From collection to reflection : on designing Freed, a tool for free and flexible organization of designers' digital work

Philip Mendels

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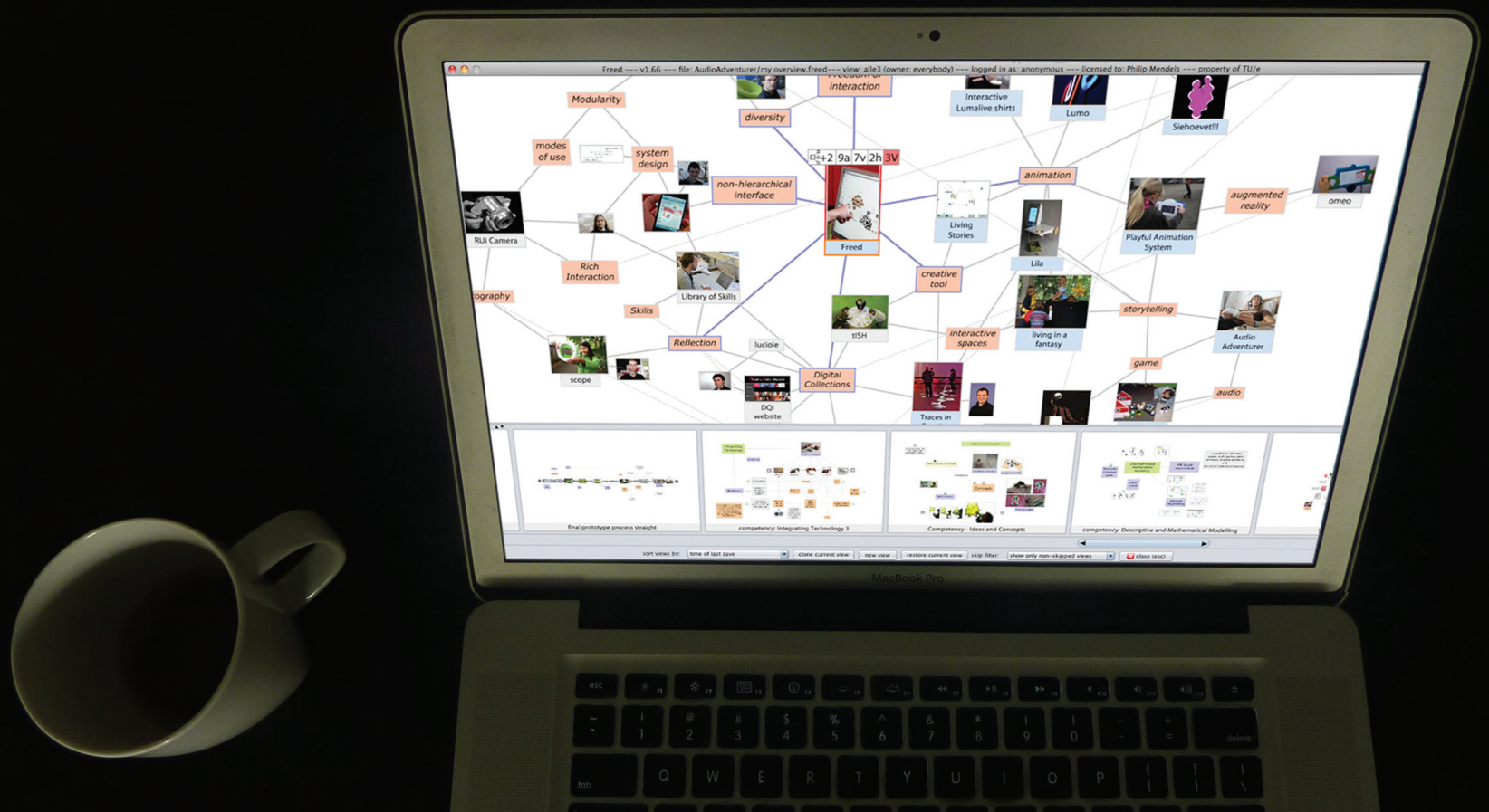

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PROEFONTWERP

ter verkrijging van de graad van doctor aan de
Technische Universiteit Eindhoven, op gezag van de
rector magnificus, prof.dr.ir. C.J. van Duijn, voor een
commissie aangewezen door het College voor
Promoties in het openbaar te verdedigen
op donderdag 7 februari 2013 om 16.00 uur

door

Philip Mendels

geboren te Nijmegen

De documentatie van het proefontwerp is goedgekeurd door de promotoren:

prof.dr.ir. C.C.M. Hummels
en
prof.dr.ir. J.H. Eggen

Copromotor:
dr.ir. J.W. Frens

This project was initiated by the late prof. dr. Kees Overbeeke.

“You hear a lot of people say that they want to make software easy to use, or they want to delight their users, or they want to make things simple … Those are nice thoughts, they give you a direction to go in, but they are too vague to be directly actionable.
…
My guiding principle is that creators need an immediate connection to what they create.“

Brett Victor, designer of tools for understanding and creativity.
Quoted from presentation ‘Inventing on Principle’ at CUSEC 2012.

