team leaders needed the design prototypes to share the ideas with their teams, therefore product designers had to work ahead of the development team's schedule, and the only people who were already introduced to the problem were the team leads. Design prototypes had quickly become packed with complex information such as comments, as the product designer who had developed them was not able to present the idea further due to limited time schedule. Many miscommunications arose during the brainstorming phase that led to a “but we have already known that, and mentioned it in the documentation” or “we meant something else” situations between the teams. The amount of 1-on-1 meetings, team meetings, writing and reading

documentation has quickly occupied every team member's schedule leading to slippage in project time. Two weeks before the planned handover the team has struggled to deliver a fully functional feature, therefore the release has been postponed. Limited communication capabilities, and little to no customer co-creation has also changed the way the feature looked, meaning it did not work or look as designed in the beginning during the brainstorming sessions with the team leaders. These communication and understanding issues have led to a four month spillover of the project, and has reshaped entirely the way the design prototypes look and work.

This paper aims to answer what led to and caused these problems, and find a framework for virtual teams to overcome these interruptions in the brainstorming and development phase.

Problem Statement

Many researchers have focused on the global teams and the problems when transferring knowledge (Orlikowski, 2000; Carlile, 2002; Bechky, 2003; Sapsed and Salter, 2016), yet these researches have all focused on organizations that had the possibility to organize face-to-face interactions, or had teams that were continuing to work together in one of the locations. In this research this is not possible due to the COVID19 pandemic, as the entire organization in all of the locations has been forced into the mandatory work-from-home policy. Understanding the design prototypes as unfinished tools for starting a transdisciplinary dialog between different team members and stakeholders, I notice that there is a set of rules that need to be followed in order for the design prototype to work and bring the expected outcome. Moving an entire organization to a fully virtual setting creates even more boundaries and difficulties for knowledge transfer, therefore the role of the boundary object becomes more prominent and important, but what is it that actually changes during that shift? This paper aims to answer this question, and analyse in depth the change of the design prototype from before, during, and after the mandatory work from home policy. In this study I will also take a closer look at how the evolution process of a prototype differs, as a support for dialogue between different actors.

Research question: How does the role, function, and meaning of the design prototypes as boundary objects change when an entire organization goes online?

- What is the designer's role in the new setting?
- How does the prototype evolve in a digital setup?
- How can the prototyping phase be improved to help accommodate the new boundary objects to support the innovation process?

Strategy

To answer the research question I have laid out a plan of action for the research and framework development. To support the analysis, desk research has been made, to gather existing studies regarding global & virtual teams, and see what problems are there known to researchers already. For a better understanding of a researched topic, of how the role of design prototypes changes, a six month long ethnographic study has been conducted from within an organisation with myself acting as both as a researcher and a member of the team. My role in the organisation has been as a product designer, therefore this study will be based on first hand observations of dialogues, interactions and processes undergoing during this period of time. From this field study I analyse the change of the role of the design prototypes, how they have changed and how has the role of the product designer changed, compared with the organizational structure before the pandemic and mandatory work from home policies. The analysed organisation is an international software development firm, with multiple offices around the globe and centralised management in one of the European offices. With a couple of hundreds of people around the globe the organization is a perfect example of how medium sized businesses have dealt with the change. Due to privacy and confidentiality agreements the organization's name will not be mentioned, and the company will be referred to as 'the organization' or 'The company'.

The thesis is divided into six chapters, where I describe as follows, presentation of the methodological approach, and a summary of existing studies on global teams and virtual collaboration, researching which problems have already been described and conceptualised. Next I describe the empirical data, gathered during the ethnographic study and analyse it through the theoretical perspective. Then I discuss different approaches to solving the question and finally I propose a framework for the teams to communicate in the entirely virtual environment. Since the outcomes of the framework cannot be verified yet to be reliable, the conclusion is more an opening for discussion than concluding on a specific framework.

What is the designer's role in the new setting?

As a product designer I will compare how design prototypes have looked before the lockdown and after mandatory work from home rule, and how they differ from the ones delivered to the teams overseas. Additionally the role of the designer will be analysed based on unstructured interviews with other product designers, managers and other various team members in the organization. Observations will be a primary source of information, as many situations or set ups did not allow for a structured dialogue due to the dynamics of the case study.

How does the prototype evolve in a digital setup?

Research will be conducted over qualitative data analysis, to compare the differences that occur in boundary objects as the organization goes through a rapid change of it's structural setting. Team members have been asked "what is the design prototype, what do

they mean to you" to better understand how they understand and see the role of design prototypes. The question has been asked twice, at the very beginning of the lockdown, and after 5 months of work from home. Comparing differences may be found in the Descriptive material chapter (p. 14). Observations from the *participant observer's* position will also be collected, to summarize different outputs that were expected from the design prototypes. Comparison will be based on actual design prototypes, how they have changed visually and functionally, but also how they changed in terms of meaning to others and function they play in the development of the product and beyond.

Can the prototyping phase be improved to help accommodate the new design prototypes to support the innovation process?

To find out the better way of cooperating with other teams in the virtual environment I have prepared a workshop, over a virtual whiteboard such as Miro. The workshop's objective was analysing the team member's pain points when it comes to virtual cooperation, gathering at once anonymously feedback from all members of the organization that take active part in the development of the functionality. During the workshops the teams had also tried new softwares that could support their work in the virtual setting, which could be beneficial for the organization.

Method and Methodology

Due to limitations and strict guidelines from the authorities, the study will be conducted entirely online. The base for the research will be a quantitative data research and qualitative data analysis in two stages: unstructured interviews - to identify main problem areas, and structured interviews - to go in depth within the found problem areas. Main data source will be the participation and observation from within a company, before and during the change of the setting into a remote only company. Observations will focus on what has changed from the "business as usual" to the "new norm", and how this process has been developing and what problems and possible solutions are there to be found. Additionally the 'new norm' strategy will be observed, regarding how the company has adapted to this setting and what are the plans for the future in case of a second wave of the pandemic. To analyse the problem in depth, interviews and questionnaires will not only be done within one company, but will aim for a bigger audience, to verify the correctness of the data.

