Exploring the Role of Artefacts to Coordinate Design Meetings

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Design artefacts are vital to communicate design outcomes, both in remote and co-located settings. However, it is unclear how artefacts are used to mediate interactions between designers and stakeholders of the design process. The purpose of this paper is exploring how professional design teams use artefacts to guide and capture discussions involving multidisciplinary stakeholders while they work in a co-located setting. An earlier draft of this paper was paper published in the Proceedings of the European Conference on Cognitive Ergonomics (ECCE 2017). This work adds substantial clarification of the methodology followed, further details and photographs of the case studies, and an extended discussion about our findings and their relevance for designing interactive systems. We report the observations of six design meetings in three different projects, involving professional design teams that follow a user-centered design approach. Meetings with stakeholders are instrumental for design projects. However, design teams face the challenge of synthesizing large amounts of information, often in a limited time, and with minimal common ground between meeting attendees. We found that all the observed design meetings had a similar structure consisting of a series of particular phases, in which design activities were organized around artefacts. These artefacts were used as input to disseminate and gather feedback of previous design outcomes, or as output to collect and process a variety of perspectives. We discuss the challenges faced by design teams during design meetings, and propose three design directions for interactive systems to coordinate design meetings revolving around artefacts.

Interaction Science Key Words: design process; design artefacts; multidisciplinary teams; case study.

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1 INTRODUCTION

Design is a reflective conversation, where "doing and thinking are complementary" [33,34]: designers explore and transform ideas, appreciate the results of these transformations, and refine them in consequence. Design processes are seemingly disorderly and chaotic, and design problems are considered as "messy" [33], "ill-defined" [36], and "wicked" [31]. The reason for this is that design problems are by nature undefined and ambiguous [6]. The implication of ill-defined design problems is that there is not one, correct way to resolve them.

Maher et al. [25] describe that designers explore problems and solutions simultaneously, which means that they co-evolve in a gradual, iterative way. It is widely accepted that this co-evolution is a social process, as solutions emerge from an unconstrained, free flowing stream of ideas among the different actors [44]. According to Dorst [12], designers co-evolve problems and solutions by considering and connecting different points of view (or discourses). Exploring a variety of discourses stimulates creativity and innovation. Thus, the complexity and richness of design processes emerge from identifying, exploring, and prioritizing different points of view [41].

While the process of co-evolving problems and solutions is a source of creativity, its outcomes are hard to communicate. A source of miscommunications is the limited common ground between designers and stakeholders of the design process. As described by Clark & Brennan [2], common ground requires "mutual knowledge, beliefs, and assumptions", and is thus essential for communication and coordination. Miscommunications within design teams have a variety of causes, including the different disciplines involved, the specialized language used, and the dissimilar

priorities and preferences of the different actors [15]. However, for a design solution to be considered as such, it must be accepted by all relevant actors of the process [12]. Thus, designers must find ways to communicate not only what a design solution is about, but also why it is appropriate in the context of a given problem. In the scope of this research, we are interested in how designers use design artefacts to communicate the co-evolution of design problems and solutions with team members from different disciplines.

User-centered design (UCD) addresses ill-defined problems by involving multidisciplinary perspectives and by focusing on the needs of end-users, which is considered to promote usefulness and usability of the resulting systems [21]. However, UCD approaches are not without challenges or criticism. One of the critiques is that systems are designed "before use", implying that the characteristics of a system are defined before actual usage occurs [30]. The design-before-use critique is especially relevant when designing systems that connect a large number of heterogeneous users, with usage styles and contexts of use that designers cannot anticipate. Another critique is that the design output might not reflect on the most appropriate solution for a given problem, but one that was more readily accepted by the client or beneficiaries of the process [4,23]. Designers tend to be well-aware of these challenges, and tackle them as much as possible with different strategies. One such strategy is to organize *co-located design meetings* together with external stakeholders (e.g., clients, end-users, and project consortium) in key moments of the project.

Design meetings are collaboration points where designers engage in reflective activities together with stakeholders of the design process [11,28,40]. A property of these meetings is that they enable face-to-face interactions between the design team and stakeholders. During design meetings, critical decisions are made to advance the design process [10,43]. Although design meetings occur in a specific point in the process and occupy only a small fraction of the project, they are instrumental, even determinative, for the direction of designs [7]. Thus, analyzing design meetings helps us to understand the interplay between the people and resources present. In this paper, we report on six design meetings involving professional, multidisciplinary teams where the overarching topic was the early design of an interactive system. We analyze what kind of activities are organized in these meetings, who is involved, and what the similarities are among different teams and projects. We expand on previous literature by focusing on the structure of meetings from the perspective of designers. Furthermore, we focus on how design artefacts are used to guide the activities and discussions. We propose design directions for interactive systems to facilitate coordination of design meetings revolving around artefacts.

2 BACKGROUND

To contextualize the activities and people involved in design meetings, we explore the multidisciplinary aspect of design teams, and the role of artefacts and meetings in the design process.

2.1 Multidisciplinary Design Teams

Design is recognized as a social, collaborative process [44]. UCD projects tend to have a strong multidisciplinary aspects, as they involve a variety of people, disciplines, and perspectives. Stember [39] indicates that this multidisciplinary aspect "involves several disciplines who each provide different perspective on a problem or issue". Similarly, Jensenius [22] suggests that multidisciplinary teams involve people from different backgrounds who work together by bringing their specific knowledge to the team. Drawing upon this understanding, we use the concept of multidisciplinarity to refer to people who bring a different perspective and background to the design process.

In UCD, this multidisciplinary collaboration extends to *external stakeholders* of the design process [21], such as paying clients, domain experts, or end-users. External stakeholders have a

particular, well-defined role in the project, usually as paying customers, decision-makers, or recipients of the final product. These stakeholders could come from a variety of backgrounds, and their involvement could range from only informing to being key decision-makers in the process [9]. The role of design practitioners is creating (viable) interactive products, under tight deadlines and with limited resources, to satisfy specific client and user needs while dealing with organizational requirements. Therefore, communication and coordination with stakeholders is crucial for facilitating the best possible outcome from the design process. Designers and external stakeholders form what we call "multidisciplinary design teams," where each team member brings a unique perspective to the design problem. However, this inclusiveness also implies that people with different perspectives must strive towards achieving the same goal, which is designing a useful, usable system, which is ultimately *worthwhile* in its context of usage [3].

We contextualize this diversity of people involved in UCD processes with the notions proposed by Fischer et al. [16]. These authors make a distinction between "Communities of Practice" and "Communities of Interest" within design projects. Communities of Practice are groups of people who share similar domains, work, and knowledge. Thus, Communities of Practice have an existing *common ground* that can be used to communicate with ease. However, common ground can also become a limitation due to the potential lack of disruptive ideas. Communities of Interest, on the other hand, integrate people from different disciplines and perspectives. What brings together a Community of Interest – which can be formed by various Communities of Practice – is a shared interest in attaining a goal, such as solving a design problem. Given the implicit diversity within Communities of Interest, they are an ideal ground to stimulate creativity [16,44]. Despite its value, interweaving Communities of Practice brings about challenges for design. For instance, it is important to establish a common ground to facilitate collaboration [2]. Furthermore, while it is an objective of the Communities of Interest to "make all voices heard" in the process, it is not a straightforward task in large communities [16].