“It started as a process of experimentation, but it very quickly became a process of discovery. It’s like sitting on top of a gold mine and that you don’t really have to dig, but just scoop some dirt aside and there is a little chunk of gold, and then scoop some more dirt. … The most laborious part of the process is picking up these heavy chunks of gold and moving them.”

Jonathan Blow, designer of the award winning indie game ‘Braid’.
Quoted from the documentary ‘Indie Game: The Movie’.

Contents

About this thesis by design

During my education and work as teacher and researcher at the department of Industrial Design at the Eindhoven University of Technology, I learned that a lot of information is collected during the design process, such as background research, ideas, photos and videos of designs, feedback from various stakeholders, presentations and notes. I noticed that a lot of this information gets lost in folders on individual computers, or on pages in designers' notebooks. This is a pity, because this information can be used for *reflection*.

Reflection enables people, and in the context of this research, designers, to give meaning to their experience and to develop (Dewey, 1910). When reflecting designers think about what, how and why they design. It allows them to gain overview of, gain insight in and give direction to their design process, ideas, designs, skills, knowledge, interests and ambitions. Reflection concerns *integration*, i.e., to explore relations, and *diversity*, i.e., to explore new perspectives.

Reflection has a dual nature (Schön, 1983). On the one hand, it is an explicit action that requires designers to step out of their immediate design work and that can be difficult and time-consuming. It might therefore be considered as conflicting with intuition, the flow of designing, and the many deadlines to make. On the other hand, it is an implicit process that happens automatically during the act of designing and is an inherent part of it.

This dual nature also holds true for how reflection can be supported: On the one hand, it helps to specifically dedicate time to reflection. One can for example plan to reflect once a week, after certain project phases, at the end of a project, during the holidays or during a sabbatical leave. On the other hand, it helps if reflection can be supported and captured 'in the action', during or right after activities that are part of the design process.

In order to gain insight in how designers' reflection can be supported by means of their digital collections, I designed a software application called *Freed*. Freed is discussed and evaluated with students and colleagues at our department. This context, which has strongly inspired and influenced this work, is introduced in the first chapter. In the second chapter, I outline the foundations, goals and the Research-through-Design approach of this research.

Although Freed has not yet been used outside of our industrial design department, this project can provide inspiration for design practice, which has similar needs concerning collection and reflection (e.g. Sharmin, Baily, Coats & Hamilton, 2010). Additionally, this work may provide a fresh perspective and inspiration for other creative design contexts that deal with visual digital work, as well as for research in fields such as knowledge management, information visualization and human-computer-interaction. Related work concerning reflection, design and collection, is discussed in the third chapter.

The main process of design and evaluation is discussed chronologically in chapters four to seven. In the fourth chapter I briefly discuss the initial design concepts, my focus on software, a first software prototype and a reflection on personal use. In chapter five the initial version of Freed is discussed, as well as first feedback from design students and a case study in which the software was used for building a presentation and collection of our research group. Chapter six focuses on the use of Freed during individual student design projects. It includes a discussion of a design iteration, an introductory workshop and questionnaire, and a main evaluation. In chapter seven the focus moves towards using Freed as a tool for exploration. It contains a discussion of a final design iteration, an evaluation during which students used Freed to explore their personal views on design theory, a case study of designer-researchers using the software for organizing student projects, and concludes with a reflection on personal use of Freed.