Observations

To gather information and discover unknown problems within the researched topic, 1st hand observations have been carried out. As a part of the team I have been a '*Participant Observer'* within the organization, as I observed the interactions from the members perspective, and therefore influenced them due to my participation (Flick, 2009). Observations have been carried out for a period of 6 months, before,during and after a few months from the beginning of the Covid-19 pandemic and mandatory work-from-home policy implemented within the researched organization. Form of field notes and personal notes has been mostly used to collect material during the meetings, customer interviews and other

interactions with various participants. Notes, as descriptive observations (Flick, 2009) become a base for further unstructured and semi-structured interviews, as they have helped narrow down the researched problem and identify potential leads. Observations have been focused on the boundary object, in this case product design mockups, to analyse and follow the design and development process based on these objects. Over the duration of the observations two different projects have been carried out, with multiple boundary objects in use, to compare differences between pre and during lockdown development.

Unstructured and Semi-structured interview

To collect information from other members of the team unstructured and semi structured interviews have been conducted. To gain knowledge about struggles and pain points that other members of the organization face while working with the boundary objects, a question catalogue has been built based on observations. Since not all of the questions have been used, and the one used have been selected based on the interviewee's role and function, this can be considered a semi-structured interview (Zhang et Al, 2009). Interviews were later used for the analysis of how other members of the organization experience the change and how they see the role of the boundary object after the lockdown.

Boundary objects

In the researched topic, design mockups were used as the boundary objects between the author and other members of the organization. Boundary objects in a digital form were used throughout the study virtually, due to limitations that arose due to coronavirus lockdown. Design prototypes have been used to develop a better shared understanding of the problem, and find a solution to work around the problem. As a researched matter, boundary objects were a method for researching and the tool used by the team during the development phase of the product. Design prototypes have been used to understand how and compare what have changed when the organization suddenly becomes a fully remote company. The comparison of how boundary objects looked before and how they have changed their shape during the development phase will help answer the research question.

Workshops

To experiment with a new framework to improve the collaboration among different team members I have created multiple co-designing sessions together with other team members to design a framework that fits most of the participants. As this is a still ongoing process the final results are more an open end for discussion than a conclusion. The workshops focused on the virtual tools, use of them and what works best when it comes to communication between the individuals in the organization.

Desk Research

Global teams literature

The topic of global teams has gained significant interest from researchers in recent years. Researchers have been particularly interested in the management of a global virtual team, teamwork, communication, and how technology affects the organization using this setup. The pragmatic view of knowledge and boundaries (Carlile, 2002), using technology in practice (Orlikowski, 2000), and design prototypes as boundary objects in innovation process (Rhinow, Köppen & Meinel, 2012), are examples of research that contributes to the idea that knowledge is difficult to effectively manage in a global virtual team setting and that design prototypes can be a tool for sharing knowledge between different stakeholders. This paper aims to contribute to these studies, but from a different angle, to examine what happens to a role of a design prototype in a software development company, when an entire organization suddenly becomes a virtual global team, as a direct consequence of the Covid-19 pandemic in early 2020 and the mandatory work from home policies for most offices around the world. Previous researches mostly focus on organizations that have chosen to be remote or based on global virtual teams, in the case of the analysed organization and research question, the company had no choice but was forced to become an entirely virtual organization within one day. As the health and safety measures came from the local governments in a very short period of time this situation could not be foreseen or prepared for, even though the global and virtual teams had already been a part of many software developing companies.

Today, we know that transdisciplinary knowledge transfer is problematic in organizations, and that knowledge both enables and is a barrier to new product development and innovation (Carlile, 2002). Boundary objects are a proven approach to overcome these barriers, in this case design prototypes (Rhinow, Köppen & Meinel, 2012), that allow people from different backgrounds for interpretation of the data, due to their plasticity that is making them fit different contexts, yet enough immutable content to maintain knowledge integrity (Star & Griesemer, 1989). We also know that virtual communication and use of technology in practice has its limits, and that the technology itself cannot influence the efficiency, but rather how this technology is used by the organization's members (Orlikowski, 2000). The software development sector in particular is both heavily influenced by technology in practice, but on the other hand, develops tools for others and influences other organization's workflows and innovation processes. As technology is the embodying structure, built in by designers and then used by the users in an unpredictable way (Orlikowski, 2000). Based on previous research papers I consider the design prototypes with a premise that they are used as boundary objects in the software development industry, to allow innovation and cooperation between different teams, stakeholders, and clients. As described by Rhinow, Köppen & Meinel (2012), design prototypes are tools to open up a dialogue between different teams and stakeholders, but are a very limited representation of the design idea and often require explanation from the designers for better understanding. The lack of agency, and sometimes

possibility to communicate the design idea, therefore changing the way the design prototypes look, is what will be analysed in this paper, to contribute to the existing studies.

Limits of the boundary objects

Globally dispersed teams have become a norm in the XXI st century, as more and more businesses grew globally and required a *'around the clock*' service. This has also interested researchers, on what effect the geographical dispersion has on the effectiveness of the team and how virtual tools affect the collaboration among team members. Sapsed and Salter (2016) for example argue that teams without a regular face-to-face interaction tend to have less healthy relations, people often neglect the virtual tools for cooperation, and that the problem avoiding leads to the phenomena of '*Balkanization*' within an organization. The last observation, the Balkanization, meaning that there is fragmentation of the organization into smaller groups of individuals, in their observations in different locations, lead to miscommunication and overall drop of efficiency. Authors also observe the '*Local breakaway Behaviour*' where in their case, people who were present at one site and had the possibility to have face-to-face meetings often agreed on a group response during a conference call, neglecting their remote colleagues, excluding them from the discussion. This has led to the dominance of localized practice over the agreements made globally, making local informal decisions more important. Sapsed and Salter (2016) also stress the dynamics of the decision making process, due to different time zones in their analysed case study, whereas teams who have just begun the working day tend to make decisions after the meeting, when the other team members are already gone home. Boundary objects analysed by Sapsed and Salter (2016) meet their limits, due to the marginal nature of the concept. As the boundary objects are located at the boundaries between different teams, they can be more central for some teams than to other members of the organization. In their case study of '*The Tracker*' program boundary objects were used to enforce control over the geographically dispersed team members, thus the idea was to stop all informal decisions to take place. The boundary objects were avoided and not accepted by the dispersed team, they were not reviewed and often put aside as they were received as tension and instructions from the others.

