DESIGN METHODOLOGY IN PRACTICE
CASE STUDY OF BRINGING A SCENARIO-BASED APPROACH TO DESIGN PRACTITIONERS

Irene Anggreeni / Mascha C. van der Voort,
Laboratory of Design, Production & Management, University of Twente, The Netherlands.

irene.aubrey@gmail.com / m.c.vandervoort@utwente.nl

ABSTRACT

This paper presents a completed research-through-design on the adoption of a design methodology in practice and the development of support for the adoption process. A case study was conducted to explore how design practices apply Scenario-Based Product Design methodology and how it can be supported by a design tool. Prototypes of the tool, as an instrument of design knowledge enquiry, have informed the researcher of the practical concerns and possible implications of supporting the methodology using a design tool. The availability of support encourages a more explicit use of scenarios in design thinking and reflection and increases the clarity of rationales behind design decisions. By making explicit and supporting concrete steps in a design methodology, the cumulative practice-based experiences will deliver a more solid knowledge base required to improve the design methodology.

Keywords: Scenario-Based Product Design, design tool, scenario development.

INTRODUCTION

This paper presents a completed research-through-design on the adoption of a design methodology in practice and the development of support for the adoption process. Two main questions are addressed in this research. Firstly, how does the design practice adopt a methodology? Secondly, what kind of support can help the adoption of such methodology? The focus of this research was on bridging the rather abstract and largely theoretical knowledge on Scenario-Based Product Design (SBPD) methodology and the realistic needs of consumer product design practice. SBPD was chosen for its presence in and relevance with the design practice overall. While initially developed for the early interactive systems design (a.o. Carroll, 1995; Carroll, 2000), the use of scenarios in design has further been applied in complex product design (e.g. Fulton Suri and Marsh, 2000; Tideman et al., 2008). Being easily accessible, concrete and at once flexible, scenarios allow for rapid design iterations and validations, enabling usability studies as an integral part of the design process instead of only a detached post-design testing. However, its application in the design practice is often overlooked and the experience therein is not optimally used to strengthen the methodology.

Research-through-design requires test prototypes as an instrument of design knowledge enquiry (Keyson and Bruns Alonso, 2009). A case study was therefore developed to get insights into the adoption of SBPD methodology in practice and to explore how it can be supported by a design tool. In this study, varied prototypes were developed and evaluated in collaboration with design practitioners from different backgrounds, work cultures, and levels of experience in using scenarios. With the tool aiming to support a design process using scenarios, a deeper understanding of what is involved in the process is necessary. Design as a complex, creative and collaborative human activity comprises of interrelated elements that must all be taken into account. These are the *object* of this activity (the design problem and the emerging design solution –

the 'content'), the *actor* (the designer or the design team), the *context* in which the activity takes place, and finally the structure and dynamics of the complex activities being studied ('the design *process*') (Dorst, 2008). This study therefore considered all four aspects in careful iterations to explore the spaces and boundaries of problems and solutions.

The design iterations and validations of the prototypes have allowed the researchers to progressively gain an understanding on the practical concerns and possible implications of supporting SBPD using a design tool, which has been used to improve the proposed tool. As a result of the case study, this research delivers knowledge on how SBPD methodology is applied in a realistic context and how it can be supported to make optimal use of scenarios. To inform readers the essence of SBPD and why this research focused on understanding and supporting its application in practice, the next section presents a brief introduction to the methodology and its state of the art in the design practice.

SCENARIO-BASED PRODUCT DESIGN: DILEMMAS IN DESIGN PRACTICE

Within the context of SBPD, scenarios are basically explicit descriptions of the hypothetical use of a product or function. They provide a low-cost, easy and accessible communication tool to explain design rationales, elaborate potential solutions, and discover where usability problems might arise. A scenario is composed of various interacting elements, as shown in the overview in Figure 1. As concrete narratives with flexible media of representation (e.g. storyboards, role plays, virtual reality), scenarios facilitate making explicit how users would use the designed product in their activities. These characteristics of scenarios allow for rapid design iterations and validations, enabling usability studies as an integral part of the design process instead of only a detached post-design testing (Carroll, 2000). With nowadays product design becoming more complex, the use of scenarios in a design process potentially supports designers to perform action and reflection and explore problem and solution spaces at once, without making a premature commitment to a specific design direction.

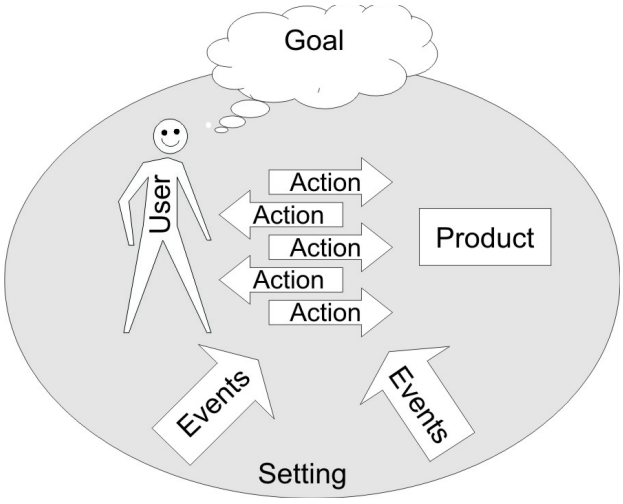


Figure 1. A scenario consists of different elements that interact with and influence one another.

