

The use of design representations for design communication : insights from practice

Citation for published version (APA):

Ozcelik, D., & Terken, J. M. B. (2012). The use of design representations for design communication : insights from practice. In M. M. Adreasen, H. Brikhofer, S. J. Culley, U. Lindemann, & D. Marjanovic (Eds.), *Proceedings of the 12th International Design Conference (Design 2012), May 21-24, 2012, Dubrovnik, Croatia* (pp. 1535-1544). University of Zagreb, Faculty of Mechanical Engineering and Naval Architecture.

Document status and date:

Published: 01/01/2012

Document Version:

Publisher's PDF, also known as Version of Record (includes final page, issue and volume numbers)

Please check the document version of this publication:

- A submitted manuscript is the version of the article upon submission and before peer-review. There can be important differences between the submitted version and the official published version of record. People interested in the research are advised to contact the author for the final version of the publication, or visit the DOI to the publisher's website.
- The final author version and the galley proof are versions of the publication after peer review.
- The final published version features the final layout of the paper including the volume, issue and page numbers.

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THE USE OF DESIGN REPRESENTATIONS FOR DESIGN COMMUNICATION: INSIGHTS FROM PRACTICE

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Keywords: design process, design representations, design communication, design tools and methods

1. Introduction

In industrial contexts design is not a solitary process carried out by designers only. Other stakeholders are also involved in the process. Considering the generic phase model of design as a process of analysis, synthesis, appraisal and decision [Lawson 1990], designers need to communicate their ideas to other stakeholders, especially to end-users, at different stages of the process, in order to validate them and proceed within the process [Stacey and Eckert 2003]. Designers communicate their ideas through various media, such as verbal descriptions, sketches, renders, simulations and working prototypes [Ulrich and Eppinger 2008]. There are plenty of tools at the disposal of designers to create these media but as indicated by Houde and Hill [1997] "...what is significant is not what media or tools are used to create them, but how they are used by a designer to explore or demonstrate some aspects of the future artefact...". Studies concerning the use of design representations usually focus on the information they communicate and the reactions they evoke from their audience. However, before they are shown to an audience there is a process where they are created by the designer and decided to be shown. In our research we would like to focus on this process and try to learn concerns, limitations and motivations of designers while they are creating and using certain types of design representations for certain types of communication taking place in the design process. Thus we approach design representations from a designer-centric point of view and explore the factors which have an influence on the quality of the look and the feel of representations that are created and used by designers. We believe that identifying these factors will provide an understanding of the current practice concerning design communication and reveal insights about how designers can be supported in this practice with future tools and methods for design communication.

Design representations have been discussed extensively regarding what kind of reactions they evoke from users, especially in usability studies (e.g. [Virzi et al. 1996], [Sauer and Sonderegger 2009]). Rudd et al. [1996] identified the characteristics and values of low and high-fidelity prototypes and provided guidelines for user interface designers on when and why to utilize them in the design process. All these studies focused on the effect of design representations on the receiver. However, in our study we would like to reveal the perspective of the sender. Of course how their representations are perceived by the viewers is also the concern of the designers; however, it is not the only determinant of the choice. Our previous studies revealed that designers have conflicting concerns regarding the effect of visual quality of design representations on the communication with end-users. They believe that early design representations like sketches are too vague for users to understand the concept. On the other hand, detailed representations would stimulate user feedback on the details, in which designers are not yet interested. Thus designers do not have a clear idea about how design representations are perceived by their audience. However in their daily practice they choose certain

representations for certain audiences in specific occasions. Thus there should be other factors which motivate designers towards a certain quality of design representation. In this research we try to reveal these factors through a case study which highlights the communication between designers and other stakeholders in the context of a specific company. The study illustrates which kind of design representations are preferred by designers, why they prefer to use certain representations for certain goals and audiences and how designers tend to use them in their practice. Through the insights gathered in the study we aim to contribute to the engineering of future tools and methods for design communication, as these insights represent the concerns of the designers who will be the users of these tools and methods. Thus our study concludes with requirements for the development of such tools and methods.