Technology in organizations

Wanda Orlikowski in her study "Using technology and constituting structures: a practice lens for studying technology in organizations" develops a practice lense to understand and examine how people's interaction with technology influences the structures and where is the place for that technology. Orlikowski puts importance on the differences between the technology and the use of technology, as the technology itself cannot influence the performance of the users, only the use of it can. The study claims that the technology-in-practice, or structures of technology use are not fixed, but are situated in the given context in particular circumstances. Drawing on this research, this paper will aim to identify the changes in technology-in-practice as organizations change their structure to a fully remote one, when technology plays the key and sole agent in transferring knowledge between members of an organization. The practice lens will be used to understand and analyse how team members communicate, collaborate and are supervised through a prism of used technology.

Leadership for global virtual teams

In a study "Leadership for Global Virtual Teams: Facilitating Teamwork Process" conducted by Dorothy R. Carter, Peter W. Seely, Joe Dagosta, Leslie A. DeChurch, and Stephen J. Zaccaro the leadership and management of the global virtual teams is taken under review. This study claims that leaders in such teams shift their role from classic managerial and controlling into *'orchestrators of collaborative interactions'* meaning that their job is to organize the interactions in such a way that allows to get the job done. The study introduces the idea of four development keys to the team's effectiveness in the online contexts that include: *team emergent states, team phases, teamwork process and team-lead functions* (Carter et Al. 2015). *Team emergent states* are the characteristics of the team that are effective, cognitive or motivational and are visible over the time in a teamwork project. These states are often used to predict the team's future outcomes. *Team phases* are the efficiency episodes, in example when there's a transition or an action required. *Team processes* are the actions made during the team phases that cause emergent states. Last but not least *team leadership functions* are what controls the right mix of emergent states and processes in the right time across the phases of efficiency. Carter et Al. created a roadmap for global virtual team leaders, on how to influence and shape interactions and between team members.

Design prototypes as boundary objects in innovation process

The research of Rhinow, Köppen and Meinel focuses on how design prototypes are a medium for communication in organizations that are responsible for the development of innovation. This study indicated that the design prototypes or regular prototypes may in the best case become boundary objects, that will transfer knowledge between different teams, management, and external stakeholders. 'Objects' refer in this case to the design mockups used by the designers, but may also be traced in different sectors as data sets, blueprints, tools, created, measured and manipulated by the individuals (Carlile, 2002). Prototypes as boundary objects impact the understanding of the design ideas, and play an important role in successful social interactions between the design team and the rest of the organization. In their plasticity boundary objects have the ability to adapt to local needs, whether it's sales, development or the management, as the same design prototype can answer the needs of all of these teams in the organization, yet be explicit and easy to understand to maintain a common understanding across the organization.

Rhinow, Köppen and Meinel recognize in their study three main reasons for prototypes that are (1) manifestation for user feedback, (2) a tool for improving team's experience and (3) a force to focus thinking in the design phase (Rhinow, Köppen & Meinel, 2012). Design prototypes foster interaction in the user-centered design between the organization and the stakeholders as well as internally within organizations, allowing for more inclusive brainstorming and development of innovative ideas. They do not need to be in-depth but rather fast simple designs that will bring quick feedback, whether the design idea will work, or will need reframing. Researchers underline that prototypes are not a result of the process but rather an evolving visualisation and representation of the idea, that can

impact the teams with tangible proof that the concept will be well received. A shared effort in shaping the idea can build a team identity and allow for common education in the problem topic. Development of the prototype with time can either bring the team together or further raise discussion topics and conflicts, as they converge thinking over time.

The authors emphasize that the design prototypes not only influence the product, but the entire organizational structure that works around them, and that they are capable of deconstructing organizational flows and structures along the innovation process. Michael Schrage in his paper *'Bringing Design to Software'* (2006), describes design prototypes as "*medium for interdepartmental integration*" as the prototypes are being often used by many different teams, who get feedback on their own from different sources and influence the '*Who, what, when'* of the project (Schrage, 2006), therefore impacting the overall project flow. The study underlines that not all prototypes get to the point of becoming boundary objects, which may slow down the innovation process, as the designs require more explanation and may confuse different stakeholders, rather than bring everyone on the same page. Ill informed top management and executives may reject good ideas, as they "*may find it difficult to see beyond prototype roughness to the ultimate product*" (Rhinow, Köppen & Meinel, 2012), therefore knowledge management, in this case decisions regarding sharing the prototype is a highly demanding task.

Structured dialogue becomes a key ingredient when working with design prototypes and knowledge transferring, as every team within and outside of the organization has a limited knowledge, based and embedded in their own specialization, that changes a perception of the boundary object. As also described by Carlie and Nonaka, knowledge is implicit and hard to transfer as both interlocutors do not know what the other does not know, and often are unaware of what oneself does not know (Nonaka, 1997), and that the knowledge is localized, embedded and invested in ones function, therefore knowledge transfer across multi-disciplinary team members will create boundaries that may cause miscommunication (Carlie, 2002). Management may use in this case a prototype as the enabler of the dialogue between the organization and the stakeholders, yet must remember that it's only a limited representation of the concept and therefore often needs explanation when presenting it to potential clients, sales or other members of the organization involved in the project. The authors emphasize that there is a need for a space and time to share boundary objects, and moreover show the path it went through, to show the formation of the final idea.

In the 'global team' setting it's important that prototypes become boundary objects, as communication is already more difficult and complicated, thus having a clear understanding of the developing product is crucial to deliver a successful product.

Descriptive Empirical Material

To give a better perspective and background on the structure of the organization I will quickly introduce relevant vocabulary and definitions that will be used throughout the research. In software development, organisations are usually divided into three (bigger organizations to more respectively) main departments, 1. Product Development, 2. Sales and Marketing, 3. Administration.

First group is responsible for the development of the product, from the design, information architecture to deployment and maintenance of the software. This group is further divided into three subdivisions: Product Design, Front-End Developers (responsible for code on the user's side - in the browser / on the device) and Back-End Developers (responsible for code on the server side - inaccessible for users). As this study is developed by a product designer, this research will be described from within this group. This group shapes the product, with the influence from all the other departments. The development teams in case of analysed organization work in 'sprints', also visible in other information technology companies around the world. A sprint is a two week planning method for organizing tasks and goals in a digestible way in the project management software. New features and updates in case of the analysed organization come every third sprint in a release.