Fischer et al. [16] suggest the utility of boundary objects to foster collaboration among Communities of Interest due to their actionable and evolving nature. According to Star [38], boundary objects are "a sort of arrangement that allows different groups to work together without consensus." Thus, within Communities of Interest, boundary objects allow teams to synchronize their efforts in a shared arrangement. Within UCD, such boundary objects include both conceptual and tangible artefacts, such as end-user requirements and prototypes [16,43]. These artefacts contain flexible representations of ideas, and are useful to externalize different perspectives. Analyzing the process for "making and using" an artefact points to the connections between teams and other artefacts [23]. Thus, we explore design meetings as collaboration points between different Communities of Practice and Interest, where design artefacts act as boundary objects to solve design problems.

2.2 Role of Design Artefacts and Meetings

The work of designers is often to create artefacts that represent a design, which is then materialized by other team members [33]. Artefacts are "almost anything that provides a visual and spatial forum for design ideas" [45]. In this paper, we use a broad concept of artefacts, as suggested by the authors above, for referring to "almost anything" that serves to represent, articulate, and externalize ideas within the design process. Artefacts are used by design teams to ground communication, embody knowledge, boost creativity, and justify design decisions [33,45]. Nevertheless, artefacts provide only a partial representation of design work. According to Dorst & Cross [13], the turning points taken by design teams to co-evolve problem and solution spaces in an iterative way contain the most valuable information about the experiences gained during the design process.

In UCD processes, artefacts include storyboards, personas, prototypes, and workflows, among others. These artefacts are often shared, in part or as a whole, with clients, end-users, project managers, other designers, and software engineers. These artefacts serve as communication leverage to glue different perspectives (i.e., people stemming from different disciplines). Given their relevance in the process, design artefacts and the turning point that led to their creation are documented and disseminated to relevant stakeholders, in both formal and informal ways. Design practitioners face problems communicating their ideas to others, especially non-designers (e.g., clients or software developers), given a lack of common vocabulary or different priorities and interests [32]. Despite this challenge, designers constantly share ideas with others, and it is critical for them to negotiate their ideas effectively with people from different disciplines [5,18]. One way of communicating effectively with people from different disciplines is to organize co-located meetings. These meetings provide advantages such as providing a physical workspace for rapid feedback, nuanced communication, and contextualized, fluid participation [27].

We identify two types of meetings that can occur in the scope of UCD projects: *design meetings* and *evaluation design meetings.* Design meetings involve co-design activities, where different actors contribute with their own point of view and skills to achieve a common goal. According to D'Astous et al. [7], during evaluation design meetings designers externalize the outcomes of the design process, justify its rationale, and generate ideas to solve potential issues. Therefore, evaluation design meetings usually involve key stakeholders of the design process, such as clients and end-users, but are not traditionally associated with co-design activities.

In their seminal paper, Olson et al. [28] analyzed collaboration in early software design meetings. They found that design meetings have a defined structure, although they seem chaotic and informal. This structure is consistent across different teams and topics [28,42]. During the meetings, most of the time is spent in discussions about design issues. These discussions serve to generate and evaluate alternative ideas. Other recurrent activities involve "going over" what has been discussed using walkthroughs and summaries, making clarifications about design issues, and coordinating activities to manage both the project and the meeting itself [28]. We extend the existing literature by investigating the structure of design meetings as they happen in-the-wild, using the agendas created by designers as input to investigate how teams organize and coordinate design activities.

3 IN-THE-WILD OBSERVATIONS OF DESIGN MEETINGS

We observed a set of design meetings in professional, real-life settings. Our study involves a total of six meetings that took place in the scope of three different design projects. Table 1 gives an overview, including details about the meetings' duration and number of participants.

Table 1. Overview of observed design meetings and participants.

	Duration (in hrs.)	*Number of participants*	
		Designers	*Stakeholders*
Design consultancy			
Airspace management project	6 (day 1)	3	11
	7 (day 2)	3	15
	6.5 (day 3)	3	7
Governmental website project	3 (day 1)	2	6
Research institute			
Social care services project	3 (day 1)	2	4
	2.5 (day 2)	2	4

Each of these projects applied a UCD approach to solve a complex design problem, including the redesign of two governmental websites, and an airspace management system. We observed two client-driven paid projects in a Flemish design consultancy firm and one research project at a university. The inclusion criteria for selecting the observed teams were: all projects involved both novice and experienced designers, extended over the timespan of several months, included design challenges that required multiple iterations, and comprised many actors and resources.

3.1 Participants

The designers involved in these meetings had a variety of skills and expertise levels, with experience ranging between 8 months and 15 years. Designers shifted between various roles according to their communicative behavior during the meetings [37]. The *lead designer* was the senior member of the design team, who had the goal of ensuring that meeting objectives were completed, and the *backing designer* supported the lead designer to achieve this goal. We refer to the entire team of designers who participated in each meeting as the *design team*. We borrow the terms "lead" and "backing" from popular music, where backing vocals accompany the lead singer [29]. With these terms, we want to convey that backing and lead designers aimed to be *in harmony* during meetings.

The other attendees were *external* to the design team. They were key decision-makers or other team members who would be directly impacted by the new system. The observed design meetings included people with a variety of backgrounds and organizational roles, such as end-users, managers, and technical and domain experts. We give details about the attendees of each session in the sections below. During design meetings, they collaborated with designers to attain shared goals, such as generating and evaluating design alternatives. Hereafter, we refer to this group as the *stakeholders*.

3.2 Design Projects and Meetings

Next, we present an overview of the projects, meetings, and multidisciplinary design teams involved in our study.

3.2.1 Airspace Management Project. The design team consisted of three designers: a lead designer with 10 years of experience (LP1), and two backing designers with 1.5 years and 8 months of experience respectively (BP1 and BP2). The goal of this project was to design a new system to improve and bridge the air-traffic control activities that were managed by two separate systems. The new system was expected to control the operations of a variety of actors across different departments of the organization. The external stakeholders group included: end-users (air controllers and similar roles), and project managers from a variety of divisions. A meeting was organized over three consecutive days. The first two days of the meeting focused on extracting and discussing the work practices of the target end-users and how the existing systems support them (or fail to do so). The third day of the meeting dealt with synthesizing the outcomes of the previous two days.

3.2.2 Governmental Website Project. The design team involved two designers: the lead designer had 15 years of experience (LP2), and the backing designer 1.5 years (BP3). The goal of the project was to redesign a multilingual website for a governmental institution. This project had a limited scope, involving only the front-end design and evaluation. A design meeting was organized to discuss potential design alternatives for the layout of the website with external stakeholders, including project managers of different divisions, a software developer, and web content editors. The goal of this meeting was for the design team and stakeholders to ideally select one suitable layout solution for the website.