2. Design representations

A design process is an interdisciplinary process which requires strong collaboration between stakeholders. Effective communication among the stakeholders is vital for a successful collaboration. Design representations are the artefacts which are commonly utilized by designers in order to communicate their ideas with other stakeholders, throughout the design process, so that the stakeholders can envision the outcomes of the design before it is built.

Visser [2006] described design as a construction of representations. According to her, design representations are intermediary artefacts which constitute the specifications to form the final artefact. These can be “mental cognitive artefacts”, such as the vague ideas and images that designers have in their head. In the course of the design process designers externalize these cognitive artefacts into external representations, such as verbal descriptions or sketches and other drawings. As they are discussed with other stakeholders in the design process their level of precision increases and they evolve to the final artefact. Similarly, Stacey and Eckert [2003] also describe the representations of design as mental or physical abstractions which do not reflect the whole specifications of the design but a chosen part of it. Thus in order to interpret these representations, to understand which aspects are fixed and which others can vary is important. Getting the representations right has major benefits to the process.

The design representations referred to in this study are visual external artefacts, which are created and utilized by the designers in order to communicate and validate different aspects of the design concepts, especially concerning the user-product interaction, with the other stakeholders.

3. Study

The study was carried out in collaboration with an in-house design team of a company that produces professional products. Thus it is a case study which examines the use of design representations in a specific design team. Nine designers participated in the study with four different roles: two product designers, three interaction designers, three visual designers and one usability engineer. Product designers are responsible for the design of 3D components of the products. They are also seen as partners in the managerial meetings concerning brand image and the vision for new product development processes. Interaction designers are responsible for the feel of the products. They design the man-machine interface. Like product designers they also take part in managerial meetings about the vision of new product development processes. Visual designers are responsible mainly for the visual design of graphical user interfaces (GUI), but also for packaging and labelling. They work in close cooperation with interaction designers. Usability engineers are the user experts in the company who are responsible for enhancing the usability of the products. They support the work of designers by bringing the view of the user into discussions. They also perform user studies with end-users. The experience of the designers ranged from two years to ten years.

Face to face interviews were the main data collection method used in the study. Workbooks were given to the participants one week before the interview sessions, to make them think about their design process, the communication in the process and the tools and methods they utilize. The interviews were carried out in the company. They were semi structured and were questioning the design process in the company, the involved stakeholders, communication among the stakeholders and the design

representations used for communicating the design concepts. The interviews lasted between half an hour and forty-five minutes.

After the study, the interviews were analyzed through verbal analysis by the first author [Chi 1997]. Interviews were transcribed and segmented according to the topics they revealed. Reasoning chains were included in the segments, as the reasoning of designers was very important for the study. The segments were coded based on the main questions of the study. The following categories were used for the coding: the design process, user involvement in the design process, design representations used for eliciting end-user feedback, design representations used for communicating with internal stakeholders. In the analysis, the interviews of the designers with different roles were considered separately in order to discover the differences among these roles.

4. Findings

The findings of the study will be examined under four headings: the design process of the company, the involvement of users in the design process, the design representations used within the design process and the factors which affect the choice of the design representations.

4.1 The design process

The design process of the company was represented by the designers as a process of four main phases: the analysis phase, the design phase, the validation phase and the detailing & transfer phase. Although these phases look sequential, the process is quite iterative. Table 1 shows the active involvement of different designers in the design process along these phases.

Table 1. Involvement of designers in different design phases

Analysis Phase	Design Phase	Validation Phase	Detailing & Transfer phase
Usability Engineers Product Designers Interaction Designers	Product Designers Interaction Designers Visual Designers	Usability Engineers	Product Designers Interaction Designers Visual Designers

4.1.1 Analysis phase

The analysis phase starts when the design team gets their assignment from the company Headquarters (HQ), in terms of requirements and specifications. In this phase designers try to get an understanding of the aim of the design process and work on developing a design vision to address this aim. Moreover, they try to get an understanding of the design problems and identify opportunities to address them. Two types of design communication take place in this phase: communication with HQ in order to set a design vision and communication with end-users and experts to explore the design space and identify opportunities. Designers indicated that in order to start hands on designing, requirements given by HQ are not enough and they need a clear vision. Thus usually product designers and interaction designers make proposals to the HQ to establish an agreed vision. After the vision is established designers carry out a research process to explore the problem space and to identify opportunities. Visiting the customers' offices, reports about the customer visits made in the past and conversations with colleagues, who have a wide knowledge about the market, are the main sources of information in this phase.