Second group is the sales and marketing department responsible for sales and distribution of the product, in this case software, oriented on meeting the sales targets and 'getting the numbers right' every month. Sales and marketing is usually also the first department to talk to customers and identify potential improvements required by the clients.

Third group is the management of the entire organization, working on bigger picture, strategizing and developing a business plan for the entire organization. This group has the final call in any actions made by other members of the organization and consists of project managers, directors and the managing board. Admins set priorities and create the workflow for other departments to meet the demands of the clients and follow the product roadmap, a plan of what functionalities / function the product needs in a specific timeframe.

Knowing that I would like to present some descriptive material collected during the ethnographic study, that represents the researched problem within the organization. The following material is the '*business as usual*' scenario from the beginning of the study that presents the design process of a new functionality. All dialogs have been observed from the *participant observer* position, therefore the researcher had influence on the course of action (Flick, 2009). The organization and its members prefered to remain anonymous, therefore members' names have been changed to respect their privacy.

This research has been based on a 6 month long case study in one of the software developing companies. The study is written from a first hand perspective of a team member, working as a product designer, responsible for delivering design prototypes and cooperation between different members of the organization. The analysed company develops a commercial software for stock keeping, helping other companies to keep track of their assortiment. The product of the company is a very complex system, developed by hundreds of people across four continents. The company has multiple offices across many countries,

therefore has implemented a '*global team*' approach, having multiple people in different countries working over the same project virtually, and smaller teams in each office working on smaller tasks that support the development of the project.

Design prototypes are used on a daily basis by product designers, developers and other teams as a tool for collaboration between different departments, but focus mostly on supporting developers in creating and developing the software. Design prototypes are utilized in many forms, as initial hand sketches, low fidelity computer drawings and high fidelity mockups that are '*ready for development*' meaning that they are in their final shape and the developers can start their work based on these drawings. These prototypes, also referred to later on as design mockups, assist the development phase throughout its entirety, and are developed together with the shaping of the design idea for the functionality. On their own design prototypes are never finished and can be changed in any phase of the development to adjust to the situation where they are used, therefore are a popular choice due to their plasticity for transferring knowledge. Following conversations and events are examples of use of design prototypes in the software development and innovation process. Described interactions occurred between the product design team, development team, sales and the managing board, as examples of difficulties met during the first weeks and after a few months of mandatory work from home policy.

The team has received a task to develop a new functionality for the software that will enhance the users possibilities and broaden the product's capabilities. As a product designer I have been asked to work together with the development and sales team on a brainstorming session to analyse the problem and come up with some ideas of how to solve it. The development team analyzes the technical limitations, while sales, who is the frontline talking to the customers, analyze the customers needs and requests. These sessions allow for creation of the MVP (MInimal Value Product) which is the first fully working and most basic iteration in software development that is released to clients. After a brainstorming session I have been asked by a project manager to visualise the initial idea in a form of simple sketches "draw what we have discussed, it's easier to discuss it over a visual" he said, before presenting the idea to the management board for further decisions. At the same time I have received a request from the sales manager to design an "idealised version of the idea" so they can present it to potential new clients and stakeholders as a sign of future functionalities and test out if that's what they need to solve their problems. Both prototypes have been developed for a different reason and separately, therefore were not entirely alike, as they were to fit their purpose better.

Design prototypes in the early stage of development play a role of visualisation of the idea, very simplistic and often hand drawn, that allow for further brainstorming and dialogue between different teams who can now see approximately how the functionality will work in the end. As for some, mostly non-designers it is hard to imagine how the product will look, and also developers tend to spot potential troubles quicker when looking at an approximate shape of the functionality. Developers know what layouts, patterns or components can influence for example the performance of the application or complexity level, from their experience when working with previous projects, and they are the ones who understand how the application is coded and what technical limits are there to impede development. This input allows for quick adjustments even when working with a very basic and low-fidelity

design mockup. Sales and Project Managers (PMs) also can use these simple drawings to evaluate in the early stage of what is needed from their side, and agree on the functionality that will be shown by the sales in the early stages of development to the clients.

Early in the development process one of the development teams has signalled a small potential thread, with the current idea, that could theoretically lead to a major problem in the future. The team has gathered with other members of the organization to explain in depth why this is a thread and how this can potentially influence the future of the functionality, but required additional two weeks of preparation to work around it. With the tight timeframe and limited resources, the project managers decided to neglect this small issue, for now and plan a fix for the future “We cannot waste our time on all small issues found on the way, we will have 1 sprint dedicated for fixes afterwards”. But the backend team persuaded the idea, as the fix of this issue required a different information architecture from the beginning of the project. During a meeting together with the project manager, product designer and front end team, the idea has been explained in greater detail, and drawn on a printed version of the mockup, to visualise changes needed in the interface to accommodate the fix. Negotiations between the teams have led to a solution that was suitable for both developer teams, management and the designer, but required a change of scope of the MVP, as some features had to be left out, in order to meet the deadline. The decision of changed scope did not fit the sales department, as this meant getting rid of the Artificial Intelligence (AI) features, which “is now popular and sells great” in their opinion.

Design prototypes have been used throughout the entire development phase, and were developed by all team members to some extent. Currently they have been used for three specific functions: 1. A tool for developers to preview and collaborate on the project, 2. Marketing tool to attract new clients with future features and 3. As a leaver to convince the managing board for the particular idea. Each function required a tweaked version of the design to fit the needs of the user group. Detailed step by step designs for the developers, idealised and content full chosen parts for the sales, and generalised drawings of different ideas with key features of each highlighted for the managing board to choose the one that fits their needs.

The word “Change” has often caused disagreements and insecurity of other teams, that depend on the team that needs to implement the change. Oftenly though, changes were not as drastic as one would have thought, and layed out on an updated design prototype have helped other teams understand what will be actually changed. As other teams depend on each other, they need to know how this change will affect their work, but due to often meetings and close collaboration this could have been solved quickly, causing little to no disruption in the projected time frame.

So, what is a design prototype?

