

USER CENTERED DESIGN IN THE WILD

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ABSTRACT

Modern hi-tech product development is becoming increasingly complex, posing difficulties for achieving technically sound products that also address the user needs. User Centered Design (UCD) methodologies have been developed, but are not easy to fit into modern industrial practice, with large and often distributed teams of specialists. We describe UCD practice in new product development (NPD) practice at Océ. This company has a distributed R&D developing high tech products. The UCD professionals are embedded in NPD teams. Specifically we describe the social nature of product development in large and close coupled teams, whereby the contribution of specialists is orchestrated whilst developing. The combinations of all contributions together are hard to predict, and are enacted into prototypes that serve as boundary objects. It was found that boundary objects that depict the intended outcome strongly contribute UCD, just as boundary experiences. These concern events that can be experienced and reflected on by all specialists involved. To orchestrate the contributions of specialists, a powerful tool is creating a product story. This is a coherent, plausible and shared narrative explaining what the product will be. Lastly it was found that synchronizing the natural UCD rhythm to the natural NPD rhythm also enhances UCD.

Keywords: User Centered Design, collaborative design, design thinking, boundary objects

1. INTRODUCTION: UCD IN THE WILD?

People in our digital and networked society are confronted with high tech systems every day. More and more functionality is made available, while human abilities and skills to cope with complex tasks essentially remain the same. To empower users to benefit from the functionalities offered, the challenge is to design intelligent systems that offer a simple and enjoyable interaction between system and user. Key word is usability, which is defined in the ISO 9241-11 standard as “*The extent to which a product can be used by specified users to achieve specified goals with effectiveness, efficiency and satisfaction in a specified context of use*”. User Centered Design (UCD) is a design philosophy / methodology in which the specific abilities, likings, cognitive skills and cultural backgrounds of the users is determining for design decisions at each stage of the new product development (NPD).

Modern NPD of high tech products has been getting more complex last decade. Firstly several products have quintessentially become ‘open’: the tasks people perform are no longer confined within the physical limits of one product. To illustrate this: both cars and copiers have incorporated much new functionalities and technology last decades. But whereas cars are still developed as an integrated product, copiers included e.g. printing and scanning. To access these functionalities, the tasks users perform are no longer confined to the physical borders of the copier; and includes a range of other hardware and software products. These products, like operating systems and software applications, mediate strongly the user experience of printing. Secondly the methods in NPD changed considerably last decade: innovation itself is becoming ‘open’. In the ‘closed innovation’ paradigm R&D knowledge was fenced within the gates of the firm. In the ‘open innovation’ paradigm the boundaries between a firm and its environment have become more permeable in order to transfer innovations outside, or incorporate innovations of others [1]. Modern NPD teams nowadays comprise sub teams that are distributed spatially, culturally and across organizations. They are spread amongst several sites, in different countries, speaking different languages. Often the team members hardly know each other. They communicate through emails, video conferences and telephone. Even though these changes received considerable interest, the impact on UCD has not been studied yet, as far as we know. Methods for UCD (e.g. [2], [3], [4]) are implicitly confined within organizational boundaries and focus mainly on the product and its user. The empirical studies on UCD within product

development organizations are scarce, and limited to UCD within organizational boundaries [4], [6], [7]. Nevertheless the lack of collaboration within NPD teams was named as an important negative factor contributing towards the usability of complex products [4: pg 263][6: pg 587].

In short: there is a gap between the literature on UCD and UCD in the wild, as it is practiced in the development of complex products and services. The aim of this paper is to provide insights from the everyday practice of NPD, in order to understand how UCD effectively can be integrated within complex forms of NPD; both in non-distributed and distributed teams. This study is framed around 'UCD professionals', which refers to somebody with the skills, knowledge and expertise to work on usability issues, and has a formal organizational role. This study was instigated by UCD professionals who have been embedded in NPD teams for a long period, and who experienced the impact of the changing context of NPD. Therefore the research questions are:

1. What is it that UCD professionals do, that contributes to NPD teams and organization, if UCD professionals are embedded within these teams?
2. What are other factors that influence the success of UCD within the NPD teams and organization?
3. What is required in the organization of NPD projects for enhancing UCD within NPD teams?

2. A RESEARCH GROUNDED INTO PRACTICE

Apart from [4], [6] and [7] not much can be found on the topic of enhancing or embedding UCD within NPD teams. Starting with a theoretical model on UCD in NPD teams seemed inappropriate, due to the lack of empirical findings so far. Therefore a fairly open ended action research was started. A large, distributed NPD organization in which usability is considered critical for business success provided the platform for the study.