4.1.2 Design phase

This is the phase where designers begin hands-on concept generation. Here the main tool of designers is pen/paper sketching, as it is accessible and fast. The speed of sketching is very important for designers in this phase. Since they think quite fast about new ideas, they would like to put them on paper in parallel with their thinking speed, before the ideas fade away. In this phase the designers communicate design ideas with their designer colleagues mainly in collaborative brainstorm sessions. Pen/paper sketching is preferred as a communication medium for these sessions as well, as it is fast and accessible for everybody. Moreover, designers believe that sketches have room for personal

interpretation and thus stimulate divergent thinking. Once designers have a short list of promising concepts, they would like to validate them with their colleagues, usability engineers and experts who are knowledgeable about the users. Users are not involved in the process at this stage, as it is believed that the possible representations are too vague to be shown to users. This generation-validation process can iterate several times until the designers are comfortable with their concepts.

4.1.3 Validation phase

This is the phase where the concepts generated in the previous phase are validated with end-users through formal usability tests carried out by usability engineers. The design concepts are communicated to end-users through professionally prepared prototypes. It is important that these prototypes are prepared such that they allow end-users to experience them similar to how they would experience the end-product, in terms of use, functionality and look and feel. In the cases that a working prototype is not available, full scale wooden mock-ups or rapid prototyped casings are used to simulate the look. Clickable demos are built to simulate the graphical user interface (GUI) and a Wizard of Oz technique is utilized to simulate the functionality. These usability tests are carried out by usability engineers and broadcasted live to a meeting room so that designers can observe the session. The usability tests catch quite some attention from the members of the project as it is the first time that different parts of a concept come together.

4.1.4 Detailing & transfer phase

The aim of this phase is to detail and transfer the concept to the engineering team. In this phase designers are preparing their concepts to communicate them with engineers who will further develop the concepts for manufacturing. Product designers hand their concepts to mechanical engineers and interaction designers together with visual designers hand their concepts to software engineers. Detailed and accurate representations are used for the communication in order not to leave any room for personal interpretations. CAD files for the design of hardware and pixel accurate drawings and clickable demos for the design of interaction and the interface are chosen for this purpose. Text files accompany the representations in order to prevent misunderstandings.

4.2 User involvement in the design process

Active user involvement takes place in two phases: the analysis phase and the validation phase. Users are not actively involved in the design phase. In the analysis phase usability engineers elicit user insights through visiting customer sites. In those visits they observe users in their daily work practice and they also ask questions to the users. These visits are carried out three to four times a year. Designers can also join these visits. Most of the designers really like to carry out these visits. One of the designers explained the reason for this enthusiasm with the following words: *"I am very much convinced that you see a lot more if you are there, at a customer, just seeing what they are doing there and not just what they say. So I am really looking forward to do that."* These visits are documented in structured reports to communicate the results with designers who are not involved in these visits. Designers believe that each visit made to a customer site contributes to the general knowledge of the design team about their customers and the users.

Usability testing, done in the validation phase, is the second occasion where the potential users are involved in the process. It is indicated that these tests contribute both to the validation of the concepts and to the general knowledge of the designers about how users perceive and use their products. Usability tests are always carried out by usability engineers. These tests are broadcasted live to a meeting room so that interested designers can observe the test. Designers are very keen to observe the usability tests as they believe that reading a report afterwards or watching a highlighted video does not inform them as much as observing usability tests. The results of the usability tests are communicated with designers who were not able to observe the session through reports and high-lighted videos.