3.2.3 Social Care Services Project. The design team consisted of two experienced designers: a lead designer with 10 years of experience (LP3) and a backing designer with 7 years of experience

(BP4). The goal of this project was to create a prototype for a governmental service to offer assistive technology for impaired users. Two non-consecutive meetings with external stakeholders, which involved physiotherapy and revalidation science experts (three researchers/practitioners and a professor), were held to gather feedback on artefacts created and to generate new ideas for a next iteration.

3.3 Methodology

3.3.1 Study Procedure. Our focus is on analyzing how design meetings are structured, and on the artefacts and techniques that are used to mediate collaboration between the design team and the stakeholders. We used an ethnographic approach for these observations for gaining first-hand experience about social interactions as they happen in the field [26].

The observer had a passive role during the meetings, not intervening in any way in order to avoid disrupting or influencing the group processes. As suggested in [17], the observer focused on documenting the "actions and interactions" that took place during the meetings. Before each meeting, the observer informed all attendees about her research objectives and role in the meeting, and asked their consent to be recorded on audio and video during the session. After the meetings, whenever possible, the observer asked the designers for clarification about certain activities or events in order to improve her understanding and reduce possible misinterpretation.

3.3.2 Data Gathering and Analysis. Design meetings were audio and video recorded. The recordings were accompanied with notes, artefacts, and photos collected during the observations. We partially transcribed the videos for analysis. We examined the activities of the meetings on a higher level instead of utterance-by-utterance. This approach was taken because of the complexity of the data: very often more than one person spoke at the same time. This inhibited full transcription of all conversations. Therefore, we created a chronological *activity log* based on these transcripts. We focused on transcribing the utterances and communicative acts that captured how designers handled the meeting (e.g., how they introduced the activity, explained evaluation criteria, and settled conflicting opinions). The resulting activity log was complemented with details about goals, tasks, team roles, artefacts, and outcomes of each activity. These details allowed us to identify the overall structure of the meetings.

We categorized each activity in the log with a coding scheme according to the objective of the activity. This coding scheme was analogous to the one proposed by Olson et al. [28]. Similar to these authors, we identified and categorized the moments of the activities that involved "project and meeting management." These were, for instance, coordination moments to organize the activities by stating their purpose, or to clarify the status of the project by presenting a timeline. When engaged in design activities, we identified moments where designers used "summaries" and "walkthroughs" to recap discussions, and when they encountered "digressions" (i.e., when the discussion deviated). Additionally, we found that designers frequently stated the "goals" in order to progress the activities more fluently, and made "clarifications" to avoid or correct misunderstandings with stakeholders.

Differently from Olson et al. [28], we coded the moments when designers talked about "issues", "alternatives, and "evaluation" as *problem-solving*. Thus, we clustered these three codes simplifying them into a single code, but kept their original meaning. The moments coded as problem-solving involved the points of the meeting where designers or stakeholders articulated a design problem, proposed alternatives, and evaluated them against relevant criteria. Additionally, we identified categories related to the *team roles* assumed by designers (document session, facilitate activity), *source of the information discussed* (generated, retrieved), *spaces* (arrange, refine), and *artefacts* (validated, amended, created).

After coding all meetings, we compared the coding categories used in each activity within the different meetings. For example, activities categorized as project/meeting management tended to precede those of problem-solving. As a last step, we matched our activity log with the *agenda* of

each meeting. These agendas were the schedules used by designers to coordinate each meeting. This step was useful to refine the activity log, using the agendas as a guideline. We utilize these agendas as a source for reporting on the structure of the meetings, as described in the next section.

4 STRUCTURE OF DESIGN MEETINGS

In-depth analysis of the chronological activity logs generated from our observations showed that different meetings follow a similar structure. This is consistent with previous literature on design meetings [28]. The structure we found consisted of an interplay between three phases: *preparation*, *introduction*, and *design*. Fig. 1 provides an outline of the agenda for each observed meeting, which we annotated with the specific techniques that were used during the meeting.

The structure shown Fig. 1 was consistent across the different meetings, regardless of their differences in context, topics, and duration. However, the phases were not necessarily executed in sequential order. The design teams repeated or alternated between phases as required, even reiterating over preparation and introduction phases. For instance, the preparation phase was more prominent immediately before meetings and during breaks (i.e., coffee breaks), but also took place during design activities when the design team felt the need of "regrouping" to coordinate their activities more efficiently. The structure was not arbitrary though, as design teams deliberately used these phases to organize their activities and make progress.

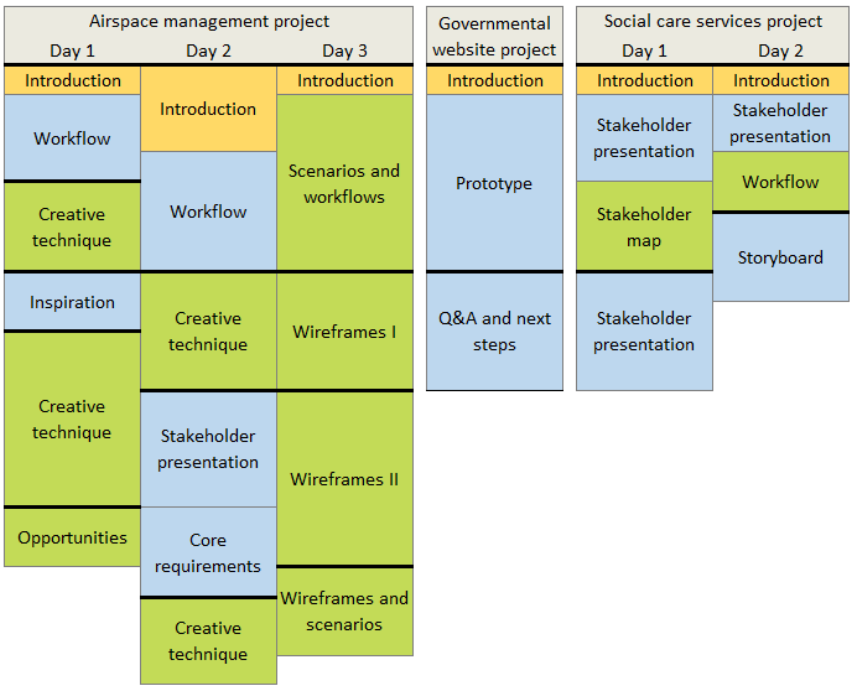

Fig. 1. Outline of the agenda items of the observed meetings, including the following phases: *preparation* (black bold lines), *introduction* (yellow) and *design* (green - *artefacts as input* activities, and blue - *artefacts as output* activities).

4.1 Preparation Phase

The preparation phases involved the coordination activities that happened "behind the scenes", which had the purpose of managing the process and progress. During this phase, design teams coordinated and adjusted their tasks, team roles, and digital and material resources for subsequent or ongoing activities. One key characteristic of the preparation phase was that it revolved around internal coordination within design teams, without direct involvement of the external stakeholders. As illustrated in Fig. 1, preparation activities took place throughout the meetings. The activities undertaken in this phase mostly involved the *arrangement of workspaces* and *division of team roles*.