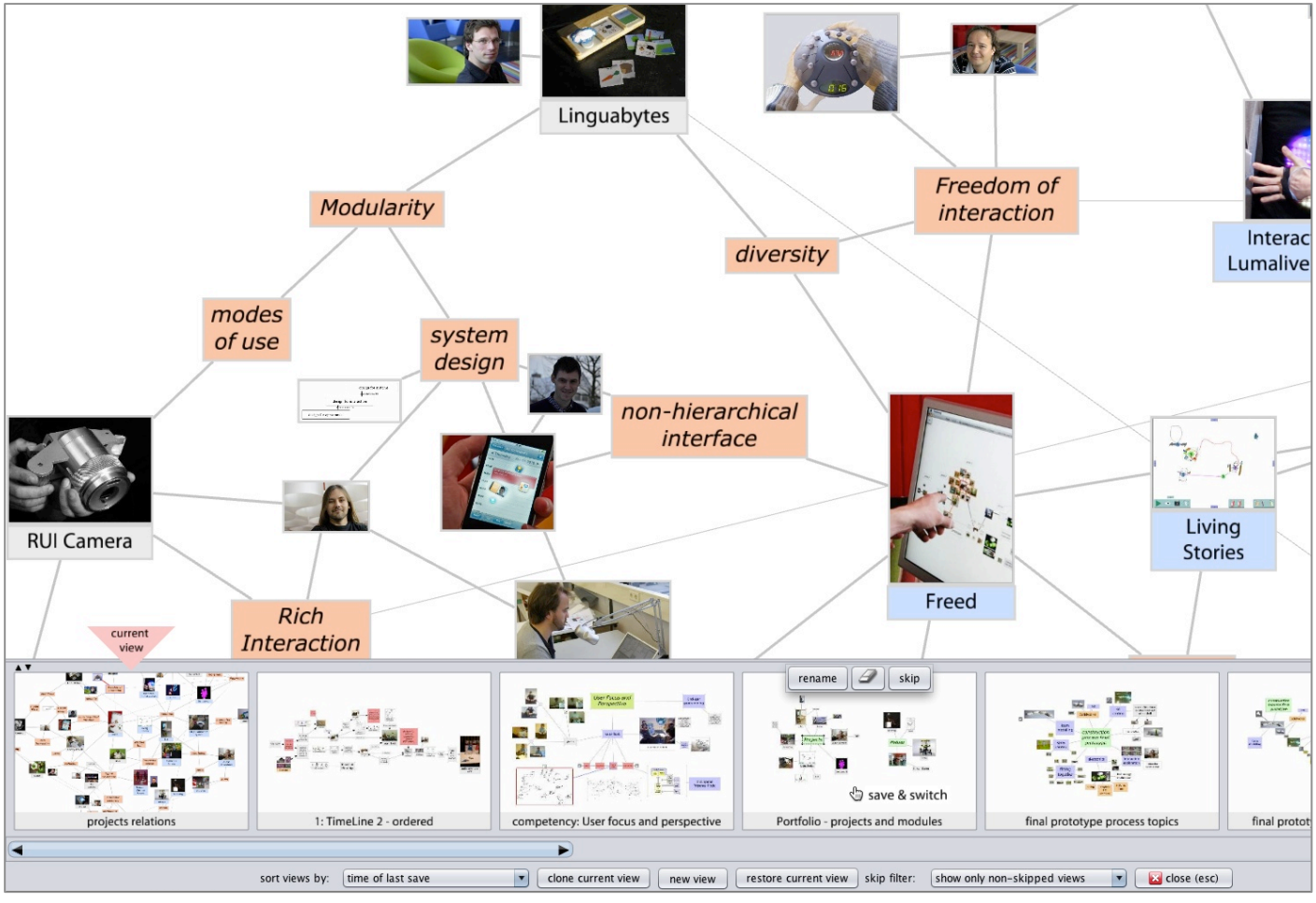
In chapter 8 I reflect on this research as a whole, by discussing ‘conditions for collection and reflection’, opportunities for future work, and Research-through-Design.

An impression of Freed

Freed is a software application that allows for free and flexible organization of designers' digital work (Mendels, Frens & Overbeeke, 2011; Mendels, 2011). Its main goal is to facilitate reflection. Prominent elements of Freed are a zoomable unconstrained canvas, a force-based layout, and the possibility to create multiple organizations of the same content. The purpose of the force-based layout, in which related content attracts each other and non-related content repulses each other, is to encourage the exploration of relations and different spatial organizations. These organizations, or 'views', can for example be used for a specific design activity or project phase (e.g. presenting, mapping related work), for creating an overview of the entire design process, for a portfolio of multiple projects, or for explaining the perspective of a given designer or stakeholder.

The software, as well as a video impression of the software, can be found at:

http://dqi.id.tue.nl/freed/



Freed features an unconstrained zoomable canvas on which content can be flexibly organized with the help of a force-based layout. Additionally, it allows for creating and exploring multiple linked spatial organizations ('views') of the collection content.

1 Context and personal motivation

The topic of this research is based on a strong personal motivation, which is shaped by my education and my work as teacher and researcher at the department of Industrial Design at the Eindhoven University of Technology. It is this department that provides the context for this research. I will therefore introduce my focus on reflection and digital collections based on my personal experiences, following three different yet highly related perspectives: My education in design, design teaching and design research.

1.1 My education in design

In the year 2001 I started my university education as part of the first batch of students at a brand new department: The department of Industrial Design (ID) at the Eindhoven University of Technology. ID was set up in close collaboration with industry, which realized that there was a need for academically trained industrial design engineers that were able to bridge new technological and business opportunities with societal- and user desires and needs. The motto of the department, *Designing Intelligent Products, Systems and Related Services,* connected to research areas such as ubiquitous computing, pervasive computing or ambient intelligence (the latter developed at Philips in Eindhoven in the late nineties: Aarts & Marzano, 2003) that imagine a world in which electronic devices are embedded in our everyday environments, working together intelligently to make our lives easier.

Besides the focus on innovative content, the department also chose for an innovative project- and competency based learning system. The contradiction with high school could not have been greater: I switched from a system of *structure*, memorizing and grades, to a system of *freedom*, self-responsibility, creativity and qualitative feedback. In this system, forty percent of time was spend on assignments in which relatively specific skills and knowledge were learned. The other 60 percent of time was spent in longer team-projects, often with real clients, in which the knowledge and skills learned in assignments and previous projects were applied. These projects were divided over several domains, such as *entertainment, home, communication* and *work*. The first bachelor year consisted of six team projects, the second year three, and the final Bachelor year an internship of one trimester and an individual final bachelor project of two trimesters.