Although users are actively involved only in the aforementioned two phases, the designers think that users are involved all through the process. They also keep on mentioning that they find the user involvement quite important. However, what they refer to is quite an indirect involvement. They believe that they have a good understanding of their user profiles and always keep the users in mind

while designing. In the design phase they conduct informal early concept validations with their colleagues, mostly usability engineers, who have a good knowledge about the user group. When it was asked why they prefer talking with colleagues rather than talking with potential end-users, they indicated that in that stage concepts are represented by rough sketches and/or mock-ups and they are rather hesitant to show these rough representations to the users. It is believed that sketches need an interpretation process and end-users are not able to make these interpretations. On the other hand the usability engineers have more confidence in end-users than the designers, as a usability engineer said *“I noticed that it is sometimes expected [by the designer] to be difficult for users to imagine how it would be using a real touch screen. But it is not a problem. They can quite easily see through that it is paper and it does not limit them in giving feedback.”*

4.3 Design representations used by the design team

The study revealed that several design representations are used within the process. In this study we are primarily interested in the design representations which are used for early validations in the design process. We will discuss these representations under two headings: the design representations used for communicating with end-users and the design representations used for communicating with internal stakeholders.

4.3.1 The design representations used for communicating with end-users in the early validation phase

Designers have varying opinions about and preferences for design representations which are used in communication with end-users in order to elicit feedback. Here we will discuss the opinions, beliefs and the preferences of each designer group concerning different aspects of design (Table 2).

The concepts are validated with end-users after some concept development has been done. These validations concern not the usefulness but the usability of the concepts. Usability engineers are the people who conduct these validations with users by using the representations provided by the designers. They believe that in the early phases using low fidelity prototypes elicit quite useful feedback, as users *“are not afraid to give critical feedback because they can see that the concept can still be changed.”* They think *“fancy”* prototypes hinder user feedback because such prototypes stimulate feedback on the details, such as the colour and the shape. However, they also add that if the details are important for user understanding and behaviour, then they should be represented.

Product designers think in parallel with usability engineers and in the early phases they prefer the use of 1/1 wooden mock-ups for the purpose of eliciting user feedback on the look and feel of the hardware. One of the product designers said *“The users should think that they are invited to discuss what they see. They must feel confident that they are allowed to discuss. If something is looking like really finished, people do not think that their ideas are appreciated. If they do not like something, they do not simply tell”*. The mock-ups are used to elicit feedback about the visibility and reach of the screens and controls, and also about the dimensions. However, the designers also added that thanks to the advances of rapid prototyping, nowadays, it is less work to get their parts rapid prototyped than to build wooden mock-ups. Thus recently they started to use rapid prototypes much more than the wooden mock-ups.

Interaction designers prefer representations which are quick to build and which do not carry any distracting details. In order to elicit feedback on the feel of the interaction with GUI, they prefer the use of pen/paper prototypes together with Wizard of Oz technique or Power Point demos. PowerPoint demos are slideshows of screenshots of the GUI which are ordered according to a use scenario so the user can walk through the interface within the designed scenario. They are specially preferred if there is a limited time to prepare a more elaborate prototype. However they have a disadvantage. They require the facilitation of the usability engineer (e.g. when you press that button, you go that page) so they cannot be left for the free use of the users. If the behaviour of the user wants to be observed and if there is enough time to build a prototype, then clickable demos are preferred. They are more final than paper prototypes and Power Point demos, and animations can also be incorporated in them.

Visual designers are the only designers in the team who think that sketchy representations would absolutely not work in eliciting feedback from end-users. They think that for the graphical design of the interface the colours, the shapes, contrast, and the animations are very important. They do not

think that these things can be represented in a sketchy manner. They think these sketchy representations can be used for in-team validation but users cannot understand these sketches: “*Most people have problems to understand something on the basis of sketches. Maybe it is something for creative people. So to talk with users I would choose a realistic look*”.