The arrangement of workspaces included mostly mundane tasks to find the ideal setup to accommodate the stakeholders. For instance, design teams rearranged tables and chairs to optimize the physical space, and distributed the required stationary material (e.g., placing post-it notes and markers on tables, arranging whiteboards, and preparing handouts). The value of the preparation phase was taking care of mundane tasks before the start of the design activities, facilitating designers to focus their time and resources on the discussions. However, the arrangement of workspaces was not limited to menial tasks. It also included key tasks such as the fine-tuning of slides in anticipation of the meeting, and retrieving material to support the design activities (e.g., inspiration sources, and videos and reports containing previous design decisions).

The division of team roles required coordination among designers to establish their responsibilities during the meeting. For instance, during preparation activities, the design teams agreed on "who does what" in consideration of the agenda for the meeting. The detected team roles were consistent with those described by Sonnenwald [37]. Lead designers prominently assumed the role of facilitating interactions, mediating conflicts, and ensuring that activity goals were met ("agent" role). Backing designers frequently assumed the role of documenting activities by taking notes ("gatekeeper" role). Both lead and backing designers took the "boundary translator" role, who explained the perspective of the design team to stakeholders.

Design teams organically switched between roles, and intentionally adapted when a lack of coordination was detected. This was a frequent occurrence during the three-day meeting for the *airspace management project*, mostly because the large number of attendees made communication and task division challenging. For instance, if a backing designer assumed the "agent" role to facilitate a discussion, and the topic started to diverge widely from that of the activity, the lead designer overtook the "agent" role. Furthermore, we detected an unspoken hierarchy within the roles assumed during the meeting. The backing designers seldom overtook the role of the lead designer. Conversely, if the lead designer overtook the role of the backing designer while facilitating an activity, the backing designer shifted his or her role to support the lead designer.

4.2 Introduction Phase

Design teams consistently started meetings with an introductory speech. The value of this introduction was essentially to clarify the current status and next steps of the project. Thus, introductions served to set a design mindset and to enable an initial common ground. The introduction briefed stakeholders about the details of the meeting (e.g., goals and agenda) and status of the project (e.g., timeline and milestones). This phase took place at the beginning of the session, and had an approximate duration between 15 and 30 minutes. These activities are marked in yellow in Fig. 1. In addition, there was a brief introduction at the beginning of each design activity. These introductions gave an overview of the tasks to take place, clarified practical details (e.g., duration and organization), and made explicit the objectives of the activity, such as the kind of information that needs to be gathered and its scope. These introductions were not only useful on a practical level to coordinate the activities, but also helped to engage stakeholders into a *design mode*, which was crucial to promote participation.

We exemplify this with a quote of the lead designer (LP1) of the airspace management project (day 3) while introducing the scenarios and workflows design activity: "*And there will be some give and take. We'll go back and forth, that's not a problem. That's OK. We're designing here, it's OK to make mistakes.*" This utterance was useful to reassure and engage stakeholders to actively participate in the activity, without worrying about initial correctness of the scenarios. Furthermore, it was common for designers to rephrase the introduction speech in different ways in order to explain how to complete the activity in a way that is accessible for the stakeholders. This was the case in a conversation between the lead and backing designers (LP1 and BP1) and a stakeholder during the introduction phase of the same design activity:

> *"LP1: We're really interested in the user perspective. Try to document a normal day at work. Like annoying phone calls coming in. These kind of things interest us, because this is what will happen with [the system] in real life.*
> *STAKEHOLDER: Turn all this into plain text?*
> *LP1: Into plain text.*
> *STAKEHOLDER: The scenario… As a story?*
> *LP1: As you're about to go and make a film.*
> *BP1: A script.*
> *LP1: A script, exactly…"*

By using analogies to concepts that might be familiar to the stakeholders, the design team attempted to reach a common ground. In turn, introducing the activities carefully could result in more appropriate and useful outcomes of the activity. Notice in the quote above that the backing designer (BP1) supported the lead designer (LP1) in the "boundary translator" role to clarify what a scenario is in the scope of UCD, and that BP1's contribution was well-received by LP1.

4.3 Design Phase

Design activities were the heart of design meetings, as they contained the richest, and most relevant activities for both the design teams and stakeholders. These activities included discussions, some of which were steered with brainstorm techniques, to generate ideas, create sketches, and iterate artefacts such as storyboards, prototypes, and workflows. Preparation and introduction phases served to ensure that design activities ran as smoothly and productively as possible. The length of the design activities varied widely, with the shortest activities lasting approximately 30 minutes and the longest three hours. Fig. 1 shows the approximate duration and topic/technique of each design activity.

We found interesting similarities in the introduction phase that characterized the transition to the design phase: *an artefact was the starting point for triggering the actual design activities*. In addition, despite the lack of a formal process, we found similarities between activities with regard to their goals, tasks, team roles, and outcomes. We can distinguish two groups of design activities: where artefacts are (1) the *input for* the activity and (2) the *output of* the activity. We elaborate on these types of design activities in the next sections using excerpts from the observed meetings.

5 ARTEFACTS AS INPUT FOR DESIGN ACTIVITIES

Design teams used artefacts as input to guide and facilitate discussions during the design activities. We label these moments as *Artefact as Input (A/I).* The goal of these activities was to disseminate and assess an existing design artefact. We detail the activities and artefacts involved in A/I activities in the sections below.

5.1 Artefacts Used During A/I Design Activities

Six out of eleven A/I activities included artefacts created by design teams before the meetings. These artefacts, which are traditionally associated with UCD processes, included lists of end-user requirements, workflows, and prototypes. During design meetings, design teams used both tangible and digital representations of these artefacts, such as slides, digital prototypes, and printouts. Fig. 2 illustrates the storyboard activity of the *social care services project* (day 2). The design team created this storyboard in anticipation of the meeting. This storyboard was used to illustrate a use case on how the future system could support potential end-users, such as patients and healthcare providers. During the meeting, the design team placed the storyboard in such a way that it was visible for all attendees. The lead designer (LP3) explained each scene, using gestures to signal where to look at. Thus, the storyboard became the focus of attention, which was pointed at, referred to, and iterated over by all participants.

Fig. 2. Storyboard used as input for an A/I activity (*social care services project*, day 2).

Besides the artefacts created by the design teams such as the aforementioned storyboard, we observed four A/I activities which included the dissemination of artefacts made by stakeholders in preparation to the meeting. As stakeholders created these artefacts, their content was new for the design team. Thus, the design team focused on taking notes and synthesizing the information whenever these activities took place. For instance, during the *airspace management project* (day 2), the design team listened closely to a presentation given by one of the stakeholders (see Fig. 3).

After the presentation, the design team organized an impromptu A/I design activity to synthesize the content of a presentation about the stakeholders' work practices. These activities are shown in Fig. 1 (*stakeholder presentation* and *core requirements*). The outcome of the A/I activities is the information – gathered from stakeholders' feedback – required to iterate an artefact. This information is documented by the design team either directly in the artefact (see post-it notes in Fig. 2) or in the form of private notes. These notes were often shared with the rest of the design team after the meeting was finished. Interactions were mostly passive, as teams focused more on communicating information than on discussing it. For instance, in the case of the activity depicted in Fig. 3, the backing designers listened attentively to the presentation of the stakeholder, but whenever there were discussions, they remained silent. These discussions tended to include only the lead designer and the key decision-makers. The role of the lead designer was to keep the discussion within the scope of the topic at hand, and to reach consensus about the next steps and priorities for the artefact and project.