2.1 Organization: Océ

This company, Océ, is a large high tech multinational company. It delivers business to business solutions to manage and share information within organizations, in a range of markets. These solutions include hardware like printers; software applications; consultancy and services. The company positions itself amongst competitors as delivering integrated systems, as opposed to products that need to be integrated by clients. This perspective manifests itself also in its focus on usability of products and systems, resulting in awards for ease of use, e.g. by Nielsen Norman Group in 2008. The company develops products, applications and services itself, by a R&D organization of 2000+ employees that is based in 9 different countries all around the world. Each of these R&D sites has its own specialism and for many NPD projects several R&D sites are involved, resulting into distributed NPD teams. The NPD organization of Océ is characterized by its deference to expertise, positioning responsibilities at specialists. Océ has a structured innovation process, in which both technology development and product development are addressed, essentially a stage-gate process [8].

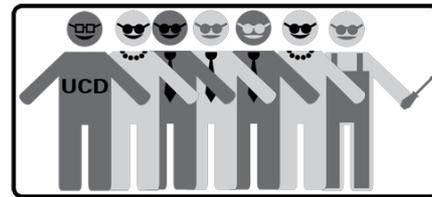
The company has an in house design department (> 20 persons) with sub disciplines as product design, graphic design, package design, interaction design and usability research. Main focus of this design department is on enhancing usability. The design department is part of the R&D structure, since three decades, meaning that design and usability are well embedded. Several employees are not designers; therefore we refer to all employees of the design department as UCD professionals. The UCD professionals traditionally are assigned to NPD teams, are fully part of these teams, and are mostly located within these teams.

2.2 The emergence of organizational boundaries

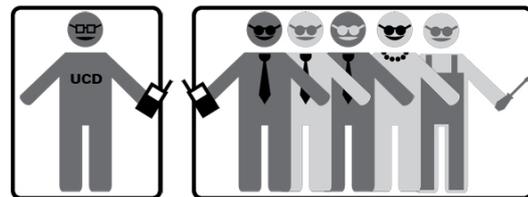
Before 1995 all NPD activities were conducted within one large R&D site based in the Netherlands, and products were developed by multidisciplinary teams (20 -200 persons) that worked in one open work space. All team members -regardless of seniority, discipline or hierarchical position- are located in a shared room, in the midst of prototypes, competitor products, CAD stations, and so on. Since 1995 gradually more sites were founded or acquired, and the appreciated one-room policy slowly changed into distributed teams, although still the core of any project is a multidisciplinary team within one room. Precisely the change in organization context and its impact on UCD caused doubt at the UCD professionals. They are located in the Dutch R&D site and noted that it mattered whether they were part of the teams or that they collaborated with teams on other sites. Working methods differed considerably, and also the lack of a joint working history mediated the mutual expectations on UCD

and how it should be conducted. Organizational boundaries became apparent to these UCD professionals. These boundaries are known to mediate collaborative efforts, either hampering it [9], [10], [11], [12], or serving as a source for innovation [12] [5]. It needs to be managed carefully, also in relation to UCD. The UCD professionals inside Océ consider the changes as complicating for their work, potentially eroding the usability of the products. The question arose, what the difference was whenever UCD professionals are embedded within NPD teams and have a joint working history (situation A in fig.1), as opposed to the situation that UCD professionals act apart from a NPD team as a result of organizational boundary, also involving a much shorter joint history (situation B in fig. 1).

Put differently, the aim of this study is to get insights into the know-how residing within a proficient organization, i.e. the knowledge that can be found within an organization or a team but which cannot be articulated by the team members. This is often referred to as “know-how” [13] or “tacit knowledge” [14]. We prefer designating it as the tacit dimension of knowledge, as it is deeply rooted into practice and part of all knowledge [15]. To play piano, people need to be trained to play the piano itself, a skill that not can be put to words. Within teams this tacit dimension of knowledge is not possessed by one, but is developed collectively by means of interactions and joint experiences [16]. It resides in organizing principles, it resides in tools deployed, it resides in language used, and it resides in cultural norms. It is often studied in relation to NPD organizations [10], [17]; and is embedded within every day practices, the “knowing in practice” [18]. It is considered difficult to transfer as it is “sticky” [19] and hard to imitate [10], [20]. This tacit dimension of knowledge is deeply ingrained within the activities of teams and organizations, hence our research of UCD in the wild.



Situation A:
UCD professionals part of NPD teams



Situation B:
UCD professionals apart from NPD teams.

Fig. 1: The two situations UCD professionals work.

In situation A, they are part of teams, i.e. spatially, culturally and organizationally embedded. In situation B the UCD professional (-s) are working apart from the NPD teams.

3. METHOD

3.1 Deweyan inquiry

A research project was formulated in collaboration with the Delft University of Technology, Faculty of Industrial Design Engineering. In this project practioners from within an organization attempt to understand their own practice together with external researchers. It can be described as a Deweyan inquiry [21] whereby a doubtful situation in practice incites and guides a search, conducted by those who are part of the doubtful situation. The goal is not only to articulate the underlying constituent factors, but also that the practioners know what to do, in order to deal with the doubtful situation at hand properly. A Deweyan inquiry is based on what we learn while interacting with the world over time, in the flux of events [22]. There are two aspects that need mentioning here. Firstly the aim of an inquiry is warranted assertibility: ascertaining a settled belief / knowledge that enables to deal with the situations that are encountered and that incited the inquiry [21]. It does not claim its findings are generic beyond the doubtful situation at hand. Secondly an inquiry has a cyclical character: it starts by observing practice, thereby comparing findings with existing bodies of knowledge. But it also ends in practice as active experimentation in practice is part of an inquiry. An inquiry is instrumental, as the insights gathered serve to be put and validated into practice [21].