Table 2. A summary of the design representations used for communicating different design aspects with users in the early validation phase

Look and feel of the hardware	Interaction with GUI	Look of GUI
1/1 wooden mock-ups, 1/1 rapid prototypes	Paper prototypes, PowerPoint demos, Clickable demos	Detailed digital sketches

4.3.2 The design representations used for communicating with internal stakeholders

Communication with internal stakeholders is done for three main reasons: to persuade, to discuss and to collaborate. The goal depends on the role of the designer and the role of the stakeholder (Table 3). Product designers are mainly in communication with project leaders, product managers, mechanical engineers and other designers. Communication with project leaders and product managers takes place for two purposes: to establish the design brief and to discuss the design solutions. The first type of communication is mostly about the brand image and the vision. The aim of the designers is to attract attention and to persuade. They use stories supported with sketches. They think that the quality of sketches is very important. Although the sketches used here represent a global idea, designers pay attention to make them look nice, in the words of one of the designers “*seductive*” (Figure 1). One of the designers explained the importance of nice looking sketches as follows: “*What you have to realize, is that the selling part is very important. It is very easy to discard an idea so what you need is to motivate the solution. Motivation is the most important part. The second thing is that by making a sketch like this, you sort of lift the attention. If you make a very quick sketch, people might think the idea is not well thought through.*” Designers also use renders and 1/5 rapid prototyped models for the same purpose (Figure 1). The second type of communication is for discussing the design solutions. Sketchy representations such as pen/paper sketches and 1/1 wooden mock-ups are preferred for this purpose. Designers believe that high quality representations invite for a decision so the designer can only get “yes” or “no” and cannot access the underlying reasons. On the other hand sketchy representations are ambiguous and invite for discussion. Moreover, these discussions support the feeling of shared ownership of the design. Product designers also communicate with fellow designers and mechanical engineers during the process. The communication with fellow designers is mainly for collaboration. They prefer quick pen/paper sketches as a medium for this type of communication, as it is quick, accessible and stimulates further ideas. When the design is ready, mechanical engineers take over the concept and prepare it for manufacturing. However designers start communicating with mechanical engineers early in the design process in order to reach the right product with little iteration. CAD platform is the main medium for this communication, as it is a common language which allows exchange of data and collaboration.

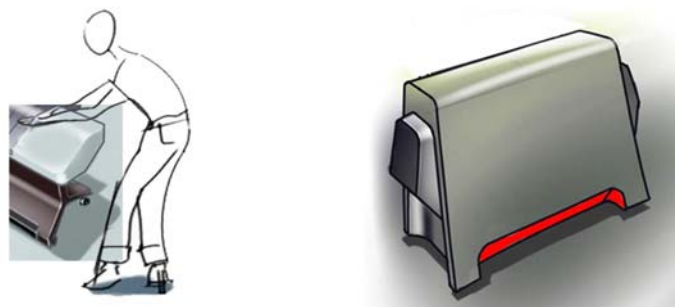


Figure 1. A seductive sketch (left) and a render (right) used to convince by product designer

Table 3. A summary of the design representations used for communicating with internal stakeholders

Roles	Representations	Purpose	Stakeholders
Product Designers	Stories, “seductive” sketches, renders, , 1/5 rapid prototypes	To attract attention To persuade	Project leader Product manager
	Sketchy representations like pen/paper sketches, 1/1 wooden dummies	To discuss To create a feeling of shared ownership	
	CAD files	To collaborate	Mechanical engineers
	Quick pen/paper sketches	To collaborate	Fellow designers
Interaction Designers	Digital sketches, clickable demos	To persuade	Project leader Software architects
	Pen/paper sketches, paper prototypes, sketchy interactive prototypes (like Power Point demos and demos prepared in Microsoft Sketch Flow)	To discuss	
	Pen/paper sketches	To collaborate, to co-create	Visual designers
Visual Designers	Pen/paper sketches, digital sketches	To collaborate, to co-create	Interaction designer
	Mood boards	To collaborate	Fellow visual designers

In the early phases interaction designers are mainly in dialogue with project leaders, software architects and visual designers. The aim of the communication with project leaders and software architects is either to persuade them about the vision, or to discuss the concepts. If the communication involves persuasion they use nice looking representations like digital sketches or clickable demos. If the aim is to discuss, they prefer pen/paper sketches. Two of the designers tend to sketch their concepts during the meetings (Figure 2) in order to help non-designers to follow the story, so that they can think along with the designer, interfere and contribute to the concept, which leads to a shared ownership and eases the collaboration. On the other hand, the third interaction designer uses Microsoft Sketch Flow to create sketchy interactive prototypes (Figure 2). He says that his sketching abilities are not very good thus he prefers not to use pen/paper sketches in these meetings.