Fig. 3. Stakeholder giving a presentation, as designers listen closely in the back of the room during an A/I activity (*airspace management project*, day 2).

5.2 Example of A/I Design Activities

We illustrate A/I activities, their goals, artefacts, and team roles with a representative activity that took place during the *governmental website project* (see Fig. 1, *prototype*). Additionally, we reflect on the challenges encountered by the design team and their resolution.

5.2.1 Disseminating the Artefact and its Rationale. The A/I activity started as the lead designer (LP2) introduced the activity by explaining its objective, which was to present the results of an expert review of the existing website, and two prototypes that materialized design alternatives. Afterwards, the lead designer presented the usability issues found during the expert review. These issues were accompanied with screenshots of the website and evaluation criteria, such as design principles and usability heuristics. The evaluation criteria were referred to by LP2 as the "*ground or game rules.*" The meeting attendees listened closely to the presentation of the lead designer, but only agreed or disagreed discreetly (e.g., nodding) or gave very limited remarks.

After introducing the usability issues and evaluation criteria, the lead designer presented two semi-functional prototypes with design alternatives. These solutions were first introduced in a verbal way, as the lead designer presented the rationale for each solution without showing the actual prototypes. Only the two key decision-makers from the stakeholders' team made comments during this presentation. Despite the lack of discussion, it was clear from the comments of these two stakeholders that following the rationale of the prototypes was difficult. Being aware of this situation, the lead designer reassured attendees that the solutions would become clearer once the prototypes were presented, as shown in the next quote by LP2: *"I'll show you what it looks like in a minute. Are there any questions now? […] This was the theoretical part, but I mean, this sets kind of... This frames the solutions that we came up with. We haven't just invented it, we've been thinking about it. And these are the reasons why we opted for certain directions."*

After explaining the rationale in a verbal way, the solutions were presented in a visual way using the prototypes. The lead designer used a walkthrough to present the possible interactions with the website. Additionally, he externalized the design rationale of the prototypes by presenting inspiration sources, such as other websites and previous decisions made in the scope of the project.

5.2.2 Assessing the Artefact with Feedback from Stakeholders. The feedback given by stakeholders regarding the prototypes was central to this activity. One of the challenges faced by the design team was to achieve a common ground on the criteria to evaluate the prototypes. Regardless of the effort that was put into this, a common ground was not properly attained. We observed these efforts, for instance, as the design team struggled between guiding stakeholders to select the "most appropriate" solution based on relevant criteria, and giving them freedom to decide according to

their own understanding of the design process. Fig. 4 depicts this activity, with LP2 *pointing* to the prototype in order to show its different elements in a precise way.

Fig. 4. Design activity where the designer points to a prototype in order to explain its different elements to the stakeholders (*governmental website project*).

The strategy used by the lead designer was reiterating the design rationale and process (e.g., alternatives, heuristics, and end-user considerations). However, as the discussion digressed to topics less relevant for the artefacts (e.g., fuzzy organizational rules), LP2 prompted them to reflect on the issue and to keep the discussion for a future moment: "*But you can ask yourselves… do you need [certain element in the website]? Anyhow… I'm just provoking to help you understand why we came up with certain solutions."*

To keep track of the discussion, the backing designer (BP3) had the role of taking notes on a laptop. Thus, the ideas that the designer found important enough to record as future input for the artefact were not evident for the stakeholders. For instance, there were no corrections or amendments done directly to the prototypes. The lack of visual feedback made it difficult for stakeholders to grasp the impact of the meeting's discussions and decisions on the artefact. In this way, the value of the A/I activity was to disseminate the design rationale for the prototypes and to gather the feedback required for their iteration. However, challenges emerged as feedback from the stakeholders was limited, as not all stakeholders found meaningful ways to contribute to this activity.

6 ARTEFACTS AS OUTPUT OF DESIGN ACTIVITIES

A variety of artefacts were created as output of the discussions during design activities, which we label *Artefact as Output (A/O)* activities. These activities served to integrate the points of view of stakeholders and designers. A typical A/O activity involved a creative technique to collect and process the comments from stakeholders in order to be included in a design artefact. We detail the characteristics of A/O activities in the next sections.

6.1 Artefacts Used During A/O Design Activities

The design teams focused on gathering relevant information from stakeholders. This information was used as the basis for generating new artefacts, such as workflows, sketches, and mock-ups. These new artefacts ensured that a transition from a conceptual discussion to tangible results could

be accomplished. Design teams actively facilitated and structured A/O activities to cluster comments and resolve conflicting items. In one of these activities, illustrated in Fig. 5, the lead designer of the *airspace management project* collected the input from the stakeholders using post-it notes and categorized it into a whiteboard. In the meanwhile, one of the backing designers took notes using his laptop.

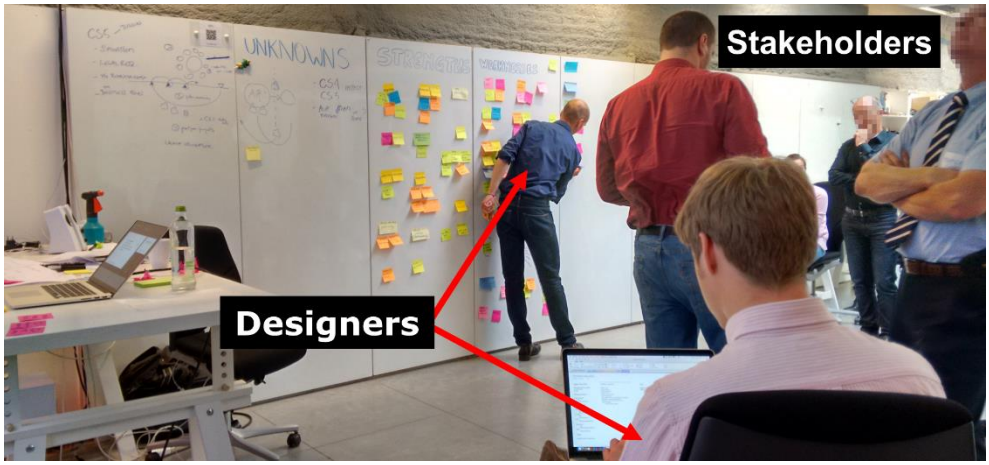

Fig. 5. Creative technique to collect input from the stakeholders (*airspace management project*, day 1).

During A/O activities, design teams had to arrange the available workspace (e.g., whiteboard or flipchart paper) to facilitate the visualization of the evolving artefact and avoid cluttering. For instance, during the *social care services project* (day 1), the design team asked stakeholders to reflect on the beneficiaries of the system to create a *stakeholder map*. The lead designer (LP3) collected the comments on post-it notes, and clustered them together with the stakeholders. However, one challenge was that the workspace was soon cluttered with many notes, which made it visualization of the evolution of the artefact difficult (see Fig. 6).

Fig. 6. Stakeholder map created during an A/O activity (*social care services project*, day 1).