The application of scenarios in a design process is guided by methods, techniques and tools that altogether compose the SBPD methodology. With the initial framework developed for the design of early interactive systems (Carroll, 1995; Carroll, 2000), the later use of scenarios has expanded into the domain of (complex) product design (e.g. Fulton Suri and Marsh, 2000; Tideman et al., 2008). There is no prescribed approach for SBPD as its application always needs to be customized to each particular domain or case. As Weidenhaupt et al (1998) already recognized in the domain of system development, actual scenario usage often falls outside what is described in textbooks and standard methodologies, creating scenario management problems not yet addressed adequately in theory or practice. Similarly in the domain of product design, the knowledge base of SBPD is built mainly from unique exemplars of scenario uses which often cover only parts of each specific design process (e.g. Moggridge, 1993; Howard et al., 2002; Aoyama, 2005; Blythe and Wright, 2006) or strongly from the perspective of non-commercial research (e.g. Nielsen, 2002; Lim and Sato, 2006). Consequently they might miss relevance with the full spectrum of practical, real life design projects in profit-seeking companies.

In practice, design practitioners are still mainly unguided in setting up and conducting a design process using scenarios. They often need to rely on their intuition to integrate scenarios into their design process overall, sometimes by trial and error. Design teams always have to adjust their approach and be

eclectic in planning, implementing and evaluating their scenario-based approach according to their own situations. A more concrete guidance in implementing SBPD seems to be necessary to support the design practice into using scenarios more efficiently. This hypothesis provides a starting point for a case study to discover the actual motivations and needs for using scenarios in industry and the form of support that fits the realistic context. The case study elaborates the iterations that have been developed to enquire the layers of support for SBPD methodology in practice.

THE CASE STUDY

The aim of the case study was to get insights into the adoption of SBPD methodology in practice and to explore how the adoption can be supported by a design tool. To ensure a realistic context to base the study, building contact with industry was carried out as an initial step. Based on the preliminary interviews with several representatives of design/engineering industry, a small/medium-sized design agency (hencefort, *the company*) was chosen for a more intensive collaboration for its flat hierarchy, directness and transparent work process. To reflect the variety of design practices (e.g. different project/organization sizes, work cultures, and varied levels of familiarity and commitment to using scenarios), a diverse group of design practitioners was involved in different phases of the study to give a realistic feedback from the world of practice. To break down the underlying research questions on the adoption of a design methodology in practice and how to support it, the case study served to answer these specific questions:

1. *What is the current state of scenario use in product design practice?*
2. *Which activities present challenges to design practitioners and can be supported by the use of scenarios?*
3. *What form of support is applicable in a realistic context of design practice?*

Literature studies and the preliminary interviews revealed that SBPD in practice heavily involves the use of scenarios for synthesizing design information. Table 1 summarizes five main scenario uses, which are based on the scenario use roadmap developed by Anggreeni and van der Voort (2008a; 2008b). In practice, this process is not always explicit and the creation and use of scenarios is often a series of one-off design activities. Consequently, the resulting scenarios are often immediately translated into more formal artefacts (e.g. requirements, specifications, failure modes, etc), affecting the clarity of rationales behind design decisions. This generic challenge is amplified in the context of design teams in which multiple disciplines, backgrounds and interests interact with one another.

CURRENT-BASED	FUTURE-ORIENTED
Actual practice scenarios register observations and interviews; the use situations might be fragmented or not complete	**Future practice scenarios** capture design directions to communicate within the design team and with other stakeholders; rough sketches are sometimes used to illustrate future use situations
Possible problem scenarios what could go wrong during product use; designers criticize their concepts and peer-review each other's work when needed	**Interaction scenarios** (detailed) sketches of product use; scenarios are explicit and expressed in ad-hoc manner (e.g. annotation on the sketches, oral stories, gestures); thus documentation is not reliable
Validation scenarios ensure product's success in all possible use scenarios (according to both current and future situations); explicit and documented because validation should be a formal process	

Table 1. Common scenario uses in the design practice.

In accordance with the paradigm of research-through-design, test prototypes were developed to assist the researchers in the enquiry for design knowledge. As mentioned in the Introduction, the beginning portion of this study addressed the aspects of design: *actors* (designers), *context*, *content* and *process*. Multiple iterations were conducted to explore the problem and solution space. Consequently, the test prototypes (artefacts) developed in the study have taken different forms. Their forms depended on the design questions in each phase, and were not directly incremental towards the final design of the tool. The steps taken in the case study are described in the following subsections. For clarity, the artefacts and outputs from each step are identified and illustrated as necessary.

PROBLEM AND SOLUTION SPACE

During the initial enquiry, both the researchers and industrial partners mutually recognized scenarios as syntheses or refinements of design information. Our hypothesis was that by providing support that fits in the explorative/early design phase, the use of scenarios can be sustained over a design project and therefore be optimal. Subsequently, with the processing of design information as an application area of scenarios, practice-based problems in this area were identified through a series of workshops and questionnaires with design practitioners. The workshops were conducted in collaboration with practitioners from *the company*. Further, to confirm the problem areas and to probe for more details on potential solutions using scenarios, the questionnaires were distributed to other design practitioners from different companies and with different levels of familiarity with SBPD.

Artefacts: various scenarios exploring the context of problems and potential solutions. Table 2 shows an excerpt of context scenarios and questions posed in the questionnaire.

This step resulted in the identification of the activities of creating, using and organizing scenarios – the backbone of SBPD – as potential areas in which support can be applied. The workshops and questionnaires have successfully gained a deeper understanding into these activities. Since they can take place as natural parts of a design process, the activities can be explained in context as a pairing of design goals and their scenario-based solutions:

Creating a consistent documentation of design knowledge - documenting design information as scenario elements.