Understanding knowledge as localized, embedded and invested in human practice, I have conducted a series of unstructured interviews among members of different departments, asking them that exact question: “What is a design prototype to you?”. Below I summarize the objects and ends required by each team, that by the close collaboration become an integral part of the design prototype:

Development Team	
Objects	**Function**
Components: building blocks of the software	Specification for the elements used to build applications
Measurements: detailed information on location of the components	Specification for the development of the functionality
Interactions: animations and behaviour of the application	Have an overview of motion in application
Design: colors, fonts, icons	Making sure the application looks the same across different pages
Management	
Schedule: how much time it will take for the developers to develop these designs	Estimate the workload and cost of the development of the functionality
Simplified overview of functionality	Something to present to the managing board, for approval
Sales & Marketing	
New features highlighted	What “sells well now”, features must be in demand.
Minimum value for the customer	Product has to meet the requirements of the clients.

Considering all of the above mentioned objects that need to be a part of the design prototype, it is visible that across-disciplinary collaboration is necessary in the software development process in order to meet the goal and develop a profitable application. This example also shows that knowledge within practices shouldn’t be entirely localized, embedded and invested (Carlile, 2002), as missing influence from other teams may lead to developing a useless feature. In example, sales could interest more clients claiming that we support all of the “well selling” features, yet it could be impossible for the development team to develop it within the organization in a given time frame.

Analytical Theory

Pragmatic view of knowledge and boundary objects will be used as the main theoretical perspective in this research. This theoretical approach will help understanding differences that have shaped the way boundary objects evolve during the structural change of the organization, from the knowledge transfer perspective. Understanding the knowledge boundaries through the understanding of a pragmatic view of knowledge will be used to identify them, and search for a framework that can work around these boundaries in the fully remote and virtual environment. In this paper understanding design prototypes used in software development as boundary objects that are shared among different teams for collaboration is taken. Differences of how the teams collaborate based on these boundary objects before and during the pandemic is analysed for comparison.

Boundary objects

Developed by Susan L. Star and James R. Griesemer, the concept of boundary objects was created based on the development of the Berkeley Museum of Vertebrate Zoology, and cooperation of various social groups that have worked on that project. The researchers define boundary objects as information, in their research in a form of specimen, maps and field notes, that is used in different ways by different social groups (Star & Griesemer, 1989). They describe boundary objects as plastic, adaptable to different group's needs and use cases, yet robust enough to stay coherent among different groups. Boundary objects have the capacity to support collaboration between practitioners from different social worlds as artifacts that allow knowledge transfer across the boundaries (Carlile, 2002; Star & Griesemer, 1989; Nicolini, Menegis & Swan, 2012). Star and Griesemer underline the importance of boundary objects and methods standardisation in the development of the Berkeley Museum of Vertebrate Zoology, as individuals from various social worlds collaborated on a shared task for different reasons, therefore the collected information may vary in quality, shape and function, and will be used by different groups of people. In case of the museum an integrity and coherence of different information is achieved by a managerial system providing guidelines for collection and preservation of specimens, field notes etc. The structure of the boundary objects is vague in common use, but becomes highly-structured in an individual use, in particular cases. In the researched problem, boundary objects are developed by designers and non-designers at first and become developed by a single party at the end, the influence of the single party designed boundary objects for collaboration is analysed.

Star and Griesemer (1989) distinguish four types of boundary objects, later also used by Carlile (2002): (1) repositories - reference points of data, measures and labels that provide a shared definitions and values for problem solving; (2) standardized forms and methods - a shared format in a mutually understood form and terms to define and categorize potential problems in different practices or social worlds; (3) objects or models; and (4) maps of boundaries. As boundaries are not always visible and not all dependencies are known, upfront boundary objects also help identify these dependencies to locate where the

boundaries may occur (Carlile, 2002). In Carlile's research only the third and the fourth boundary object types combined can create an effective tool for knowledge transfer, as then they help individuals learn about the differences between their fields (Carlile, 2002; Kelllogg et Al., 2006). Other researches questioning the effectiveness of the boundary objects also add other requirements for the boundary object to become an effective one, such as engagement with critical elements of the practice context, such as prototypes or designs (Bechky, 2003). Other researchers, such as Sapsed and Salter (2016), analyse the limits of the boundary objects and conclude that virtual tools serving as boundary objects may not become as effective as face-to-face interactions in integrating different perspectives.

Pragmatic view of knowledge and boundaries

Important, in the understanding of why design prototypes as boundary objects play such a crucial role in the innovation development and knowledge transfer is the notion of knowledge boundaries, why do they exist and how to work around them. Paul R. Carlile in his study "A pragmatic view of knowledge and boundaries: Boundary objects in new product development" creates an ethnographic study which takes a critical look upon the knowledge transfer and collaboration between different teams within organizations. Author describes knowledge as Localized, Embedded and Invested in practice (Carlile, 2002), meaning that knowledge is centralised within a specific function that one performs in the organization. Carlile draws conclusion upon an example of miscommunication between the sales, engineering and design teams, as their perception of the goal, educational background and synthaxes differ.

Localism of knowledge comes from the need of team members to be specialised in their practice, and be able to solve problems particular to their specific function. Knowledge not necessarily needs to be only localized within one situation or location, but can be used similarly across different practices that are focused on a similar set of problems (Carlile, 2002). Knowledge is also embedded in practice, meaning it is hard to recall as it has been collected through experience and engagement within specific functions. As well as in experiences, knowledge can be also embedded in the tools and methodologies used by individuals in a given practice. The fact that knowledge is embedded within a practice is also one of the reasons why individuals may be able to say less than they actually know, and why knowledge is harder to transfer the further apart practices are. Last but not least, knowledge is invested in practice, achievements, methods and how things are done within a given practice. People tend to invest their knowledge into solutions that helped them achieve the goal and will reuse that knowledge to solve future problems. Because of that, people less likely will change their knowledge, as this requires a new learning process and a stage of how do I use this knowledge to solve a task, without previous experiences and previous outcomes. Invested knowledge in one practice is also hard to be implemented in another group's practice, even if it is dependent on it. These three characteristics of knowledge are crucial for team members to be able to perform their tasks, but create boundaries between different divisions and departments making the cross-disciplinary knowledge transfer problematic. This paper will be based on these assumptions that knowledge is localized, embedded and invested, to answer the problems met by different members of the described

organization when working remotely during the pandemic. Tacit nature of knowledge as hard to transfer and implicit will be used in the analysis as a starting point.