1.1.1 Reflection during the design process

The project descriptions were usually very open, describing the client and sketching a target user group and topic of interest. This implied that there was a lot of space for designing new products and systems, rather than improving on existing ones (e.g. Figure 1.1-1). In terms of the resulting design process, this usually implied that the topic of the project was explored by doing background research into the client, user and related work, and by generating many ideas. These ideas were then developed into a few more detailed

‘concepts’ by means of a process of selection and combination. These concepts were presented in an interim presentation, and finally one concept was chosen and worked out by means of sketches, scenarios and models. At the end the project was summarized in a final report and presentation.

The sense of freedom within the projects had something beautiful: It was exciting to ‘invent’ new things. But the freedom also came at a price: The lack of structure in the form of clear problems to solve, existing work to improve or iterate on, and existing design cases and processes to draw inspiration from, made it easy to loose *overview.*

This overview was needed to *converge:* to *integrate* aspects of the design situation, such as goals, ideas, concepts, directions, insights, observations, feedback, doubts, issues, questions, requirements, personal opinions and planned activities, and to *focus* on the ‘right’ aspects. Moreover, the overview was necessary to make sense of what we were doing, and to think about what we considered to be ‘right’ for the specific project. If we had the feeling that we were not on the right track, or that our explorations were too narrow, we needed to *diverge* and think about additional directions or perspectives to explore.

In short, we needed to *reflect* on our actions and experiences. Doing this was not easy. First of all, it was often hard to step out of the immediate design work: Detailing a design concept, or getting a prototype to work was generally easier, more fun, and seemingly more result-oriented (with deadlines approaching), than to ‘stop and think’. Secondly, gaining overview was hard because our work was scattered over many pages in our physical notebooks, loose A4-sheets, A0-sized flip-over sheets, and many different digital files (e.g. reports, presentations, images, videos, text files, CAD-files, graphs or diagrams) in folders in our individual laptops (Figure 1.1-2). Additionally, (enough) space for creating physical overviews of work, for example on the wall, was not always available.

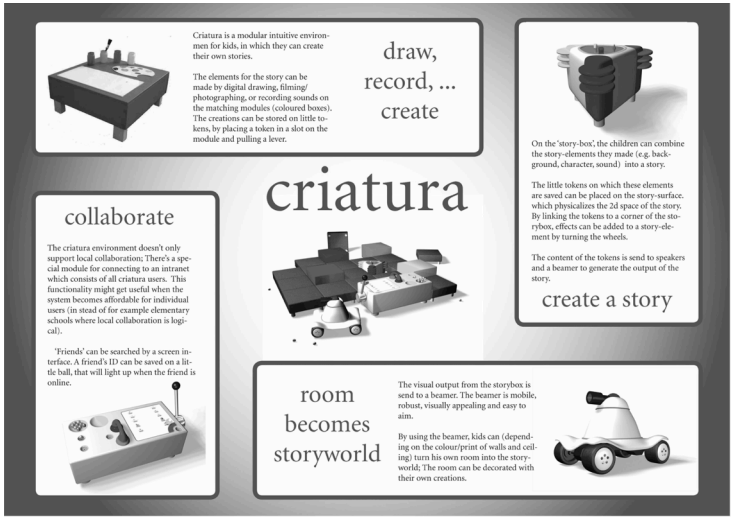


Figure 1.1-1. Poster describing the final concept of one of my first-year team projects in 2001 (6 weeks, 4 team members). The final concept is a creative collaboration system for children, which blends the physical world (their room) and a virtual story world.