The communication between interaction designers and visual designers is for collaboration. They think that pen/paper sketches are the most suitable medium for this kind of communication. The aim of this process is to understand each other and to generate a joint idea about the design direction. Thus in this process they not only sketch to show their ideas but also to show how they interpret ideas of each other.



Figure 2. A hand sketch made in a meeting (left), a digital sketch made with Microsoft Sketch Flow (middle) and a screen shot from a clickable demo by interaction designers (right)

In the early phases of the design process visual designers are in a dialogue with interaction designers and fellow visual designers. Both dialogues are for collaboration. In a new design project the dialogue with interaction designers starts with long and iterative ideation sessions. The sessions start with co-sketching using pen and paper; in the later iterations digital sketches are also used. Visual designers think that bringing digital versions of the sketches to these ideation meetings is also important because these sketches give more realistic information about the placement and sizes of the icons (Figure 3). Early dialogue among visual designers also aims for collaboration, mainly regarding the visual styles and metaphors used in the interfaces. They do brainstorm and mood board studies together (Figure 3).



Figure 3. A pen/paper sketch (left), a digital sketch (middle) and a sketch made in a brainstorm (right) by visual designers

4.4 Factors affecting the preference of designers for design representations

According to the findings, there are six factors which affect the preference of designers for design representations in their communication with other stakeholders: the phase of the design process, role of the designer, the audience of the designer, the goal of the communication, Since the other factors have already been discussed in the previous sections, this section will focus only on the effect of the time needed for preparing the design representation and the skills of the designer.

Speed is an important factor which affects the preference for a certain design representations. Speed can sometimes overrule other concerns. Designers appreciate building the representations with little effort in a short time. For example, although product designers think that prototypes which look finished would create a threshold for eliciting end-user feedback, they tend to prefer 1/1 rapidly prototyped models to 1/1 wooden mock-ups because they can be created faster with less effort. Similarly interaction designers also think that sketchy looking representations are better for stimulating the dialogue, however, they tend to switch to digital sketching and building Power Point demos pretty early in the process, as they can create quick new representations via editing old ones. When we asked why they prefer building PowerPoint demos one of the interaction designers replied: *“In a lot of cases it was because this material was already available and a lot of stuff is reused. To sketch indeed would cost me more time”*.

Last but not least, the individual skills of designers are very important determinants of which kind of representations designers tend to use in their communication with other stakeholders. Based on their skills, designers tend to use different representations for the same audience and purpose. For example one of the product designers uses *“seductive sketches”* in the meetings with managerial stakeholders to persuade them, while the other product designer prefers renders and 1/5 rapid prototypes because he cannot make *“seductive”* digital sketches. Two of the interaction designers prefer to sketch in the meetings with managerial stakeholders, as they believe pen/paper sketches would stimulate the dialogue in these meetings. However one of the designers also added that it is because she is not very good at making graphics so she prefers sketching, writing down some words and drawing arrows. The other designer also said: *“Visually I am not strong. My strength is in the logic”*. The third interaction designer prefers sketchy prototypes created with Microsoft Sketch Flow, for discussion, as he thinks his hand writing and his free sketching skills are quite bad.

5. Conclusions

This study revealed insights into the concerns, the limitations and the motivations of designers which make them create and use certain types of design representations for communicating their design ideas with stakeholders, especially early in the design process. Although our findings represent the current practice in a specific company we believe that they reveal some insights for the development of future tools and methods concerning design communication. We conclude our paper with a discussion about the requirements that are derived from this case study.