To manage large amounts of information, the design teams used four basic actions to build artefacts. Designers *added* something to the shared workspace (e.g., a post-it note or a drawing),

and *discussed* its content together with the stakeholders. As a result of this discussion, a new item was *created* (or an existing artefact amended), and/or an existing item was *moved or removed*. We contextualize these basic actions with a representative example in the following section.

A positive aspect of A/O activities is that they enabled the creation of more inclusive artefacts, since all the stakeholders generated content to build the artefact. Stakeholders appreciated a direct link between their ideas and the evolving artefact. Thus, A/O activities can potentially lead to shared ownership of and accountability for the results of the design process. Conversely, the limitations of A/O activities were related to the fact that some participant(s) dominated the discussion and muted other opinions. Our observations showed that this often led to topic digressions, as stakeholders believed that the new topic was more relevant than the design activity at hand.

6.2 Example of A/O Design Activities

We discuss a representative example of A/O activities that occurred during the *airspace management project* (day 3) for the *scenarios and workflows* activity (see Fig. 1).

6.2.1 Collecting Comments from Stakeholders. The activity started as stakeholders were divided in two sub-groups. They were instructed to create a scenario about future usage of the system using a pre-defined scenario template that captured information such as outline, goals, and setting of the scenario. The two backing designers were in charge of facilitating the activities for the sub-groups. We report on the activities of one of these sub-groups. The activity kicked off as the backing designer (BP2) restated the instructions for creating the scenario, and gave details on the information required to complete the pre-defined scenario template. The stakeholders were solely in charge of creating the scenario. The backing designer followed their discussion closely, asking questions to clarify the information that was unclear from her perspective, and prompting them to focus the conversation on the topic at hand. In parallel, the backing designer created post-it notes to reflect on potential "system screens" to realize the scenarios. Fig. 7 illustrates this activity. These notes were kept private, and the designer iterated them throughout the discussion.

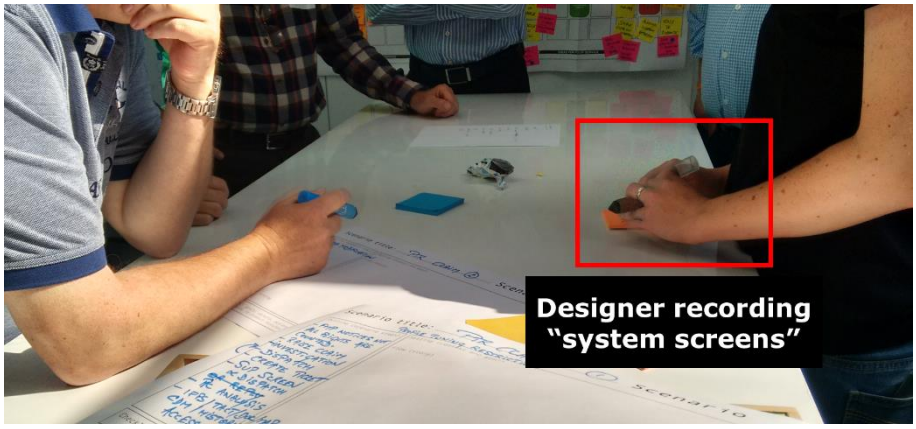

Fig. 7. Backing designer creating "system screens" to record the discussion of stakeholders while they define a typical usage scenario (*airspace management project*, day 3).

6.2.2 Processing, Integrating, and Revising Comments about the Artefact. After the group of stakeholders completed the scenarios, the backing designer explained the next steps of the activity. The designer invited the stakeholders to move nearby a whiteboard for creating a workflow using the system screens extracted from the scenarios (See Fig 8 (a)). For each system screen, she

explained what tasks it supported, and encouraged stakeholders to complement or correct the input. The backing designer used markers to add arrows to connect related screens, and annotated them with relevant information, such as user roles and tasks. The whiteboard turned into a "hotspot" where the stakeholders and the designers created the workflow collaboratively. Every time a post-it notes or element was added, the designer made a walkthrough of the workflow to make sure that the information is coherent and valid. This was done using her own words and understanding, as a way of appropriating the screen workflow to the design process. BP2 used utterances such as: *"As I understood, correct me if I'm wrong, [explanation of process]."* Translating the comments from stakeholders into the "design language" was important to prevent miscommunications.

Four basic actions enabled the designer to methodically revise all the collected comments and to process them in coordination with the stakeholders. The most recurrent actions were to discuss content to be included in the workflow and to create a new item (e.g., new post-it note or arrow to connect items).

Fig 8. (a) Backing designer and stakeholders co-creating a workflow (framed in red) using (b) four basic actions. This A/O activity resulted in (c) a finalized workflow and wireframes (*airspace management project, day 3*).

In 14 instances, previously created content was added (e.g., post-it note created by the backing designer during the scenario). The least frequent actions were moving items to a different place in the artefact with four occurrences (e.g., post-it note or arrow changed place), and removing content (e.g., discarded an idea contained in a post-it note), with one occurrence. This activity lasted around 30 minutes, and is illustrated in Fig 8 (a). The four basic actions we identified, shown in Fig 8 (b), reflect the fact that artefacts under construction are central to facilitate interactions. The backing designer made frequent walkthroughs through the workflow to make sure that the information was coherent and valid for stakeholders. The designer pushed to include all ideas, as during our observations only one single idea out of more than 25 was discarded immediately.

6.2.3 Updating for Completeness and Workspace Layout. Shortly after finalizing the workflow (see Fig 8 (a)) the backing designer informed the lead designer (LP1) that the activity was concluded. The lead designer approached the whiteboard and gave stakeholders a print-out that reported on the concepts discussed and agreements reached during the previous two days (day 1 and 2 of the meeting).

The lead designer gave the stakeholders the task of ensuring that the information in the print-out was adequately reflected in the workflow. This strategy was used to ensure consistency and coherence with previous agreements, but also to enhance the accountability of stakeholders about their contributions to the process. However, we noticed that only two out of five stakeholders were actively involved in this task. We believe this was in part because the design team was not supervising or enforcing this task.

By the end of the activity, during the coffee break, the backing designer refined the layout in order to be presented to the rest of the stakeholders in its complete form and to serve as input for the next activities. The finalized workflow is presented in Fig 8 (c), in conjunction with other artefacts created during the three-day meeting. The value of the A/O activities was to create artefacts in collaboration with the stakeholders, in a way that reflected the opinions of a variety of team members in a visible way. However, these activities needed to be closely facilitated by the designers in order to keep the discussion in line with its objectives.

7 DESIGN DIRECTIONS TO SUPPORT INTERACTIONS AROUND ARTEFACTS

In accordance with previous research, our findings revealed that design meetings are organized in a thorough way [28,43]. Elements such as included people, activities, and materials were not arbitrary, but rather planned to have an impact in the process. However, the dynamics of the meeting did not always occur as anticipated. Consequently, design teams had to improvise and adapt quickly to resolve *unhelpful occurrences*, as they hindered the process from moving forward.