Designers compile their design information from enquiries with target users and stakeholder, observations on competitor products, close investigations of established standards (e.g. safety or ergonomics) and other sources. They employ techniques such as ethnography, observation, interview, focus groups and participatory design methods to get a good insight from the user perspective. This may result in a large amount of information lacking organization. Scenario elements can serve as explicit categories to document design information in a structured yet also flexible manner (see Figure 1). Especially in complex design projects, the dynamics in the product's use situations stress the need for the design team to collaboratively use such structure.

Observed Problem	**Proposed Solution**
Please reflect on the following fictive situation…	Imagine a different situation…
A design team is working on a project of designing a new breed of bicycle baggage transporter. Designers Alice and Bob are assigned some tasks. Alice is going to visit an exhibition of bicycle latest technology to find out the market situation. While Bob is going to observe/interview buyers at one reputable bicycle store in town, and hopefully get some users who have suitable profiles and are willing to participate later on in their research…	*Alice returns from her field visit to a bicycle fair in Utrecht. She has made many contacts with bike manufacturers at the fair. She's quite satisfied with what she has learned of the latest bicycle-related designs and technologies. During the fair, she had a chance to observe the state-of-the-art of bicycle baggage transporters. She took many photos that highlight their main features so she could show and discuss them with the team. She also took some brochures to get references/contacts of the companies…*
After a long day, Alice and Bob come back with a lot of information. They have taken along notes, photos, brochures, etc. Both Alice and Bob are wondering how they can organize this information neatly and share it quickly with their team members. Preparing a document could be a good idea to share the info with the team, but it takes time especially with the different (physical) media of information that has been collected. Alice and Bob wish there is a system to which they can just "drop" their findings and automatically keeps everyone in the team informed.	*Back in the office, Alice wants to document and share her findings with the team. She drops the photos to the company's network server. She then opens her internet browser and runs an application called "Scenario Central". Alice finds the photos she just uploaded. She annotates a photo of competitor product X with stories she gathered during her inquiry. Later, Bob reads Alice's review and wants to add his insights. He writes down profiles of users he met, each of whom has different experiences with this product. Bob connects their stories with the profile photo of product X.*
Question: Do you find this challenge familiar in your work setting?	**Question:** Do you think this functionality of *collaboratively reviewing existing (competitor) products* can be useful in your organization?

Table 2. Scenarios exploring problems and solutions aid practitioners to reflect while answering the questionnaire.

Proposing solutions and identifying requirements - creating scenarios to help make sense of the information.
Although designers use scenarios to communicate and reflect on their design, these scenarios are rarely documented in the project because there is no clear designation for narratives. For instance, in the case when unexpected product use is discovered, it is often directly translated into requirements (or other formal artefacts), leaving behind stories (i.e. scenarios) that make up their rationales. To build upon a more structured documentation, the scenario elements can be combined to identify relevant and meaningful scenarios. Furthermore, scenarios can be explicitly assigned as inspiration/rationale for requirements, making the designers more aware of the value of using scenarios throughout the design process.

Rapid iteration and evaluation of design concepts - sustaining scenarios as an integrated part of formal artefacts (e.g. requirements, risks/failure modes).
In practice, ideas and concepts are tested against requirements and risks. A valid test setup however needs to explicitly include the context of the use situations (e.g. setting, user's state of mind, existence of any distraction, etc) which may not be consistently documented in the requirements and risks. With scenarios explicitly related to other more formal artefacts such as requirements and risks, scenario usage can be administered e.g. based on their purposes, on partial functionality of the product, or on the actors represented in the scenarios. Eventually, the collaborative effort from a design team to sustain the use of scenarios will benefit the project in the long term (e.g. formal reports do not have to be written from scratch) and potentially be reusable for other projects.

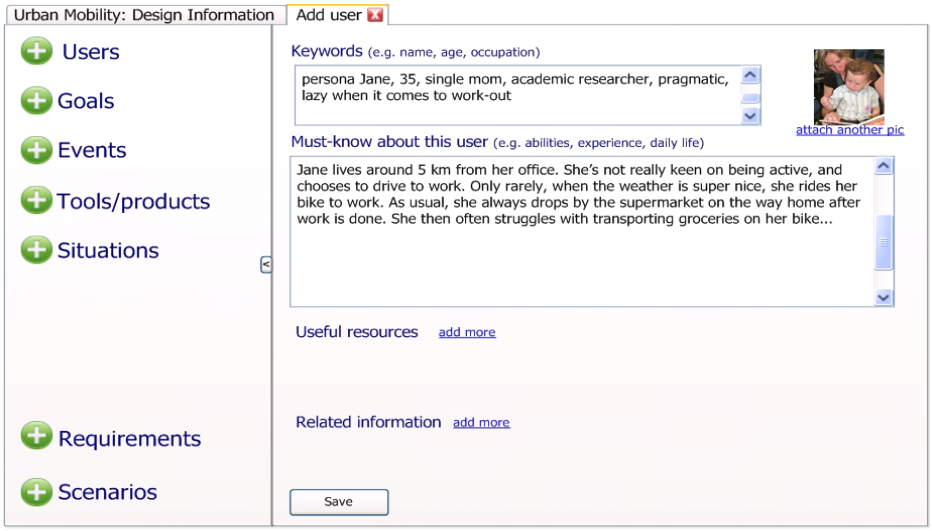
Through the exploration of problem and solution space, we have confirmed that scenarios can be a sustainable part throughout a design process, if their creation, use and organization are consistently supported. The early/explorative phase is especially crucial because the treatment of relevant design information in this phase determines the strength of the foundation for further steps using scenarios. To realize such support, its requirements and conceptual designs were defined through multiple design iterations and validations of test prototypes.