The doubtful situation at hand within Océ is the emergence of organizational boundaries, as a consequence of distributed teams, that complicated the work of UCD professionals. The goal of the project is to understand the constituent factors of UCD in practice and how to deal with the doubtful

situation in Océ properly. Any inquiry is by its nature progressive [21: pg 8]; and therefore effectively several iterative studies were conducted with specific aims that together constitute the overall inquiry. Roughly the entire inquiry can be divided in two parts. The first and largest part of the inquiry concerns observational studies, to understand what factors mediate UCD, when the UCD professionals are embedded within the NPD teams (situation A above). The second part of the inquiry revolves around experiments of the participating UCD professionals in their everyday practice, when organizational boundaries are apparent (situation B above). Eventually a large data set was gathered. A main overview of observational studies and of experiments is provided in table 1. Triangulation was performed both regarding data as regarding researchers.

*Table 1. Overview of conducted studies and experiments.
The last column depicts whether or not the study / experiment included organizational boundaries (see figure 1). A implies no boundaries, B organizational boundaries.*

Study	Aim	Main research question	Method(s) used	Sit. (fig.1)	
Case study: Design of error handling.	The team reflective practice	Understanding how UCD aims are reconciled with other aims.	How does a NPD team find and solve usability problems?	Video analysis according to [39] of a critical meeting.	A
	User and usability in arguments	Understanding who puts forward users, and what it mediates within a team.	Who, when and why addressed usability? What is the effect on teams?	Video analysis + coding	A
	Cues and frames	What cues in a meeting spark frames.	What cues enhance UCD? How and why?	Video analysis + coding	A
	The contribution of roles	Understanding what roles constitute to UCD	What roles and their interactions enhance UCD? How and why?	Video analysis + coding	A
	Interviews with team members	Understanding how UCD aims are reconciled with other aims.	What factors constitute UCD? How and why?	Interviews (13) on progressing NPD project (transcribed)	A
	Participatory research.	Understanding factors that constitute UCD.	What factors constitute UCD? How and why?	2 years of participatory research. Journal, results, reports, email.	A
Stakeholder analysis	UCD according to Océ Designers.	Understanding what UCD professionals consider important aspects influencing UCD.	What factors constitute UCD according to UCD professionals? Why and how?	2 workshops with UCD professionals, video analysis.	A / B
	UCD according to key project members.	Understanding what key project members consider important aspects influencing UCD.	What factors constitute UCD: according to key project members? Why and how?	1 workshop with key project members, video analysis + feedback round.	A / B
	Contribution of UCD professionals	Understanding the contributions of UCD professionals.	What, how and why do UCD professionals contribute towards teams?	Semi structured interviews (14) on 2 finished NPD projects. Transcribe and coded.	A / B
Experiments	Creating the product story across org. boundaries	Creating product stories (in later stages of NPD project)	How can we create a shared product story across org. boundaries?	Creating in 2 product stories in NPD projects. Video / interviews (2) / journal	B
	The power of visualization.	Eliciting do's and don'ts for creating visualizations.	What visualizations contribute in team NPD processes, when and why?	27 case studies of visualizations of UCD professionals	A / B
	UCD across organizational boundaries	Improve UCD process in distributed teams.	Experiment, reflect and validate intermediate conclusions.	Workshops with distributed NPD teams Video analysis.	B

3.2 Analysis of findings

Every study was analyzed with a specific aim and method. As such every study had its own findings and conclusions, which will not be dealt with in this paper. Ending the inquiry, aimed to understand what factors constitute UCD, workshops were conducted including all participating UCD professionals and external researchers. The aim of these workshops was to recombine findings from singular studies, and to synthesize main findings across the studies, in relation with the three main research questions. Within the workshop eventually 15 groups of interest were found, like “Product stories”, “Ownership” and so on. Potential relations were put forward, and fledgling conclusions formulated. The theses were validated with the original data, in order to establish warranted assertibility. The results will be discussed in two parts, which are reciprocally constitutive. Firstly the social nature of multidisciplinary NPD within Océ will be discussed, as it inevitably shapes UCD. It will be shown that for Océ usability is an integral aspect of development, but with a sting. Secondly factors that enhance UCD within Océ are discussed.