Carlile emphasizes that not all objects become boundary objects, and if used in a wrong setting may even become a roadblock instead. A good boundary object needs to be adjusted to fit different settings, and one boundary object may not fit to another one. Boundary objects should be able to establish a shared syntax between two parties, to represent their knowledge. For a boundary object to be effective, it needs to represent what both parties need from it, whether it's a representation for the sales department or a mockup for developers, yet using the same shared language, understandable for both sides. Shared language, might refer to technical terms, industry specific terminology or any words to search and store knowledge. Syntax needs adjusting depending on the two parties that share the object between them, otherwise it will hurt more that it can help (Carlile 2002). Effective boundary objects also provide means to learn about the dependencies between different practices, providing concrete and specific concerns and findings.

In product development the role of the boundary object as described by Carlile is being a tool used to overcome boundaries, by allowing representation of the knowledge and teaching dependencies and differences to transform the knowledge into something useful for both sides across the boundary. The role of the boundary object is twofold, both practical and political, as it establishes a shared language among different stakeholders, and opens a process of transforming what we know now to produce more knowledge where the boundary occurs. Pragmatic view of knowledge acknowledges that the localized, embedded and invested knowledge is difficult to transfer, and that cooperation between different individuals has negative consequences when working across a boundary.

Analysis

The ineffective boundary objects

With the new health and safety restrictions and work-from-home policy, all communication and collaboration has been moved to a virtual space in the organization. Before rich in fact-to-fact meetings brainstorming and prototyping sessions have now turned into a group video call of involved stakeholders. The productive face-to-face sessions could not be maintained at all, with no time to prepare for such a change. The design prototypes have moved from a pen and paper to a prototyping tool to show the initial idea and functionality in the early stage of development. Before the team has started a project in the office and delivered it till the end working as a virtual team successfully, using the same techniques as in pre-lockdown state. This could have influenced the approach towards the development of an entirely new feature, where the early stage is entirely virtual. Used as boundary objects, design prototypes were used in this setting as well, yet the development of them have changed. As the drawing tools did not prove to be enough to create a sketch live, the team has divided the brainstorming into a session of meetings, to give time to the designer to create the design prototypes in between, due to the time it takes to develop them and the CPU intensivity of the video conferencing tool making designing software unbearably slow. On the following meetings the design would be updated, to fit the scope of the task better. With more and more work, this approach on the other hand required a group of around eight people to gather on one video call, and scheduling them has quickly become a very hard task due to the amount of other meetings in other team member's schedules. The team has decided that the meetings could be held as long as crucial four team members, the designer, front-end team lead, back-end team lead and a project manager, were in place to move forward with the task. This has caused the absence of some members of the team from time to time during the decision making process. These members had access to the design prototype at all times, therefore they could track the changes in a free time to catch up with the others. Another problem initialized by this approach was the time it took to brainstorm the idea, as the breaks between the meetings sometimes were a subject of change. In the face-to-face scenario, this process usually took about a full working day, and consisted of a very dynamic discussion, negotiations and arguments between team members, often even emotional. With the fragmentation of the discussion this process became less dynamic, and did not allow for participation of other users in creating the prototype, as only the designer was working on the prototype unlike before, where different people joined sketching on the whiteboard or the sketch. This has caused less participation from the team members that have usually been very active during the brainstorming phase, such as the sales manager who have previously taken interest in the way the product presents to the clients. Absence of some members also has created a need for documenting and creating a space where decisions and ideas could have been stored and reviewed by absence team members. With time though every meeting required such a documentation, what has caused people to neglect documenting or do it sloppy. On the other hand the amount of reading material has also swelled, and people tend to only skim through the

documentation prior the meetings. Or only answering “looks good to me” without spending time on it.

As the new project went on it quickly and noticeably slowed down, as many bugs and problems were created during the early development phase, that were not accounted for. One of the examples is the difference of understanding a topic of languages in the new feature between the back-end and front-end team leaders. The teams have agreed upon a solution during the brainstorming phase, that consisted of multiple translations available for product information, and the idea has been visualised on the available design prototype, yet approaches to this topic differed. When the teams tried later on joining the code, it simply didn’t work as designed, due to miscommunication between the teams. As the visual artefacts have worked before as the boundary objects, the lack of face-to-face meetings made them less potent (also observed by Sapsed and Salter, 2016), due to limited interest in reviewing them and contributing to their evolution from different team members. The lack of face-to-face confrontation has left aside the “no, no, you got it wrong, that’s not what i meant” situations between the team members, as they were no longer able to just stand up and explain their point of view not only verbally but also non-verbally f.ex. by drawing or gesticulating. As during the meetings only one person was presenting and sharing the screen, usually the designer, the rest of the team members had to argue by speech only, as the prototyping tool did not allow for collaboration of many people in one file. Another problem that has arised from the lack of face-to-face communication was the listeners' attention. With many meetings and projects ongoing people tend to answer other team members in a chat room during the video calls, and when asked something othen the response was “sorry, what? Can you repeat it? I was responding to someone on an urgent matter”. This absence of attention on the virtual meetings was also caused by the fact that we don’t always know what the other person is actually doing during the meeting, as we cannot have everyone's screen shared during the meeting. During the first months of the pandemic people often spent more than 6 hours a day on video conferences of an 8 hour work day, leading to the lack of concentration and working on two things at a time on the meetings where they felt their voice is not as important, because the topic is not exactly connected to their tasks. As the boundary objects were located at the boundaries, they were not always exactly in the middle of the teams, in this case the design prototypes were closer to the design and front-end teams, and a bit further for all the others. This has led to neglecting revision of these prototypes by other members, forgetting that their ‘shelf-life’ is short and that they constantly evolve, causing f.ex. the backend team to accidentally use old and not updated prototypes in their planning and development. As one of the teamleads noticed: “The amount of updates and versions grew quickly, we were unsure which one is the right one afterall, as most of them were almost identical at the first glance”.