REQUIREMENTS AND CONCEPTUAL DESIGNS
In this step, requirements and conceptual designs were developed and evaluated with the involvement of design practitioners through a series of focus group meetings. We started with a hypothesis that a design tool – instead of e.g. a method or technique – would be the easiest form of support to be adopted by companies. Such a tool needs to conform to the creative nature of the explorative/early design phase for which its use is crucial. The focus group meetings aimed to ensure the fittingness of the support tool in the work practice and subsequently, its acceptance by the design practitioners. The meetings were organized as a "storytelling" about the proposed support tool followed by a discussion to get the participants' feedback. To create an interactive "storytelling", MS Powerpoint was used to animate the tool prototype.

Artefacts: conceptual designs and scenarios to aid the "storytelling". A mock-up of the tool was developed using MS Visio and accompanied with context scenarios, as illustrated in Figure 3 and 4.

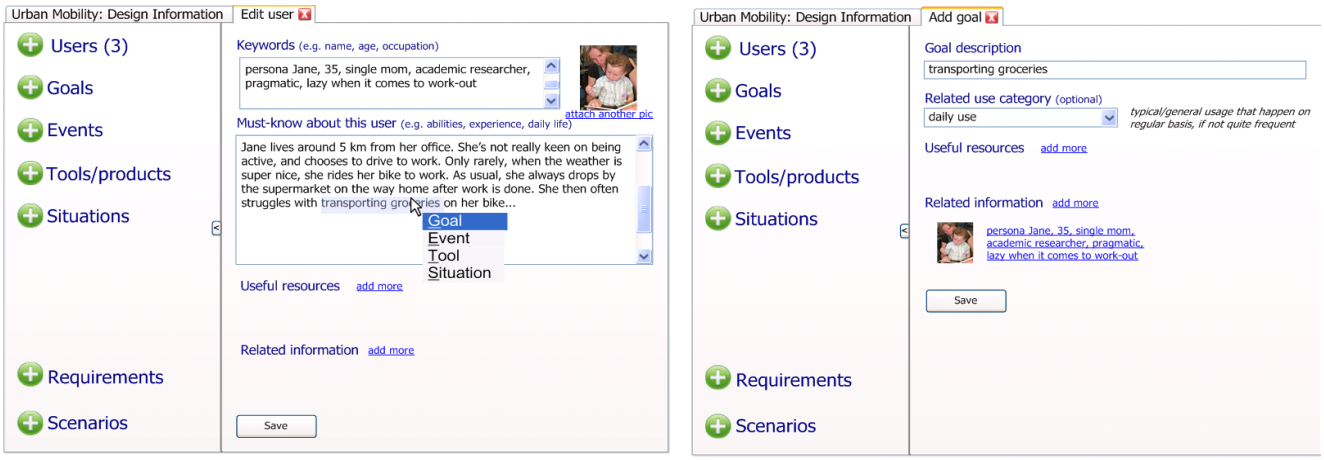
This step resulted in a set of confirmed requirements for the support tool and a chosen concept for further development. Multiple small iterations have delivered practice-oriented requirements for the support tool and its respective added value in the work practice. As a guideline, to be accepted in the world of design practice the tool needs to posses these characteristics:

- *Flexible* and *independent*: its adoption should not depend on other methods and tools applied in the design process, and vice versa; the role of such tool would be to combine and process the results of other used methods and tools,
- *Informal*: fitting in with creating and using scenarios to "*sketch*" the use and inspire functionality of a product, the tool needs to be inspirational and not obstruct creativity,
- *Simple* and *lean*: to avoid the organizing of scenarios becoming too prescriptive and exhaustive,



John creates a user profile using the scenario support tool
John summarizes what he has learned from the focus group session. Both participating users are quite similar in the way they are using bike pannier. Therefore John creates a fictive user Jane that combines their characteristics.

Figure 3. A mock-up screen showing a function to document user profiles using the tool along with a scenario describing the designer (John)'s rationale in using the function.



John identifies and extracts other scenario elements from a user profile
John revisits the user profile Jane and breaks it down further by scanning for other useful information. For instance, he notices a goal 'transporting groceries' is implicit in the user description. He marks the piece of text and by right-clicking, registers it as an explicit goal. The new goal keeps a reference to the user profile Jane as its source of origin.

Figure 4. A mock-up screen illustrating the extraction of a 'goal' element from a user profile (Jane), accompanied by an interaction scenario explaining the steps the designer (John) takes.

- Good *interfacing* with other tools/activities: to maintain a sustainable use of scenarios, and in turn also address the complete cycle of scenario creation, use and organization.

In addition to the requirements, the iterative feedback from the industry has defined a solid concept to be developed further into an interactive prototype. With a clear envisioning of its future use, the interface and interaction of the proposed tool were explored and evaluated together with the design practitioners. Furthermore, the web has been identified as an ideal platform for the tool for its accessibility and scalability. For brevity, the chosen concept is not presented in this paper. Instead, the interactive prototype – its development and evaluation – will be addressed in the next step.