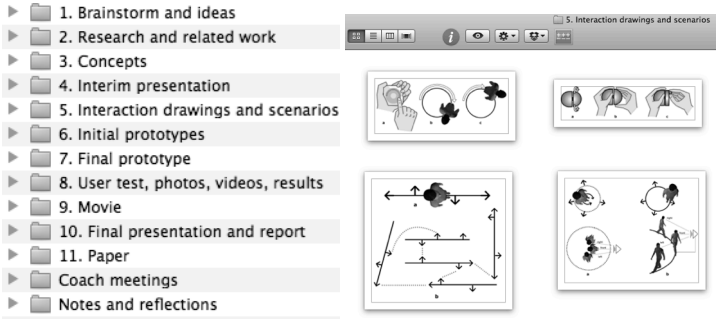


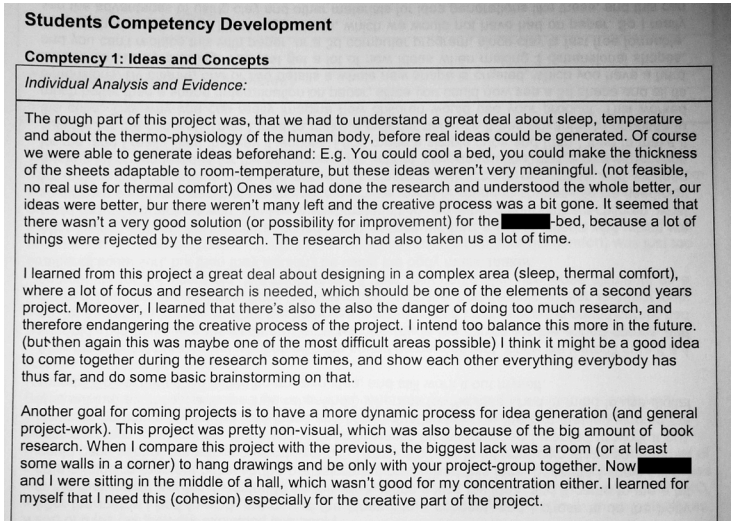
Figure 1.1-2: Standard file browsers do not provide an integrated overview of work and thereby do not allow for the exploration of non-hierarchical relations (e.g. between work of separate project phases) and the integration of visual work and text, such as notes, user/coach/client feedback and reflections.

1.1.2 Reflection on learning and on the design process

There was not only freedom within the projects, but also in planning our own education. Many assignments and projects were available to choose from and were running concurrently, and each had their own specific possibilities for learning. We could select projects and assignments based on our interests, but there was also something else at stake: At the end of a learning period (a trimester) we were mainly assessed on our *competency development*. Within our department, a competency is defined as an individual's ability to select, acquire, and use the knowledge, skills, and attitudes that are required for effective behavior in a specific professional, social or learning context. Examples of competencies were *ideas and concepts, integrating technology, form and senses, user focus & perspective* and *design and research process*. It was our own responsibility to make the proper choices for obtaining a balanced competency profile. A particular challenge was that the competency goals were sometimes conflicting with the project goals, which required additional planning, discussion and reflection.

Apart from being 'guided' by this competency framework, we were also coached: Our project coaches gave feedback during our projects and provided us with written qualitative feedback at the end of the project, and assignors gave us written feedback at the end of an assignment. Competency coaches helped us to keep track of our competency development, and wrote qualitative feedback at the end of the trimester. An assessor would then assess us on a *self-evaluation* that we had to write, and provided us with final feedback and advice for the next trimester.

The self-evaluation was a digital document template in which we had to reflect on our competency development, on our learning activities (two projects and four assignments) and on all the feedback that we had obtained (figure 1.1-3). We also had to include hyperlinks to 'evidence' in the form of deliverables (e.g., reports, images, videos) and feedback. In contrast to the often implicit and non-documented reflection *during* our learning activities, the self-evaluation forced us to reflect explicitly, but *after* the learning activities.



Students Competency Development

Comptency 1: Ideas and Concepts

Individual Analysis and Evidence:

The rough part of this project was, that we had to understand a great deal about sleep, temperature and about the thermo-physiology of the human body, before real ideas could be generated. Of course we were able to generate ideas beforehand: E.g. You could cool a bed, you could make the thickness of the sheets adaptable to room-temperature, but these ideas weren't very meaningful. (not feasible, no real use for thermal comfort) Ones we had done the research and understood the whole better, our ideas were better, bur there weren't many left and the creative process was a bit gone. It seemed that there wasn't a very good solution (or possibility for improvement) for the [redacted]-bed, because a lot of things were rejected by the research. The research had also taken us a lot of time.

I learned from this project a great deal about designing in a complex area (sleep, thermal comfort), where a lot of focus and research is needed, which should be one of the elements of a second years project. Moreover, I learned that there's also the also the danger of doing too much research, and therefore endangering the creative process of the project. I intend too balance this more in the future. (but then again this was maybe one of the most difficult areas possible) I think it might be a good idea to come together during the research some times, and show each other everything everybody has thus far, and do some basic brainstorming on that.

Another goal for coming projects is to have a more dynamic process for idea generation (and general project-work). This project was pretty non-visual, which was also because of the big amount of book research. When I compare this project with the previous, the biggest lack was a room (or at least some walls in a corner) to hang drawings and be only with your project-group together. Now [redacted] and I were sitting in the middle of a hall, which wasn't good for my concentration either. I learned for myself that I need this (cohesion) especially for the creative part of the project.

Figure 1.1-3. Excerpt from one of my self-evaluations from the end of the first trimester of the second year of my bachelor education (in 2002), in which I discuss some of the creative problems in a project about increasing thermal comfort in beds. We focused too early on 'intelligent' solutions for automated temperature control, and forgot to explore solutions for letting the users control the temperature themselves.

The main part of the self-evaluation consisted of distinct sections for reflecting on the separate competencies. An advantage of this structure was that it helped to write about what was learned, rather than what was done. A disadvantage was that the structure made it difficult to discuss the learning process of a learning activity in one coherent story. Especially the projects were related to various competencies, and the project reflections were therefore dispersed over many document sections. Additionally, because there was overlap between the competencies, it was often hard to choose where to put the reflections. Finally, it was hard to show relations between competencies, and it was hard to gain a good overview of the 'evidence'.