This lack of control and participation of the different team members has led to missing where the dependencies are, and some decisions that were made often impacted the teams but they did not realise that until starting to work on it. The lack of regular face-to-face meetings, where every participant is focused and active has caused the boundary object to be less updated, even though it’s shelf life time did not extend, only some information was not included as there was no participation from some team members. The frequency of the meetings and brainstorming sessions has also impeded the negotiations, as

all changes required also update of all of the documentation and design prototype. Negotiations have lost their pressure, as the discussed issues were spread over weeks and people started forgetting what points were already discussed and what is new, as one of the project managers mentioned: “It takes us weeks before we can move on with fixing issues, our board takes a lot of time to vote if we can proceed or not and as soon as we get an answer there are new more urgent issues”. As gathering the board of directors together was a very hard task in between the numerous meetings, the board that was the only decision maker in the more important issues, had bi-weekly meetings where they discussed multiple topics and gave a go or no go decision. Decisions were made based on the design prototypes, but with no one who actually built them present at the meeting to explain or defend the design idea behind the prototype. The board did not look at the technical documentation attached to the design prototype.

As the design prototypes were developed and discussed over with the team leads and managers, people who have actually used them did not know anything about them until they picked them up and started working with them. This approach has maybe reduced the number of people in the conference calls, but has caused the design prototype to be a standalone guideline for the developer, who received it sometimes with no explanation. This has caused the developers to ask many questions that have been already discussed over the brainstorming sessions, therefore the design prototype started to come with additional documentation written by the corresponding team leader and comments added by the designer to the prototype during the video conference. This has moved the importance of the prototype aside, as the technical documentation was now a crucial part of it, that was not needed when developers were part of the start-up meetings. Product designers in this example become also the source of the information, as most questions were aimed at the design team who has prepared the prototypes. This has caused many meetings to emerge between the designer and individual developers, where the designer walked through the developer through the designs step by step, making sure that they were on the same page. Whereas in the brainstorming sessions people tend to lose their focus, in these 1-on-1 meetings developers were actively participating in the walkthrough, and have sometimes spotted mistakes that were omitted during the brainstorming sessions. Concerns of the developers that had to be verified had to be approved by the project manager and others, therefore have been a subject on one of the design syncs. The syncs after the brainstorming sessions took a weekly format, therefore all topics collected during the week were discussed in bulk. Before the meeting concerns and possible workarounds were prepared on the design prototype to visualise and explain to the others what has to be changed and how this will influence the overall functionality. If not documented properly some ideas have been lost in this process over the course of the project.

Seeing this I have noticed that the design prototype as a boundary object in the entirely virtual setting has stopped playing it’s previous function, as now it was a subject of discussion prepared by one person individually and adjusted later on. This asynchronous collaboration over the prototype has led to some team members neglecting it, and working from their own documentation, whereas the prototype though thought to be the single source of truth was the current version of the design idea. Missing input from other members who were not as active as before in the development phase caused the inter dependencies to

fade, and often these dependencies were found very late in the process causing a stop in progress and sometimes even led to scraping some parts of work. This way the design prototypes have lost their effectiveness in the Carliles (2002) understanding, as they did not work anymore as boundary mapping tools. The design prototype has moved from the center of attention of all of the teams, and has moved closer towards the teams that use it closely for the development of the software. As the outcome the development process became very unstructured and the dependencies were indistinct, causing the project to extend from planned 6 weeks to over 4 months and still counting. Miscommunication and different understanding of the design prototype has caused crucial information to be lost in the process, and the outcomes of the work were sometimes unpredictable and surprising to some members.

Discussion

As the research sought to answer the research question of how the design prototypes change when the organization moves to the entirely virtual reality, the analysis uncovered problems areas around the design prototypes that caused them to not work properly anymore as boundary objects.

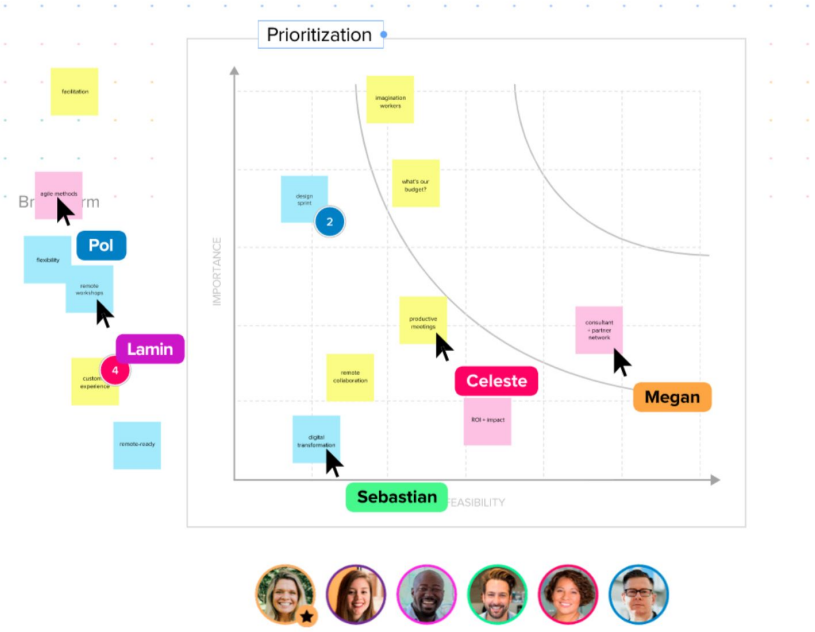
How could the boundary objects be effective again?

Seeing that the design prototypes as boundary objects have shifted from the center of attention the the side track, I have been cooperating closely with the team to create a ‘space’ where we could brainstorm and collaborate together from homes, and develop the design prototype a bit more like it was before, with the influence of more people who are involved in the development process. Since the lack or face-to-face communication seemed to be the most important factor that was lacking in this setting, as all the other tools and frameworks remained unchanged in the beginning, the new workflow had to include and motivate more people to take active part in collaboration and creation of the boundary object to move it more into the center of the boundary.