4. RESULTS (1): THE NATURE OF NPD AND DEVELOPING USABILITY

4.1 The troublesome nature of collaborative multidisciplinary NPD

Within Océ, at least for the development of complex hardware products as printers, the NPD teams comprise of many specialists from distinct knowledge disciplines, ranging from mechanical engineers up to physicists; and also including UCD professionals. It was found that these specialists all frame and interpret the project and the encountered problems in their own specific way. This echoes other studies on NPD, that found that team members have different framings of the product they are working on, due to their different backgrounds, experiences and interests [9] [12] [24] [26] [27]. It was articulated within interviews that it is impossible to oversee all aspects and problems that underlie a NPD project by one person at any given moment. As a result it is impossible to make an a priori and all inclusive decomposition into sub units or disciplines. Yet, choices of one specialist or sub unit impact the work of others. Therefore the NPD process is inevitably a social process, whereby team members continuously explain things, ask questions, negotiate and reconcile conflicting aims. Interestingly, it is not merely the technical complexity which is the key problem that makes it impossible to oversee a priori the problems team members are dealing with. Three other factors could be discerned as well:

1. Specialists must understand what the other specialists need to know. What they devise and the choices they make: it constitutes and changes the work of others, and vice versa. This specific knowledge of other specialists’ domains is required to work in a multi disciplinary context in the first place. It only slowly grows and –by definition – can never be all inclusive, as otherwise the divide in specialisms is gone [28]. In the everyday practice it was observed that skilled seniors - regardless of discipline- involve others quickly by actively “*pulling the information out of other*”, e.g. by means of reviews. Also it is common and accepted to exchange roles swiftly during meetings, whereby e.g. specialists make proposals in other knowledge domains and vice versa.
2. Knowledge is often in between persons, and the effects of choices of specialists together only emerge when enacted with the help of prototypes. No one oversees it all beforehand. A choice made by e.g. a mechanical engineer, and a choice made by a software engineer are both based on what they know at the moment of taking the decision. However, within the study it was observed that these choices influenced each other, resulting into unexpected problems. Within the NPD teams studied, this is considered an inherent aspect of multi disciplinary teamwork. Hence, there is an attitude to make and test prototypes quickly, which enables specialists to validate their own proposals quickly and to facilitate discussions with other disciplines, enhancing collaborative learning.
3. Specific kinds of problems that are addressed within the NPD teams of Océ are so called ‘overall aspects’ which are those aspects that are influenced by all specialisms, like cost price, energy consumption, usability or environmental impact. These are integral aspects of the development, as individual decisions from all team members add to (or subtract from) the quality. To lower cost price all specialisms must consider how they can contribute towards this specific ‘overall aspect’ within their domains.

4.2 Interdisciplinary and cyclical

Working closely together, and across specialists' domains rightly can be named interdisciplinary collaboration. This term is used to oppose it to multidisciplinary collaboration, whereby a decomposition of a project enables specialist to work relatively on their own, apart from others. Within Océ an interdisciplinary collaboration could be observed: no longer merely a strict decomposition is made. Due to the nature of developing high tech systems, team members continuously interact and cross disciplinary boundaries. They showed an inclination to act with heed, i.e. to do and interact with others carefully, critically, willfully and purposefully rather than habitually [29]. The patterns of these interrelations are a result of collaborative activities individuals deployed so far within teams, which manifest themselves in prototypes, shared CAD files and so on. These objects span knowledge boundaries between specialists. These kind of objects are named boundary objects, i.e. objects that can be observed and reflected on by all involved; bridges between specialisms and across interfaces that enable transforming knowledge [12], [30]. Within Océ boundary objects tacitly are considered decisive for collaboration: e.g. prototypes are not only in the midst of NPD teams but also built by team members themselves on location. Notably, meetings are often staged around prototypes (see figure 2).



Figure 2: A team meeting staged around a prototype. Team members are evaluating a potential usability problem together, and solving problems in situ.

Within Océ during the NPD project a range of prototypes are built in which all constituting parts, modules and software come together into one integrated prototype, to validate and verify the state of affairs at product level. A natural and cyclical rhythm of hardware development was observed, whereby the construction of these integrated prototypes provides the heartbeat. Designs of specialists are built into integrated prototypes that serve for testing, learning, discussing, negotiating and so on; sparking another cycle. In time the prototypes transcended from laboratory-like and fragile to production prototypes. But always providing a state-of-the-art insight of the entire and integrated team effort. All critical stage gates that need to be passed are supported by a specific level of integrated prototypes. In many ways, the observations resembles notions of dynamic product development [25], whereby short iterative cycles of development and building prototypes are key as it enables team members and management to see and experience the state of affairs; thereby dynamically guiding the activities.