FUNCTIONAL PROTOTYPE

In this step, an interactive prototype was developed and evaluated with the design practitioners through a series of focus group meetings and a multiday trial. With the web identified as an ideal platform for the tool, an open-source development kit Drupal was chosen to implement the prototype. This step aimed to verify the correctness of the implementation of the tool functionality, and to assess the intuitiveness and ease-of-use of interacting with the tool. Another objective was to confirm the usefulness of the tool in delivering its purpose in supporting the creation, use

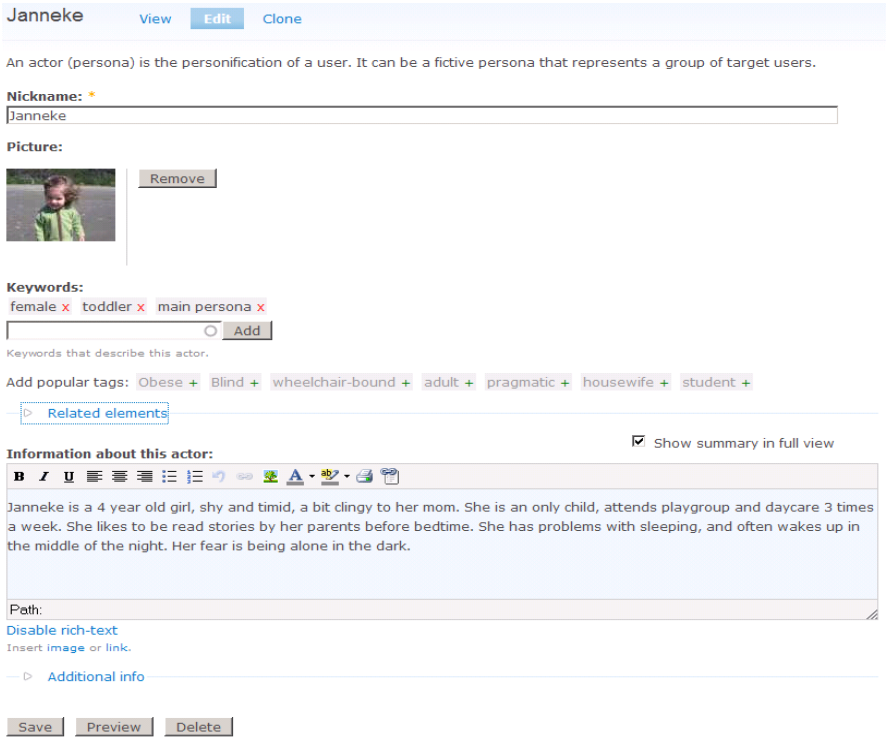
and organization of scenarios in a realistic context of design practice. Two companies, one of which is *the company*, were involved in the evaluation to probe for the scope of applicability of the tool in industry at large. They each represented small- and big-company work culture.

Artefacts: an interactive prototype to test the realistic use of the tool in its context. Interaction scenarios were developed to familiarize the testers (i.e. design practitioners) to each available function of the tool. Figure 5 to 9 partially illustrate the implemented interactive/functional prototype, accompanied by scenarios that explain the interactions with the tool.

This step confirmed the implemented functionality and acquired additional feedback on the interactions and interfaces of the tool. The evaluation with the companies resulted in verification of the overall usefulness of the tool in their work practices. Both groups of design practitioners reaffirmed the identified requirements, which indicates that the development of this design tool has been on the right course. Additionally, they provided specific feedback on actually implementing the proposed support tool for each particular company's characteristics, which indicates the applicability of the tool in different company cultures.

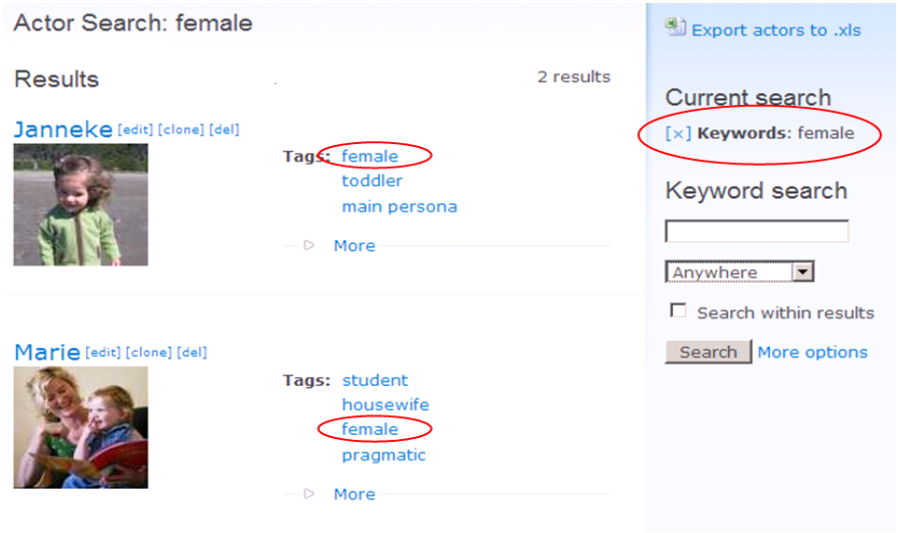
From the perspective of small-company culture as represented by *the company*, the functionality offered by the tool fits its work practice and delivers the intended benefits. The feedback is therefore more focused on the practical implementation of the tool. On the other hand, practitioners representing the big-company culture mainly explored the potentials of fitting the tool better into their more formal work practice. Complex organization structure and the large size of development teams make the adoption of the tool more difficult, particularly due to its informality. In this setting, there is often a communication protocol between departments/functions, enforced by formal deliveries from one department/function to another. The current state of the proposed tool does not cover all activities in their respective departments/functions. Therefore, its adoption is limited to how each work practice is organized.

The overall feedback from both perspectives is summarized below. While these concerns and feedback deal specifically with each particular organization, they are relevant to consider in the practical implementation of the support tool.



John creates a user profile
John writes down basic information about user Janneke and attaches a picture. To easily find this user profile later, John also adds keywords to identify Janneke. He chooses 'female' from the list of available tags by clicking on it. John types the two additional keywords 'toddler' and 'main persona' in the box, as Janneke is the first actor with these attributes. John saves the profile.