Another disadvantage of the competency-based, top-down style of reflection was that it made me often put too much effort in reflecting on each competency, and therefore spend too many words on minor learning points. Part of this effort might have been better spent using a bottom-up approach to reflection: By focusing on the most important learning points of the learning activities.

Finally, writing the self-evaluation was difficult because it had to be done in a short time at the end of the trimester. In this time span we did not only have to write, but we also had to revisit and select work, notes and feedback, and digitize these if they were not already digital. A more structural and integrated reflection and collection process *during* the learning activities was greatly missed.

1.1.3 Reflection on development, identity and community

Towards the end of the Bachelor, and during the Master, keeping a balanced competency profile became less important. We were allowed to become more specialized by making more choices that fitted our own interests. The projects also changed from team projects to individual projects. I highly value the diversity that

developed between students, which was supported by the large variety of assignments and projects to choose from, the aforementioned openness of the projects, and the possibility to set up your own individual project. These changes also asked for another level of reflection. Instead of reflecting on design content, process and general competencies, and thereby gaining an awareness of what design was about, it became more important to reflect on our *identities* and the specific topics and competencies that matched these identities.

Over the years I found out that recurring themes in my work were imagination, storytelling, creativity and expression. I learned that I needed to trust more on intuition and exploration than on literature research and theory. I also discovered that I preferred to create products that give people the *freedom* to actively explore and to express themselves, rather than products that try to make life easier for people by automating tasks. I worked for example on animation software for elementary school children, toys for exploring audio narratives, an interactive installation for dance-events, and a portable device for playing audio adventure games (figure 1.1-4, figure 1.1-5).

Although I gradually became aware of my identity by reflecting on my developing knowledge, skills and interests, I did miss an overview of my accumulated work of multiple years: A lot of work from previous projects and assignments, such as ideas and concepts, collected related work, research and feedback was scattered over different physical notebooks, hard-drives, and back-up CD-ROMs. The lack of a visual overview made it difficult to use previous work as information or inspiration for later work, but also to see relations between projects.

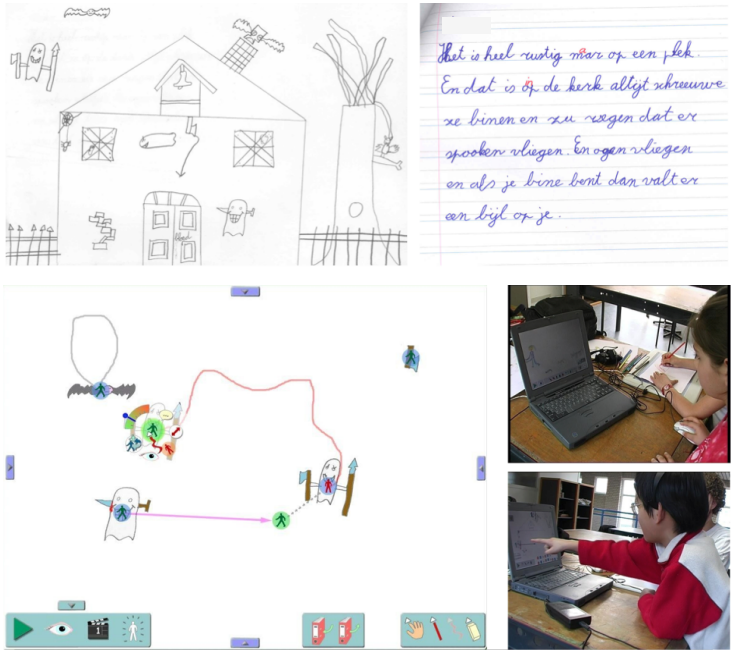


Figure 1.1-4. My individual Bachelor graduation project (2004): animation software for elementary school kids. After initially taking a top-down research-driven approach in which I tried to structure and automate aspects of the children's stories (e.g. plot, character-roles), I switched to a bottom-up, intuition-driven approach and gave the children the freedom to breath life into their own drawings and stories.

Finally, reflecting on identity and development does not only mean reflecting on personal work, but also on the *community*. I missed the possibility to place my own work, interests, knowledge and skills in the context of those of other students. And not only of other students: I missed an overview of the work of the entire department, with all its educational and research themes.