4.3 Usability as an integral aspect of development

Usability is considered also an 'overall aspect' of a NPD project within Océ: the integrated combined efforts of many people shapes the required user experience. In one study an attempt was done by involved researchers, to articulate all choices impacting a specific usability aspect; including the relations amongst these choices. Even though it was just one small aspect (job recovery after an error) the amount of considerations and choices were overwhelming. Some choices that impacted the final solution preceded the actual product launch by years, and some decisions were mediated by other NPD

project teams. But it is an 'overall aspect' with a sting. For e.g. cost price or sound-emission clear requirements can be made, and turned into a decomposition amongst sub units; but for usability this is not possible, for a number of reasons:

- Usability is holistic: the user experiences the product as a whole, not as a combination of different parts or sub units.
- Users are hard to predict: what they consider good, sufficient or inappropriate cannot be pinned down a priori into quantifiable data. It is the combination of interactions with an integrated product that a user experiences, and it is his contextual knowledge with other products that shapes his judgment. Because of this only the integrated product can provide the representation of the user experience. This includes both in the final stages of the project and in the early stages, which poses specific challenges for e.g. usability testing in the early phases (see figure 3).



Figure 3: A usability test in the early phase of a project. The intended product is mimicked, including sound, and behavior of the product. A test person pressed a 'button' to open a paper drawer which was opened manually by a team member in the back.

- Discussing usability requires a normative stance. Often usability requirements cannot be turned into objective and quantifiable data, which enable a go / no go approach. NPD teams need to judge what could be a usability problem and why; and what solution suffices. Long discussions were observed in which usability was discussed, whereby team members perform role plays as users, in order to establish a joint understanding on the problem at hand and whether a solution suffices.
- What is an 'integrated product'? The products of Océ are open, i.e. interact with other existing products and software applications of Océ or of third parties. As such the user experience also incorporates the interactions of these different products, and mediating the feel of consistency. This poses serious and new challenges and is not addressed well. It was found no common denomination exists between NPD team members on what an integrated products means. It is mentioned that "*it has become very hard if not impossible to oversee all implications*".

5. RESULTS (2): FACTORS ENHANCING UCD

What is it that UCD professionals do, that constitutes NPD teams and organization, if UCD professionals are embedded within these teams?

UCD professionals have certain attitudes and skills. Within the interdisciplinary NPD teams of Océ it was found that UCD professionals have a perspective on problems that discerns them from other team members. Firstly they focus on the problem at hand outside-in as manifested in video analysis. This concerns both the problem and solution space: UCD professionals tend to interpret the problem at hand and solving it at product -user level: if this is the situation, than what does it mean for the entire product, the user experience and how can we solve it? Other specialists tend to analyze the problem at

hand: if this is the situation, what causes it and how can we solve it locally? Secondly, and not surprisingly, UCD professionals refer more to users in their arguments and reflections: they tend to be ambassadors for users that eventually will interact with the product. Lastly, UCD professionals rely on visualizations, narratives, sketching and scenario's, thereby visualizing the product or the product – user interaction. These skills were widely known inside Océ, and also used outside the context of strict NPD, e.g. for helping technological roadmaps or developing and explaining strategy. These aspects together echo insights from the body of literature on design thinking [31] [32] [33] [34] [35]. This can be explained as most of the UCD professionals within Océ have a design background. Of particular interest here is what it contributed at team level. Firstly it was found in the video analysis that the outside-in framing helped the team to consider the problems at hand at product level. It was observed that the different framings, with a different resolution (global product versus local parts) resulted in a fruitful dialogue.

Also the artifacts of UCD professionals have a decisive contribution on UCD inside multidisciplinary NPD. UCD professionals create visualizations that are holistic and show the intended outcome of the NPD project, as the user will perceive it. It shows what the impact is of the work of others, in a way which is easily understood by all, as all developers 'know' the world of products and user interactions. UCD artifacts are genuine boundary objects. Notably, the language, visualizations and prototypes of UCD professionals propel many other discussions forward, beyond UCD. Language is intrinsically ambiguous. Especially in the beginning of NPD, when discussions are about the 'big picture' and no prototypes exist, different interpretations of the same document occur often. Ample support was found showing that within Océ the existing and difficult boundary between (strategic) marketing and R&D is reduced by means of UCD professionals with their specific skills, and their artifacts.

What are other factors that constitute UCD within the NPD teams and organization?

Integrated prototypes not only enhance collaborative efforts; they also strongly support UCD. Only by means of interacting with the integrated (prototype of the) product, the collaborative efforts of the NPD team can be experienced and the usability validated. It was mentioned and observed that whilst developers personally interacted with a prototype, a usability problem was detected. Within some projects, it was even obligatory for team members who were performing functionality tests, to deal with the prototype as if they were a user. Besides, a grounded assessment of the state of usability with real users can only be made when an integrated product, or prototype of that product, is present. Surely parts of the product can be tested, as is often practiced, but that inherently brings some risks [7].