Design teams faced challenges related to practical aspects (time constrains, physical space), UCD approach (ill-defined problems, multidisciplinary), and tool support (technologies available). Artefacts were used to resolve some of these unforeseen occurrences, as they helped to focus the discussion. During meetings, artefacts were actively used to externalize knowledge in a visual way. This was useful to link different Communities of Practice and advance the shared goals of the Community of Interest.

In this section, we discuss how designers addressed unhelpful occurrences with the use of artefacts, both created *before* or *because* of group discussion (A/I and A/O respectively). We articulate the challenges found in the meetings together with the strategies used by design teams to resolve them, and reflect on the role of artefacts during design activities. Table 2 lists the challenges that we repeatedly encountered during our observations.

Furthermore, we synthesize a set of "design directions" [35] that serve to inspire and ground design spaces for interactive systems to support multidisciplinary design meetings. The proposed design directions can inspire technologies to support a variety of design activities. While our study

focuses on co-located teams, we believe these directions are flexible and high-level enough that they can be useful to reflect on the possibilities of digital tools to support remote meetings.

Table 2. Challenges and design directions to facilitate design activities during early stage design meetings.

Challenge	*Design direction*
Engaging diverse team members into design activities	Share a workspace for design artefacts
Considering multidisciplinary points of view	Capture ideas with digital notes
Making decisions and sustaining them over time	Dedicate space for design decisions

7.1 Engage Diverse Team Members with a Shared Workspace

The observed design meetings involved actors from different Communities of Practice who strived to achieve shared goals. However, achieving these goals is not straightforward, as the different Communities of Practice had little to no knowledge about each other's domain. On the one hand, design teams invest time and resources – both before and during the meeting – to learn the domain of the project. Designers are usually proficient in this activity, being used to collaborating with people from different disciplines and having to adopt the vocabularies of a specific target domain in their projects. Stakeholders, on the other hand, are not necessarily active in learning about the design domain. During meetings, however, it is relevant for stakeholders to have an overview of the process to be able to contextualize design choices. For this reason, design meetings require mutual learning, as two (or more) Communities of Practice have to learn from each other to achieve shared goals. It is not only the designers who learn about their stakeholders, but their stakeholders also learn from the designers. Mutual learning has the potential to promote creativity and innovation by building on top of each other's ideas in a collaborative way [16].

We found it was not always easy for stakeholders to engage in (often unfamiliar) design activities. For instance, for stakeholders it was not always clear what was the role of an artefact in the design process, how a scenario could be used to inform a high-fidelity prototype, or how a usability guideline was reflected in a design decision. One explanation for this lack of clarity from the point of view of the stakeholders could be that designers were presenting the rationale of artefacts without the full information required for giving feedback or making a decision.

A lack of context to understand and situate design artefacts can lead to discarding relevant design elements or selecting less appropriate but familiar solutions [4,23]. This was the case of the exemplified A/I activity, where the lead designer had problems explaining how certain guidelines informed their prototype since the stakeholders could only see (and react on) a polished outcome. This would imply that the stakeholders could benefit from revisiting intermediate (and potentially more exploratory) versions of artefacts in order to contextualize them into the process.

Other reasons for this challenge include not only the lack of shared knowledge, but also the fact that stakeholders lack a way of "talking about design." This led to the following unhelpful occurrences due to a low level of engagement during design activities:

- Stakeholders do not fully understand the value/goal of a certain design activity, or were unable to follow the "train of thoughts" of designers;
- Limited remarks or feedback about artefacts, since it was not clear for stakeholders *where* or *how* to contribute; and
- Digressions, loud voices, and "separate" discussions.

A strategy to tackle these unhelpful occurrences was to communicate value by restating the *goals* of an activity and *clarifications* of design concepts. Designers relied on familiar examples and terminologies (e.g., describing a scenario as a script). To recover from digressions and loud voices, a strategy was to create "new" workspaces to cater these comments, but refocus the discussion on the goal of the activity at hand.

As previous research indicates, it is common that only a handful of attendees actively give input during early stage design meetings [28,43]. A/O activities were useful to engage stakeholders to participate actively, as all stakeholders were required to provide input by following explicit instructions on how to contribute (e.g., create post-it notes). Furthermore, A/O activities have a strong visual component and take place in a shared, physical workspace which focuses attention on the artefact and its transformation. "Conceptual" workspaces (e.g., where no visual aids were used) were more complex for the stakeholders, and discussions were more limited. In this sense, visual artefacts contained in shared workspaces are "emergent boundary objects" [8], as they are used to focus the discussion with emphasis on its progression and dynamic transformation.

Design Direction #1 – Share a Workspace for Design Artefacts

While design meetings are most often co-located, it is not always the case that all attendees share a workspace, which is defined as a physical (or digital) space that facilitates collaborators to work and focus on discussions [14]. A shared workspace provides a context for design decisions and mutual understanding. During the preparation phase, design teams often craft their workspaces carefully around (sets of) artefacts, within a given physical infrastructure. Before a design meeting starts, an initial shared workspace setting that is sufficiently flexible, yet contains the elementary artefacts, should be devised. The introduction phase is used to situate stakeholders in this workspace. From then on, the challenge is to steer the team in maintaining a single shared workspace, so they have a common infrastructure that enables group communication and awareness. Workspaces observed during the meetings included one or more shared artefacts, such as workflows, templates, or storyboards (such as the ones depicted in Fig. 2, Fig. 4, and Fig. 5) or a whole array of artefacts, such as those depicted in Fig 8 (c). In all these cases, the artefacts and spaces were used to focus discussion. Designers tend to coordinate their activities and make decisions on the spot as a reaction to various events that occur during the design meeting.

When working in a co-located setting, designers can communicate ideas using the physical workspaces to display artefacts that can trigger creativity and common ground (e.g., a whiteboard with sketches). However, external stakeholders might not have the full contextual information for situating these artefacts. The lack of context may lead to unhelpful occurrences due to a low level of engagement among meeting attendees. An interactive system to support design meetings should feature a shared workspace where artefacts can be displayed, organized, and contextualized according to the status and stage of the process. This workspace should be akin to a "blank canvas", where artefacts can be curated and displayed together with relevant information, such as design guidelines, rationales, or previous versions or alternatives. This feature can serve design teams as a strategy is to communicate with others in a way that they can maintain awareness of the project serendipitously [20].

7.2 Include Multidisciplinary Points of View during Design Meetings

We observed that interactions during the meetings were task-oriented and with a free flow of ideas. In UCD, having a multidisciplinary point of view can be used to promote inclusion, and to anticipate different usage styles [21]. This is crucial in UCD as the features of a system are defined before actual usage occurs [30]. During the meetings, however, a diversity of points of view often meant that there was a lack of common ground. Common ground is essential for communication and coordination [2]. Having radically different areas of expertise make it difficult to recognize the value in a discussion, as each Community of Practice has their own practices, terminologies, and goals. The unhelpful occurrences that took place due to the variety of points of view and lack of common ground were:

- Unbalanced floor control (one point of view dominates the discussion);
- Design teams struggled to facilitate the activity and coordinate their roles (i.e., team was out of sync); and
- Internal issues from stakeholders who take over the design meeting (e.g., inclusion of "atypical" end-users, or interrupting the design meeting to discuss internal issues).