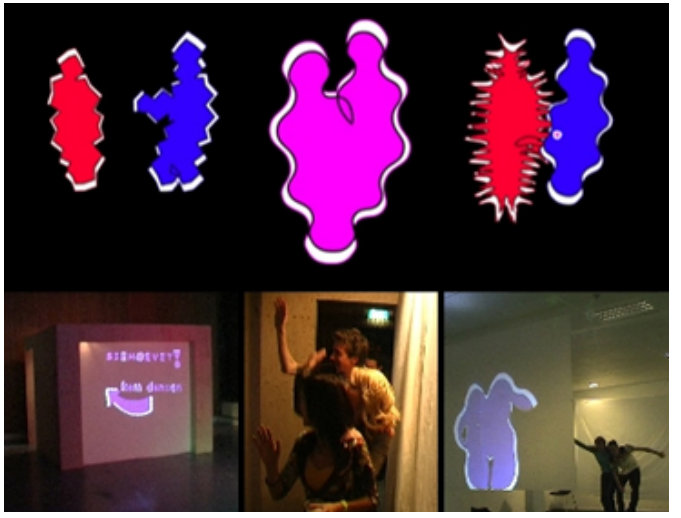


Figure 1.1-5. Various projects that show my identity as a designer of 'tools' for exploration and imagination.

Top-left: Furniture for combined digital and physical creativity.
(team project with Michael Cruz, Julia Frederking and Joris van Gelder)

Center: Non-linear audio narratives that can be explored by playing with physical toys. (Individual bachelor internship) (Fontijn & Mendels, 2005)

Top-right: An interactive visual dance installation.
(individual first-year Master project)

Bottom-right: A portable device for playing audio adventure games.
(Individual final Master project) (Mendels & Frens, 2008)

1.2 Design Teaching

During the last years of my education, many changes had taken place in design education at our department. Instead of domains, education became organized in more flexible *themes* that could easier respond to changing interests in education, research and society. Students are now assessed once each semester and have only one project per semester, allowing for more depth to be reached within projects. This extra project time, in combination with better prototyping tools and platforms, has brought much more attention for experiencing and evaluating *prototypes*. Instead of midterm and final presentations, there are now midterm and final *exhibitions*, which allow for interaction with prototypes and for gaining a better overview of the work that is done in the department.

More attention is given to the *vision* of students. This vision can be relatively modest and specific to the topic of a project, or it can be a bigger vision about how to transform society. Students do not create a self-evaluation anymore, but a *showcase*. This online learning portfolio is usually a website that the students create themselves from scratch. Its open structure allows for more personalized, visual and integrated reflection on and presentation of work, competencies, development, identity and vision. In order to support timely reflection students need to create a draft-showcase mid-semester, and a *personal development plan* at the start of the semester, which contains concrete goals concerning assignments to choose and activities to address in the project.

When I became involved in teaching and research, I came to work in this adjusted educational approach. In the following subsections I reflect on these changes, as part of my experiences in coaching and assessing students and setting up student projects.

1.2.1 Coaching student projects

From the start of my PhD project I have been involved in setting up projects for design students, and coaching these students. If my students lost overview or got stuck, I could remind them in weekly meetings of underexplored aspects of the project, or provide them with fresh perspectives. The latter was partly possible because I was more experienced with complex design situations, but moreover because I was much less absorbed in the projects than the students were. This, however, also constituted a major challenge: Although I had a reasonable overview of what *could be done*, it was hard for me to keep an overview of what the students *had done*, which plans they had, and how they had divided their tasks. This became obviously harder when coaching multiple student projects at the same time. As a result, in most meetings considerable time was spent reminding me of what was discussed in previous meetings and how this connected to what the students had done. This shows that also from a coaching perspective, a visual overview of project work was missing.

If space was available, overview could be partly gained from physical work in the students' workspaces, such as printouts from research, sketches, brainstorms and models. Almost every student

group also placed a big planning in their workspace, showing divided tasks and important dates and deadlines, occasionally accompanied by lists with requirements or diagrams of the desired design process (figure 1.2-1). However, plannings, process diagrams and requirement lists did not give an integrated visual overview of design work and process, making it difficult to see relations between work, decisions, ideas, requirements, insights, related work and feedback. Additionally, the static nature of these overviews did not capture the dynamics of the design process.

A disadvantage of longer design projects is that there are fewer moments for reflection in-between projects. In my experience this was more than made up for by the added variation and depth *within* the projects. In the projects that I coached, students often switched between activities, such as idea generation, research, and making, experiencing and evaluating models and prototypes (Figure 1.2-2). These different activities provided diverse perspectives on the project and switches between activities provided moments for reflection.

The larger variety of ideas and activities helped to give a more holistic understanding of the design situation, but it also constituted a challenge: It made it harder to keep overview. Additionally, students were often very involved in the process of making prototypes, and found it hard to take a step back and revisit their goals and insights of the first half of the project. Finally, reflection during the process still remained largely implicit, and if explicit, mainly textual. It was still difficult to make time for reflection.