Usability testing with real users and with prototypes of the integrated product can aptly be named boundary experiences. In analogy with boundary objects, these are events that can be experienced and reflected on by all involved; events that enable cross functional reflections and transform knowledge. Firstly because in order to conduct usability tests the prototypes need to be prepared. This preparation shifts the attention of team members from daily concerns like technological problems, toward usability. It was observed how several critical items already became clear in the preparation stage and were improved even before the actual testing was conducted. Secondly because usability tests are truly team efforts, often supervised by project leaders. During testing team members personally observe what is going on. These observations and the discussions following constitute a joint understanding on the perceived usability of the product, and of the individual contributions. According the participating practitioners similar effects were observed concerning workshops on creating personas, or the within Océ practiced method of contextual inquiry [35].

Another strongly contributing factor for UCD is the usage of the so-called product stories. When creating something with a team of people, the 'orchestration' of the individual contributions is essential, but within Océ's teams (up to 200 specialists) no all overseeing director exists. In order to interact fruitfully, team members need to have or develop a kind of joint understanding on both the content of what they are developing, and on the process they follow [26]. When the orchestration is done poorly, the result will be a haphazard combination of contributions, resulting in an incoherent user experience. It was found that a powerful tool to synchronize efforts is the creation of the product story. This is defined as: a coherent, plausible and shared narrative explaining what the product will be all team members are working on. It was found that a product story can't be defined fully a priori, but

has an emerging and developing character, quite in line with the development of the actual product. During the NPD process insights are gathered on used technology, on the market a product will be sold; and on users, e.g. by means of the usability validations. These insights are continuously integrated into the product story. The process of creating a product story also strongly mediates joint understanding.

UCD and the product story are reciprocally constitutive. UCD professionals mentioned that this product story is crucial for their work. The starting point for their design of e.g. a user interface revolves around few questions. What will the product be, for whom, and what can he do with it? It was mentioned that this mostly only implicitly is known, and one of the first steps UCD professionals take, is to articulate this. In a collaborative effort with the project leader and several key actors within the NPD team, the product story is elicited. It was found that by doing so, UCD professionals enhance creating the product story at team level. Even more, the typical artifacts, like models of the product and demonstrations of the user interface, mould the projects within a specific perspective: that of the resulting product and how people will experience it. Inside Océ often screenshots or demonstrations of interfaces are used to explain what the product is about, or to negotiate its functionalities with stakeholders.

What is required in the organization of NPD projects for enhancing UCD within NPD teams?

It was underscored by knowledgeable project leaders and seniors, that a dedicated person should be responsible for the usability. The integrated combined efforts of many people builds the user experience, and individual decisions from all team members add to (or subtract from) the quality. But to achieve usability is it important that this quality parameter is 'owned' by a specific person, who provides team focus on the user. He filters out initiatives of others towards usability, amplifies the effects, or leverages these matters to influence others. He also initiates proposals. The balancing act between 'usability is a combined effort' and an 'owner of usability' is essential. In the case there is an owner but no team effort, the owner becomes a consultant. When there is team effort but no owner the local 'usability improvements' will lead to an inconsistent and confusing system: these acts are without heed [29].

It was found that synchronizing the natural UCD cycles and the natural NPD cycles strongly enhances UCD. The user is part of the system under observation and users are hard to predict, as was argued before, necessitating multiple cycles. Hardware development within Océ has a similar cyclical nature, and it was found it is possible to synchronize the rhythms. When a project team needs to decide on the conceptual main choices, also the main conceptual choices for the user interface need to be made as these mutually affect each other. When prototypes are made at a specific quality level, also user interface prototypes need to be implemented within the prototype at a comparable level. The project team will experience the integrated system themselves from then on, and it was found that many usability issues are found and solved as a result. If these cycles are not synchronized, UCD can be seriously hampered.

6. CONCLUSIONS: SHARED PRACTICE

Within this paper insights are given into UCD in the wild. Océ served as a platform for the research, with a large and distributed NPD organization, in which UCD professionals are fully embedded. The products are high tech and open, and therefore the usability and user experience is mediated through the contributions of many specialists, from many different fields of expertise. However, the division of knowledge across specialists is inherently troublesome, and all contributions need to be integrated into one coherent product. For UCD, these contributions need orchestration, with a specific aim (usability). There is no overseeing control room that oversees the entire project, the problems and their underlying relations. Therefore the orchestration arises as a result of interactions among team members, and continuously learning by doing. The team (as a whole) needs to be responsive to observe, assess, interpret and mediate the in-between effects of the contributions of specialisms. Even though the NPD teams comprise numerous specialists, the team members (whilst performing their work) need to extrapolate the effects on the intended outcome and on other team members, cross functional. Simultaneously they have to interpret the impact of the contribution of others for their work. As a result of a joint history, teams will eventually act heedfully [29], towards shared goals, amongst others

usability. This aspect discerns interdisciplinary NPD from multi disciplinary NPD: team members have distinct common goals, are responsive to what passes; but team members (or units) remain relatively well discernable. They act autonomously yet with heed to others, as team members are aware that the combined efforts of these specialisms mediate the outcome - including the usability. It ensures that next to UCD professionals, also other team members 'know' what issues they encounter are potential usability problems. Tenet for interdisciplinary work, and for UCD is having a shared practice, i.e. common practice. Team members need to see what others are doing, need to interact with the same prototypes, or need to experience together what the usability is of a prototype. In figure 4 this is depicted.