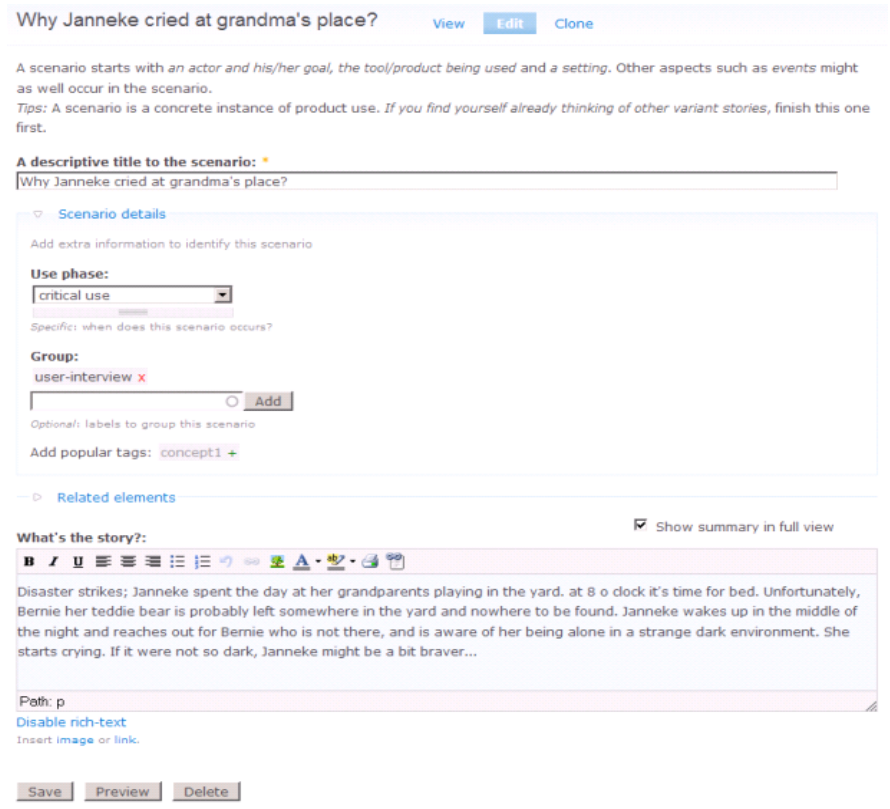
Figure 5. A screenshot of the prototype and an interaction scenario describing a function to create a user profile.



John searches for users with specific attribute

John opens the user page which lists all user profiles in the project. As he wants to show only female users, he types in the search box a keyword. Upon clicking the search button, the list is filtered. Now John only sees user profiles which contain the keyword 'female'.

Figure 6. A screenshot of the prototype and an interaction scenario describing a function to filter scenario elements (in this case, actors) based on keywords.



John composes a scenario about user Janneke

John writes down a problem scenario about Janneke. He gives a descriptive title and specifies details. As this problem scenario deals with critical use of the product, John assigns a proper use phase to it. Additionally, he gives an extra identifier using 'group' section, hinting that this scenario is based on an earlier interview with users.

Further, John makes explicit the elements that compose this scenario. He expands the 'Related elements' panel and picks other elements that relate to this scenario (Figure 8).

Figure 7. A screenshot of the prototype and an interaction scenario describing a function to compose a scenario (continued to Figure 8).

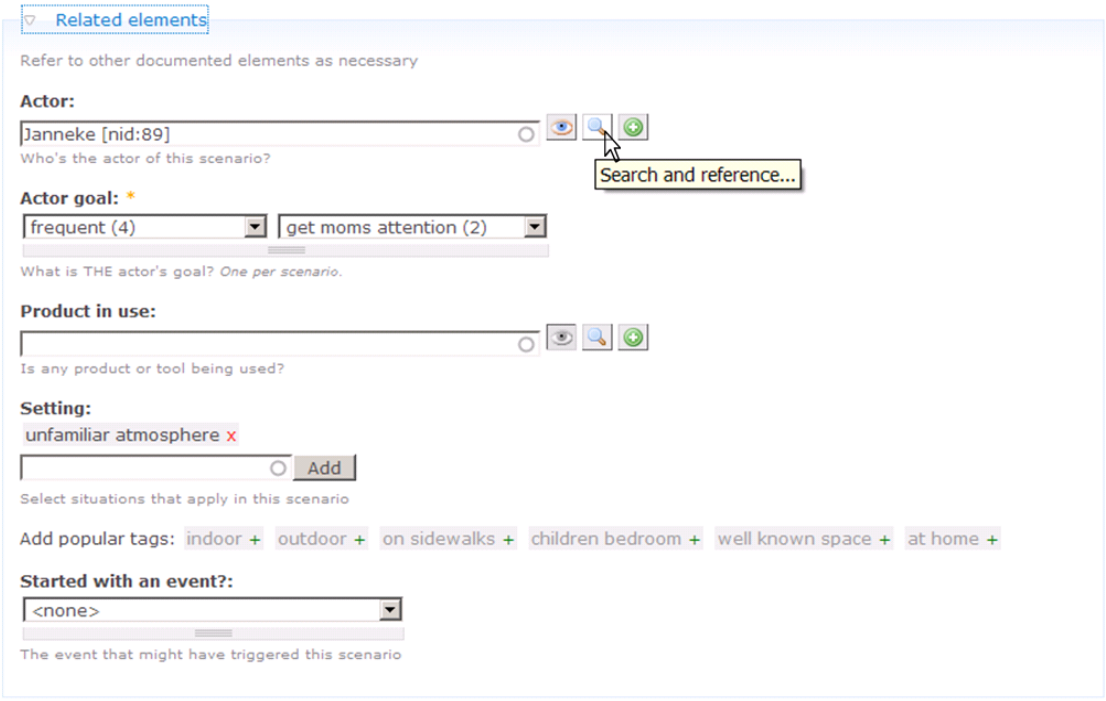


Figure 8. A scenario can relate to other types of information (i.e. scenario elements); the 'Related elements' panel in scenario creation allows making the relations explicit.