Substituting Face-to-face communication

As the design prototype has been solely developed by the product designer it was missing the non-verbal influence of the others non-designers that was previously achieved by them co-designing the low fidelity model in the beginning of the brainstorming phase. To motivate the entire team some tests have been made in order to see the influence of different virtual tools, as the face-to-face is not and will not be an option for at least a couple more months. So how to substitute face-to-face communication as well as it is possible? The missing ingredients from the face-to-face communication in the new product development phase were the focus of the participant and non-verbal aspects of it such as social bonding, emotions and competitiveness (Storper & Venablec, 2003; Sapsed & Salter, 2016). Therefore a workshop has been established to create a new framework for virtual teams, that will spark productivity especially in the early stages of development and brainstorming. Since the influence of curtain people was mostly found in the early stages of the development, that’s the first area of interest to propose a new space for development. With

the recent growth of multiple virtual prototyping tools such as Sketch, Abstract, Adobe XD and InVision, there has also been an emergence of virtual whiteboards such as Miro, InVision Freehand or MURAL. These tools were developed in a way to allow users for unlimited possibilities, therefore the way they are used is up to the organization themselves. Since in absence of face-to-face communication and the involvement of the users has been an issue, these tools will be investigated in order to support as much as possible of the collaboration. To test the potential of a new tool the team has launched a workshop that aimed to evaluate if the digital whiteboard will help centralising the design prototype once again. To start off the team has set up a virtual whiteboard before starting a new project. During the brainstorming session different team members were invited to co-create the idealization of the new feature to make sure that everybody will be happy with the result of the developed project. Representations of all teams have joined the experiment to find a better workflow for communication over the prototypes. The use of these tools aims to maximize the room for interpretation of the design prototype, so that people from different practices can evaluate it and use it in their context too. On the other hand tools are not the only thing to consider when creating a new workflow for the 'suddenly remote' organization. As said by Don Price, head of R&D at Atlassian (company developing project management tools) "If you don't understand how you want to work with someone, no tool will solve that". This quote also supports the fact that the practice is more important than the technology itself as it was described by Orlikowski (2000). In the fully digital environment we must find a way to deliver the same outcomes from these meetings as before, therefore the whole process requires rethinking and a new approach needs to be in place. In example:



MURAL brainstorming and prototyping tool Source: MURAL.co

Traditional method	Objective	Virtual alternative	Hoped outcome
Brainstorming with whiteboard and sticky notes.	Get as many ideas from different team members as possible	Virtual whiteboard tool (f.ex. Mural)	Bringing discussion and ideas between every member of the team
Sketching live low-fidelity prototype	Get the initial simplistic visual on the functionality	Freehand drawing tool (f.ex. InVision Freehand)	Allowing not only designers but more people to join the early stage designing to express their needs

These processes and methods have been great for co-located teams, and have served the purpose, but on the other hand their virtual alternatives do also come with advantages. Imagine working on a whiteboard in a brainstorming session, if one of the members is missing, documenting and transcribing all of the work is time consuming and often will lack a lot of information as well. With virtual tools we have the overview of the process and we can track it step by step, record video and audio, therefore the absent members may join the discussion after all.

To test out different frameworks and workflows the team has taken off with another project at the end of the study, therefore the results will not be presented here but the approach. The team, seeing the problems, have set up a workflow where all of the prototyping and brainstorming will be made on one board with multiple tabs. Keeping everything in one place will allow for a clearer overview of available resources for all teams. Teams will collaborate in brainstorming sessions, divided into smaller groups yet all will do the same tasks under supervision of the designer and project manager. All groups are made out of team members from different departments, and will be testing different approaches to find what suits the organization best. The outcomes of this workshop will be presented on the Master Thesis Defence, following this research paper.

The new role of the designer

Is the new role of the designer supporting the design prototype as the boundary object? Or is it actually contributing to its inefficiency? As observed in the analysed organisation the role of the designer shifts towards managing the design prototype in a explanatory way. Designers in the new setting spend more time documenting the boundary objects and walking through the developers when developing the software. Previously collaboration constantly with other team members now develop design prototypes themselves often with no support from others for a while. As design prototypes are needed ahead of the brainstorming session a lot of information is lost, and teams seem to get locked on the idea on the prototype, as it is not a low fidelity sketch, but rather a high-fidelity mockup created for the same reason. Another problem with the development of the design prototype without participation of other members of the team is the localized, embedded and invested knowledge in the designers practice, as their expertise is guided by the user

experience of the functionality, but may not reflect other areas such as technical limitations or market trends. Due to design prototypes being developed by a single person, these values were harder to implement when others started collaborating on the later on, as for non-designers it is hard to imagine the design prototype that they cannot see, but what they see on the prepared design guides them and sometimes may mislead into the wrong direction. Therefore without change of the workflow and the way the prototypes are developed in the early stages of the projects, the new designers role may compromise the outcomes by directing other teams into wrong directions and potentially cause a slippage in time it takes to develop a new functionality.

Conclusion

The thesis aimed to discover and analyse how the design prototypes as boundary objects have changed when an entire organization turns into a geographically dispersed team. Based on that the aim was to design a space for development and co-creation of these prototypes among different team members virtually.

Following the results of the analysis and discussion, the designer's role in the new entirely virtual setting has become more inseparable from the creation of the design prototype. The designers were now developing all of the prototypes themselves basing on conference calls made with other members of the team. As a source of truth, schedules of the designers become heavily packed with meetings with the developers, sales and management as the prototype could not support itself on its own. Designers have to now also document more information in order to answer more questions from other members of the team and help move the project forward.

Following the role of the designers, the design prototypes became heavily packed with additional information, such as comments and notes, as they were no more updated as often and had to be informative enough that people not involved in prototyping could get the idea of what is there to be done. The product prototypes have moved from the center of attention and further away from the boundary towards the teams that were more dependent on them, which caused many misunderstandings and problems in implementation in the later phases. Different teams were not able to contribute as actively in the development of the prototypes therefore they lost motivation and were not as influential as before, empiding finding the dependencies among different teams.

As the analysis has shown, the missing ingredient of the prototyping phase was the face-to-face communication, as people were not able to transfer as much knowledge anymore through the virtual mediums. To substitute the face-to-face communication multiple tests have been performed such as virtual whiteboards, yet the outcomes are not yet reliable to be conclusive. Improving the workflow of the early stages of the design prototype may heavily influence the later outcomes and the lack of collaboration can lead to failure of the project.

To sum up, when an entire organization goes online, as it was in the analysed organization's case during the COVID 19 pandemic, the design prototypes lose their integrity and without the face-to-face communication cannot function as effective boundary objects. When developed by just a few, and not all team members are as active as they were before, the prototypes lose their flexibility to fit different contexts, as missing input will create shortcomings in the later stages. Interdependence of different teams cannot be established as effectively as it was before through the virtual medium when the prototype is developed by a single person and neglected by other stakeholders. Design prototypes as boundary objects in the virtual setting meet their limit, where they cannot be effective on their own anymore and require a different approach towards their development in the early stages of the project.

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