First of all, the study showed that, although the designers acknowledge the added value of end-user involvement in the design process, the active user involvement only takes place at the beginning, for insights gathering, and towards the end of the process, for validation. The sketchiness of the design representations generated in the early phases of the design process seems to have an influence on this pattern. Although some of the designers state that to elicit reliable feedback from end-users they would prefer sketchy representations, in practice most of the designers are not so willing to adapt that approach. Especially the designers working on the look and feel GUI believe that users cannot understand the concept through these early and mostly pen/paper sketches. We believe that if designers can have simple but clear, readable sketches in the early phases of the design process they would be more willing to show them to end-user to elicit feedback. Thus development of tools for sketching interactions which enable creation of such sketches and are compatible with individual working styles of the designers would contribute to eliciting early end-user feedback.

The study also showed that there are several factors which affect the designer's choice of certain representations in different communicative settings. These factors were discussed in the previous section; however, here we would like to stress three of them, which we think are quite important for the development of design tools and methods for design communication. First of all, the role of the designer is an important determinant of the choice of design representations. Due to their roles designers deal with different design problems, they have different questions and they communicate with different stakeholders, even in the same design team. Thus in the development of tools and methods for design communication requires a careful establishment of the role of the designer. Generalizations should be avoided because "the designer" does not exist. If the design tools are developed for a wider group of designers representing different roles, the needs of each group should be taken into consideration. For example, a design tool which is developed for the design of graphical user interfaces requires the incorporation of the needs of both interaction designers and the visual designers, as they intensely collaborate on this design domain. It should allow the design and the simulation of the interaction easily, without detailed graphics; however, when necessary it should allow incorporating the graphical designs into the system.

Secondly, time is very important for designers. They usually work under time pressure and this affects their choice of design representations. They tend to go for different quality of representations only because they can use existing materials that they created before. This attitude promotes digital representations, as they can be created by simply editing existing materials. It suggests that tools for design communication should not be considered in isolation from design tools. The development of tools for design communication requires considering cooperation with the design tools, so that designers can use the materials that they have created while designing for their communication purposes as well. The compatibility of these two genres of tools should be given specific attention.

Last but not least, the skills of individual designers also have an effect on what kinds of representations they tend to use for communication purposes. The study showed that even the designers with the same role might prefer different representations due to their designer skills. Thus the development of tools for design communication requires considering individual skills of designers and allowing them to adapt the tools to their skills. Moreover, since it requires some effort to change the working style of a designer, the efforts of method development should also focus on enabling designers to reach their communication goals with the representations that they are able to create. In other words, not only the development of different tools for different purposes of communication but also the development of methods which support the use of different design representations for the same communication purpose should be provided.

6. Limitations and future work

We conducted the present study with the in-house design team of a company. Although this approach gave us the opportunity to investigate the concerns of the designers working in different roles in the same domain for the same company, it also restricted us with the perspective of one in-house design team. However, we believe that some of the results can be generalized beyond this one design team. The study showed that time pressure, different designer roles and different designer skills have an effect on the preference of the designers for different design representations. Designers did not relate these issues to the procedures of the company they are working for. Thus we do not think that these issues, especially the time pressure and the individual skills, are specific to the designers working for this company but they are more related to how designers work in general. On the other hand, the findings concerning the different roles of the designers and the collaboration between these roles may be specific to this company. Thus they still need to be supported with further studies.

Henderson [1999] makes it clear that communication depends on both the use of appropriate representations and the ability of the receiver to construct meaning from those representations. This study reflects the designers' view on the use of design representations for design communication. Designers shared with us their beliefs, based on their experience and intuitions, about what kind of effect design representations evoke on the audience of the designer. Future research will concentrate on the other side of the communication and investigate mainly the effect of early design representations on the feedback elicited from end-users. We are planning to address this issue with empirical studies in which we will compare different types of design representations, accompanied by different methods.

Acknowledgement

The authors gratefully acknowledge the support of the Innovation-Oriented Research Programme 'Integral Product Creation and Realization (IOP IPCR)' of the Netherlands Ministry of Economic Affairs, Agriculture and Innovation.

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