The small-company culture perspective:

- Practitioners in the small company preferred *more restriction (less flexibility) in documenting using the tool*. This is motivated by the variety of functions and levels of experience in a design team. To create a standard collaborative way of working in the organization, the tool needs to prescribe more details on which and how the data should be filled in.
- At the same time, these practitioners also wish for *more flexibility and independence in conducting other activities* their own way. The informal nature of the tool – which already allows flexibility – can be extended with a feedback functionality to ensure the reliability of work performed by the design team. Thus, instead of prescribing rigid steps to the users, the tool can for instance check the completeness of information and/or suggest relevant information for the particular design case.

The big-company culture perspective:

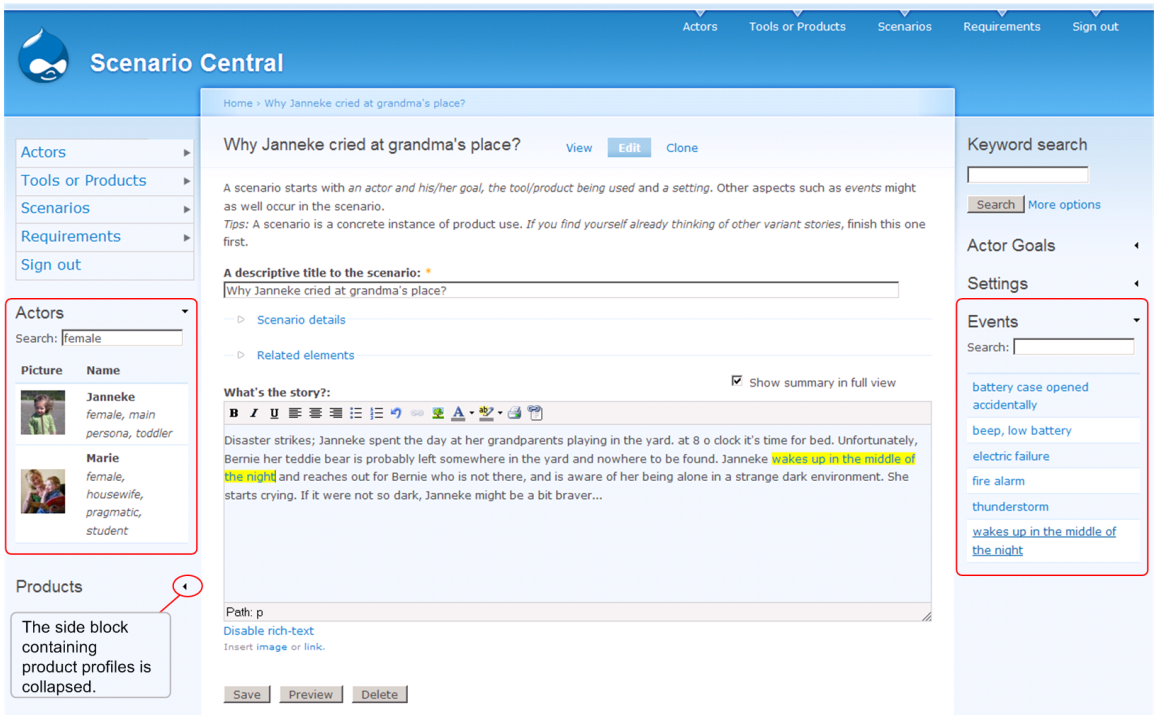
- *Responsibility* and *scope* of using the tool needs to be clear among all departments/functions in the organization. In particular, the clarity of responsibility is crucial as the team members might not have direct contact with one another. This can be supported e.g. by regulating a strict access to modules/functions in the tool.
- *Interfacing with other tools* in the organization needs to be seamless to avoid any extra work. The integration of results from various departments/functions is essential and often already addressed by a series of tools whose functions relate to one another. The current work practice needs to change as little as possible; the tool would therefore need a good interfacing and export/import function with the existing tools in a particular organization.
- The *use of visuals* needs to be more comprehensive in the tool. Scenario building is indeed a creative visual exercise, which needs to be an inspirational process. Among the formal tools implemented in a big organization, many rely heavily on text. Additional use of the tool needs to balance the practitioners' interactions with formal, largely textual artefacts with more visual, informal ones.

Summarizing, the case study aimed to answer three

main questions concerning 1) the current state of scenario-based approaches in practice, 2) the practical use of scenarios and its potential extensions, and 3) the form of support that fits in a realistic context of design practice. The above mentioned steps have given insights into these questions. The types of scenarios which are already or potentially in use to support realistic design projects have been identified. With scenarios accepted as effective syntheses of design information, activities that are problematic and thus requiring support have been specified, i.e. in creating, using, and organizing scenarios. Finally, a proposal for a support tool and recommendations for implementing the support tool in realistic organizational settings have been delivered. Design practice has adopted scenarios in a loose manner, and often not as an integrated part of the design process. With consistent support in the activities of creating, using and organizing scenarios – the backbone of SBPD, the scenarios are more visible as effective rationales to formal design artefacts (e.g. requirements, specifications, failure modes, etc). The availability of support shapes a more concrete scenario-based approach, with enough flexibility to be adapted to each adopting design organization.