To tackle these unhelpful occurrences, the design team used the preparation phase wisely, as designers coordinated their roles to facilitate communication. For instance, design teams encouraged the "expert" on each topic to take the floor (either a designer or a stakeholder). Furthermore, the introduction phase sought to establish an initial understanding about the objectives of the design activities. Artefacts "negotiated boundaries" between Communities of Practice, as a way to include, compile, and structure different points of view [24]. For instance, the stakeholders presented artefacts relevant for their practice (e.g., spreadsheets, workflows), which were used as a reference for creating new ones together with the design team. These new artefacts were not the design concepts themselves, but they pushed the boundaries and communicated ideas to others. In this way, artefacts are boundary objects in the sense that they are actively transformed and negotiated by designers and stakeholders during design meetings.

Design Direction #2 – Capture Ideas with Digital Notes

The first design direction indicated the importance of a shared workspace for multidisciplinary design teams to maintain awareness over the artefacts, relevant conversations that led to their creation, and how they fit into the overall design process. By situating all information into a shared workspace where design rationale and artefact evolution are visible, a team can strive to create shared common ground continuously. Shared workspaces for coordinating design meetings need to mediate and manage the various contributions, facilitating *shared ownership*, *accountability*, and *balanced fairness* of what ends up in the design results. Conflicting points of view, and different opinions on what is important for evolving an artefact and for the design process (e.g., features to include or discard, and aesthetics to follow) might surface much faster like this. Thus, it is important to have a shared, digital workspace where the contributions of all team members can be integrated, and where discussions can have a strong visual component (e.g., centered on artefacts). The value of visual communication has been long acknowledged in design practice [1]. Artefacts are the basis of communication, and as such, they play a crucial role in reflecting knowledge generated during the process [15,45].

We propose using the shared workspace to integrate design artefacts with the conversations revolving around them. The goal is to support designers and other team members to externalize ideas and to encourage relevant discussion. Connecting the different ideas and points of view to artefacts can help to visualize how design problems and solutions co-evolve. Interactive systems can support visual communication by simply enabling annotations on artefacts. We conceive these annotations as a digital analogy of "post-it" notes. Interaction with these digital notes should allow

the four basic actions we observed during meetings: creating or amending notes, adding previously-created notes (e.g., from a previous discussion), moving or removing notes, and discussing over a note (e.g., in a conversation thread). Making conversations and artefacts visible in a workspace facilitates common ground, as people from different disciplines recognize their contributions into the process. Furthermore, this approach could provide a dynamic way for documenting a meeting, and could be potentially be used to further coordinate tasks (e.g., assigning tasks to specific team members).

7.3 Recording Decisions Using Visible and Tangible Artefacts

While the free flow of ideas during the discussions promotes creativity and tackles complex topics in a collaborative way, it can create traceability issues [43]. Hence, it is relevant to document why certain alternatives were explored, discarded, or selected in the scope of the meetings. We observed that designers strived to progress the discussion to two points of resolution: (1) reach a decision (e.g., all people involved agree upon a course of action), or (2) fail to reach consensus, but agree upon how to achieve it in the future (e.g., who to involve or when to address the issue in future stages of the project). These decisions (or lack thereof) were often documented in artefacts (e.g., meeting minutes), or made explicit in an oral way by designers. The unhelpful occurrences related to reaching and documenting decisions were:

- Not all decision-makers are involved in the meeting, which means that designers need to justify *what* decisions were taken and *why*.
- The overwhelming amount of information that is processed during design activities made it difficult to record the context in which resolutions (decisions or otherwise) were achieved.

To overcome these unhelpful occurrences, design teams recorded the meetings and their outcomes meticulously, creating artefacts such as minutes, lists, reports, videos, and workflows. A potential risk of these recordings is that the design rationale attached to each design element may be lost, as ideas are extracted from a larger, more extensive conversation. For this reason, design teams invest time in coordinating their activities (e.g., during the preparation phase), often assigning a designer to the "gatekeeper" role to document discussions [37]. Documentation of meetings was an integral part of the practices of designers, having defined ways to create, store, and disseminate their personal and shared notes. For instance, in addition to the documentation generated during the meeting, the design team of the *airspace management project* mentioned creating a full transcript of the meetings in order to pinpoint where system requirements emerged. Part of this documentation was shared with stakeholders (e.g., via e-mail), while other information remained private to the design team.

Design Direction #3 – Dedicate Space for Design Decisions

Recording how artefacts came to be and what design decisions contributed to their current state is important. The digital post-it notes proposed in the previous design direction could be a step in this direction. However, the large amount of information generated during the design process can be overwhelming. Interactive systems for design meetings should support communication in several layers, as the designers explicitly filter and select the relevant information for moving the design process forward. Designers communicate not only what a design solution is about, but also why it is appropriate in the context of a given problem. Accordingly, we suggest a feature for capturing salient design decisions that led to a certain solution. This feature could take the shape of a simple, yet effective format for capturing decisions, together with relevant information such as team members and artefacts involved.

Spaces for capturing design decisions should have a low threshold for usage and should not enforce a particular structure in order to accommodate the different strategies of design teams. We

proposed and trialed one such format, the *Decision Cards*, reported in [19]. These cards are lightweight formats that have been used in design workshops to capture artefacts and their rationale in a standardized way, but without influencing the process. Keeping decisions in a tangible and accessible way, both those taken during the meeting and beforehand, can facilitate making informed decisions for stakeholders.

8 CONCLUSION

In this paper we investigated the role of artefacts to mediate collaboration during design meetings. We observed six design meetings involving professional, multidisciplinary design teams following a UCD approach. Consistent with previous research, we found that design meetings had similar phases, despite the lack of a formal process: *preparation*, *introduction*, and *design* phases. The design phase consisted of a variety of design activities such as brainstorming and sketching. The preparation and introduction phases ensured that these design activities ran as smoothly and productively as possible. Artefacts were used as starting points to trigger design activities, and in some cases, acted as boundary objects to mediate collaboration regardless of the lack of common ground.

We contribute with a discussion on the challenges faced by designers during design meetings, and three design directions on how interactive systems can facilitate the coordination of design meetings. First, interactive systems should offer a shared workspace, so all participants have a common infrastructure that enables group communication and raise awareness on the ongoing design activities, progress, and results. A shared workspace provides a context for design decisions and mutual understanding. Second, this workspace should provide a mechanism for annotating artefacts with a digital analogy of post-it notes. Design teams and stakeholders should be able to interact with these digital notes, being able to discuss, create, amend, move / remove, and link to existing artefacts or annotations. Recording discourses around artefacts could serve to mediate and manage the various perspectives to facilitate for shared ownership, team member accountability, and balanced fairness of what ends up in the design results. Finally, tools for capturing the design decisions should have a low threshold for usage, and cause a minimum of friction without imposing a specific working style or interrupting the design process. These three design directions are based on observations of multidisciplinary design teams, and surface essential aspects to support during design meetings. While these directions are inspired by face-to-face engagements, we believe they could be equally useful to support remote meetings.

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