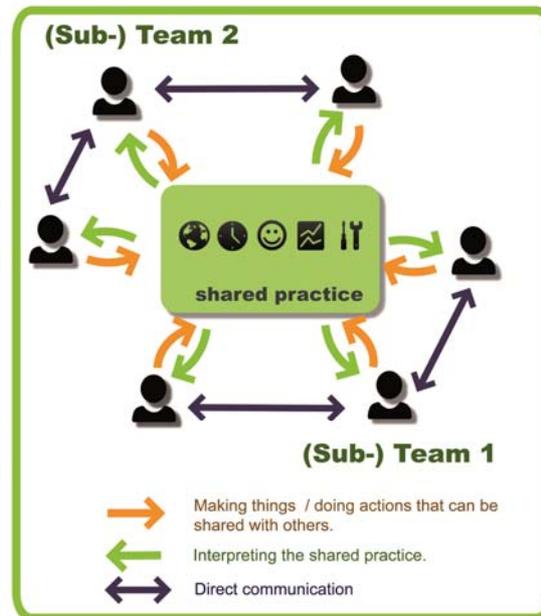


Figure 4: A model of shared practice among team members of NPD teams. Two sub teams are working on one new product, but spatially and / or culturally separated. Hence, there is not much direct communication between the teams. However, they share the same practice, which includes prototypes, CAD files, drawings, architecture diagrams, product stories and so on. They can see what this implies for their personal work; and their activities or the result of these acts constitute the shared practice noticed by others.

Several factors enhancing UCD were found for the development of complex high tech products. Undoubtedly short communication lines are important; and the easiest way to achieve this is to put all people together in one room; including UCD professionals. Within the study it was found that even a wall dividing the project in two rooms hampers communication and thus threatens the usability outcome. But the problem that incited this inquiry, was that UCD professionals within Océ sometimes are spatially and culturally divided from NPD teams, as teams became distributed. And therefore the findings below are more relevant, as these potentially can be used in the context of distributed teams. These findings are formulated as guidelines for enhancing UCD, in the first place within Océ:

1. Use boundary objects, above all those depicting the eventual product and how it will be used. This can be integrated prototypes, but also models, demonstrators of the user interface or visualizations.
2. Enhance boundary experiences that are relevant for UCD. Conducting usability tests as a team, visiting clients together, creating personas together: it constitutes team collaborative learning in relation to usability.
3. Create and recreate the product story. The product story explains a team what the intended outcome is of the project, including what the product is, for whom it is and what he can do with it. As such the product story, and the process of creating it, serves to guide team members in their everyday practice.
4. Allocate a UCD owner, who is responsible and focuses on usability. As he cannot solely achieve this aim, he filters, amplifies and leverages the contributions of others.
5. Synchronize the cyclical UCD process and the cyclical NPD process. If the natural heartbeat of UCD (design, build, validate, design..) fits the natural heartbeat of the NPD project, the outcomes

of the UCD process will be easily integrated. More important it enhances team learning in relation with UCD: other specialists will integrate a UCD stance within their work.

With several of these guidelines already successful experiments were conducted, and provide the base for future research inside Océ. The inquiry was limited to the specific context of Océ; consider e.g. the kind of products; the NPD process followed; the delegation of responsibilities; and the reliance on one shared project room as much as possible. However, we assume several of these guidelines might well be of use in other organizational contexts, and we hope other UCD practioners or NPD organizations find inspiration to enhance UCD in their own practice.

Acknowledgements

This paper is a result of the project 'Usability by Design', a co research of Océ Technologies BV, P5 Consultants, and the Delft University of Technology, faculty of Industrial Design Engineering. It was partly funded by the 'Kennis Werkers Regeling' program in 2009 / 2010 in the Netherlands. We like to thank the numerous colleagues at Océ who gladly participated in interviews and workshops, and even did not object to have their meetings video recorded, even when discussions were heated! Also we like to thank two anonymous reviewers for their constructive comments.