CONCLUSIONS

This research aimed to get insights in the adoption of a design methodology in practice and how the adoption process can be supported. Amidst the versatility of design methodologies, Scenario-Based Product Design (SBPD) was chosen as a focus for its presence in and relevance with the design practice in general. With its rather abstract and largely theoretical knowledge, a form of support was proposed to bridge the SBPD methodology and the concrete needs of design practice.
Following a research-through-design paradigm, a case study was carried out as a basis to formulate and test hypotheses. The initial inquiry has revealed that design practitioners at large have been using scenarios in their design thinking and reflection. Although scenarios can represent design rationales, in practice design choices and decisions are still mainly expressed as formal artefacts (e.g. requirements, specifications, failure modes, etc)



John explores other modules while editing a scenario
John finds the overview of scenario elements in collapsible blocks on the sidebars (*marked in red boxes*). He expands the 'Event' category to find events that might inspire the scenario. He clicks on a particular event and notices that it is automatically inserted and highlighted in the scenario edit window.

Figure 9. A complete view of all modules accessible in scenario creation/editing.

that regard only the product, often excluding the user or use circumstances. The process of using scenarios is often not documented and thereby the clarity of rationales behind design decisions is lost. By making this process explicit, design teams will gain an improved clarity of the rationales behind design choices and decisions and will be more motivated to sustain and explore further use of scenarios. These findings directed the development of a design tool to support the creation, use and organization of scenarios in design projects. Iterative prototype building and evaluation with design practitioners resulted in a support tool that aims to fit in the process of applying scenarios in realistic organizational settings. Furthermore, practical concerns from the design practices have been identified and recommendations have been proposed to improve the implementation of the support tool in organizations.

This research presents another perspective of research-through-design approach. While the intense use of prototypes is more prominent in the design of tangible products, this approach is proved relevant for design in a broader sense. Despite the initially abstract design questions, the varied artefacts that were developed in this research successfully assisted the breaking down of those questions. The roughness and concreteness of scenarios as prototypes/artefacts was useful for exploring and assessing ideas through the creation of a mutual understanding between the researcher and the practitioners, while it was still possible and relatively easy to change these ideas or even propose completely different ideas. Our prototypes/artefacts spanned a broader scope of design questions and were not always possible to be treated as tangible product prototypes. Nevertheless, by following the principle to build prototypes (in relevant forms) to answer design questions in each phase, we were able to bring SBPD methodology into a more concrete level. Practical design activities in this methodology were identified, for which concrete support has been developed.

A design methodology is generally built on concepts and therefore is explained in an abstract manner. Its implementation however requires the adopting organization to break it down into concrete parts that are relevant to the organization. Supporting a methodology in practice essentially means helping the organization to identify and make explicit these concrete parts. The availability of such support will provide a framework for design team members to transfer knowledge and develop expertise pertaining to the methodology. With cumulative practice-based experiences from the industry, a more solid knowledge base can be acquired which in turn will improve the design methodology.

ACKNOWLEDGEMENT

The authors wish to thank all participating companies, in particular the design practitioners who have participated in and helped organize the interviews and focus group sessions conducted within this research.

REFERENCES

Anggreeni, I. and M. C. van der Voort (2008a). "Tracing the Scenarios in Scenario-Based Product Design: A Study to Understand Scenario Generation." Design Principles and Practices: An International Journal **2**(4): 123-136.

Anggreeni, I. and M. C. Van der Voort (2008b). Classifying Scenarios in a Product Design Process: a study towards semi-automated scenario generation. Proceedings of CIRP Design Conference 2008: Design Synthesis, University of Twente, Enschede, The Netherlands.

Aoyama, M. (2005). "Persona-and-Scenario Based Requirements Engineering for Software Embedded in Digital Consumer Products." Proceedings of the 13th IEEE International Conference on Requirements Engineering. IEEE Computer Society: 85-94.

Blythe, M. A. and P. C. Wright (2006). "Pastiche scenarios: Fiction as a resource for user centred design." Interacting with Computers **18**(5): 1139-1164.

Carroll, J. M. (2000). Making Use: Scenario-Based Design of Human-Computer Interactions. London, MIT Press.

Carroll, J. M., Ed. (1995). Scenario-based Design: Envisioning Work and Technology in System Development. New York, USA, John Wiley and Sons.

Dorst, K. (2008). "Design research: a revolution-waiting-to-happen." Design Studies **29**: 4-11.

Fulton Suri, J. and M. Marsh (2000). "Scenario building as an ergonomics method in consumer product design." Applied Ergonomics **31**(2): 151-157.

Howard, S., J. Carroll, J. Murphy and J. Peck (2002). Using 'Endowed Props' In Scenario-Based Design. NordiCHI, Arhus, Denmark.

Keyson, D. V. and M. Bruns Alonso (2009). "Empirical Research Through Design." Proceedings of IASDR conference. Seoul, Korea.

Lim, Y. and K. Sato (2006). "Describing Multiple Aspects of Use Situation: Applications of Design Information Framework to Scenario Development." Design Studies **27**(1): 57-76.

Moggridge, B. (1993). "Design by story-telling." Applied Ergonomics **24**(1): 15-18.

Nielsen, L. (2002). From user to character: an investigation into user-descriptions in scenarios. Proceedings of the 4th conference

on Designing Interactive Systems: processes, practices, methods, and techniques. London, UK, ACM: 99-104.

Tideman, M., M. C. van der Voort and F. J. A. M. van Houten (2008). "A New Product Design Method based on Virtual Reality, Gaming and Scenarios." Int. Journal on Interactive Design and Manufacturing **2**(4): 195-205.

Weidenhaupt, K., Pohl, K., Jarke, M., & Haumer, P. (1998). “Scenarios in system development: current practice.” IEEE Software **15**(2): 34-45.