REFERENCES

- [1] Chesbrough H.W. (2003). The era of open innovation, MIT Sloan Management Review, vol. 44 (3), 35-41.
- [2] Nielsen J. (1994). Usability inspection methods. In Plaisant C. (Ed.), Conference companion on Human factors in computing systems (CHI '94). ACM, New York, NY, USA, 413-414.
- [3] Sharp H., Rogers Y., & Preece J. (2007), *Interaction Design: Beyond Human-Computer Interaction*. Wiley, 2 edition.
- [4] Kuijk J. van (2010), Managing Product usability, PhD thesis Delft University of Technology, Delft
- [5] Fiol, C. M. (1995), Thought worlds colliding: The role of contradiction in corporate innovation processes. *Entrepreneurship Theory and Practice*, vol. 19: pg. 71–90.
- [6] Gulliksen J., Boivie I. , Goransson B. (2006), Usability professionals--current practices and future development, *Interacting with Computers*, Vol.18 (4) pg. 568-600
- [7] Bouwmeester K.den & Stomppff G. (2006), Bridging the gap between literature and practice: usability testing, proceedings IEA 2006, Maastricht The Netherlands.
- [8] Cooper A. (1990), Stage-gate systems: A new tool for managing new products, *Business Horizons*, vol . 33 (3) pg. 44-54
- [9] Dougherty D. (1992), Interpretive Barriers to Successful Product Innovation in Large Firms. *Organization Science*, vol. 3 (2), pg. 179-202.
- [10] Kogut B. & Zander U. (1992), Knowledge of the Firm, Combinative Capabilities, and the Replication of Technology, *Organization Science*, 3 (3) pg. 383-397
- [11] Leonard-Barton D. (1995), *Wellsprings of knowledge : building and sustaining the sources of innovation* Harvard Business School Press, Boston, Mass.
- [12] Carlile P.R.(2002), A Pragmatic View of Knowledge and Boundaries: Boundary Objects in New Product Development, *Organization Science*, vol. 13 (4) 442-455.
- [13] Ryle G. (1949), *The Concept of Mind*. Barnes & Noble, 1949.
- [14] Nonaka I. & Takeuchi H. (1995), *The knowledge-creating company: How Japanese companies create the dynamics of innovation*, Oxford University Press, USA
- [15] Polanyi, M. (1966), *The tacit dimension*, New York: anchor day books.
- [16] Erden Z., Von Krogh G., Nonaka I. (2008), The quality of group tacit knowledge, *The Journal of Strategic Information Systems*, Vol. 17 (1) pg. 4-18.
- [17] Brown J.S & Duguid P. (2001), Knowledge and Organization: A Social-Practice Perspective, *Organization Science*, Vol. 12 (2) pg. 198-213
- [18] Orlikowski W.J. (2002), Knowing in Practice: Enacting a Collective Capability in Distributed Organizing, *Organization Science*, Vol. 13 (3) pg. 249-273.
- [19] Hippel, E. von (1994), "Sticky information" and the locus of problem solving: implications for innovation. *Management. Science*, vol. 40 (4) pg. 429-439.
- [20] Leonard D. & Sensiper S. (1998), "The Role of Tacit Knowledge in Group Innovation," *California Management Review*, vol 40 pg. 112–131.

- [21] Dewey, J. (1938 / 1986), *The Later Works of John Dewey, Volume 12, 1925 - 1953: 1938, Logic: The Theory of Inquiry* (Collected Works of John Dewey 1882-1953), Southern Illinois University Press.
- [22] Logister L.A. (2005), *John Dewey, een inleiding tot zijn filosofie*, Uitgeverij Damon, (NL).
- [24] Bucciarelli L. L. (1994), *Designing Engineers*, Inside Technology series, MIT Press.
- [25] Ottosson, S. (2004), *Dynamic product development -- DPD*, Technovation, Vol. 24 (3) pg. 207-217
- [26] Kleinsmann, M.S. (2006), "Understanding collaborative design", PhD thesis Delft University of Technology, Delft.
- [27] Smulders F., Lousberg L. and Dorst K. (2008), *Towards different communication in collaborative design*, International Journal of Managing Projects in Business, vol. 1 (3) pg. 352-367.
- [28] Postrel S. (1996) *Islands of Shared Knowledge: Specialization and Mutual Understanding in Problem-Solving Teams*, Organization Science, vol. 13 (3) pg 303 – 320.
- [29] Weick K.E. and Roberts K.H. (1993), *Collective Mind in Organizations: Heedful Interrelating on Flight Decks*. Administrative Science Quarterly, vol. 38 (3) pg. 357-381
- [30] Carlile P.R and Reberich E.S. (2003), *Into the Black Box: The Knowledge Transformation Cycle*, Management Science, vol. 49 (9) 1180-1195.
- [31] Boland R.J. Jr., Collopy F., (Eds.) (2004), *Managing as Designing*, Stanford, Stanford Business books.
- [32] Cross N. (2007), *Designerly ways of knowing*, Birkhauser Verlag AG, Basel (Swiss).
- [33] Visser W. (2006), *The cognitive artifacts of design*, Lawrence Erlbaum Associates (USA)
- [34] Brown T.(2009), *Change by design: how design thinking transforms organizations and inspires innovations*, New York: HarperCollins Publishers.
- [35] Visser W. (2009), *Design: one, but in different forms*, Design Studies, Vol. 30 (3) pg. 187-223
- [36] Holtzblatt, K. and S. Jones (1993): *Contextual Inquiry: A Participatory Technique for System Design*. In D. Schuler and A. Namioka (eds.): *Participatory Design: Principles and Practices*. pg. 177–210. Lawrence Erlbaum (USA)

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