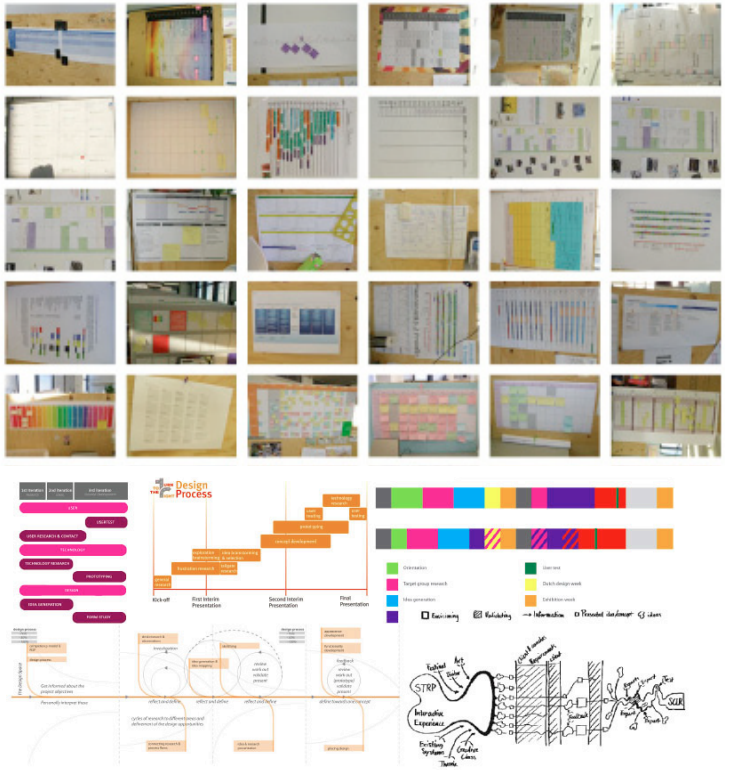


Figure 1.2-1. Plannings and process diagrams do not give an integrated visual overview of design process and work.
(source: Levy, Wijnen, Hummels and Vinke, 2011)

Figure 1.2-2. Ideas and prototypes provide valuable input for discussion and reflection. In this figure examples are shown from a second year bachelor team project that I devised and coached. The students had to design a system that allows children to make animated stories using playful and tangible interaction.

Top-left: The ideas ranged from magic mirrors to animated music installations.

Top-right: Mid-term user tests with foam and cardboard models.

Bottom-Right: The final prototype allows children to create movies that combine real-time video with overlaid real-time controlled animations.

(Bekker, Hummels, Nemeth & Mendels, 2010)
(Mendels, de Haas, Heuvelings, Leijte & van 't Sant, 2009).

1.2.2 Coaching and assessing student development

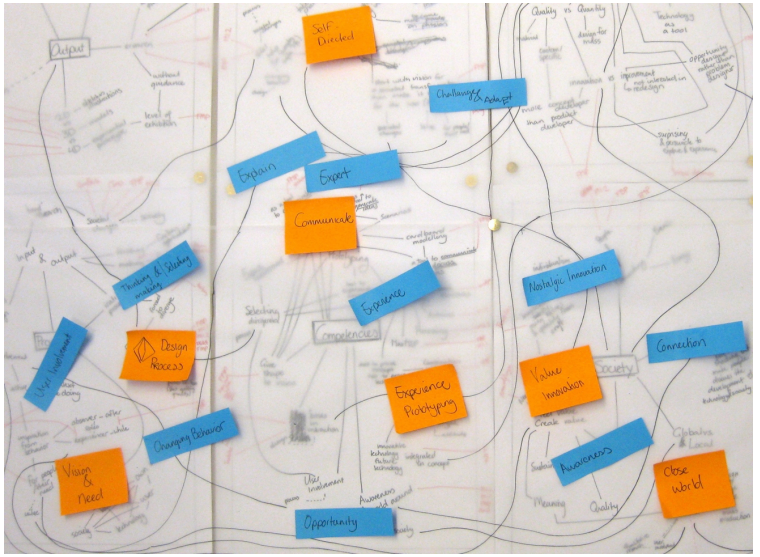
Apart from coaching students during their projects, I also had to coach their competency development and to assess the development of other students. The students' personal development plans helped me to check and possibly direct the task divisions and assignment choices. However, a large part of these plans consisted of textual information about competencies, and I often missed images and videos of work from previous projects. Additionally, I often missed information about the individual contribution to previous teamwork.

More information could be gained from the students' (previous) showcase. This gave a much better overview than the self-evaluations did, but there were still difficulties. Work and insights that students had discussed in the learning activity sections of their showcase (e.g. 'project'), was often not mentioned or linked to in the competency sections. This then required a lot of clicking back and forth between sections, which made it harder for me to get a complete image of a student's development for a specific competency and to see the relations between competencies and learning activities.

Additionally, it was often difficult to get a good overview of a student's development over multiple semesters: In the 'past' section of their showcase most students only gave a very basic overview of their previous project results, and not of their roles and competency development in these previous projects. It helped to read feedback of students' previous assessors and coaches, but an integrated visual overview of work and competency development over multiple semesters was clearly missed.

The added freedom of the showcase also provided challenges for the students. Some of my students had difficulties deciding where to place certain reflections because of the overlap between reflections on learning activities, competency development, and identity. They seemed to loose overview of the structure of their showcase. These problems, combined with the technical challenge of building a website, distract from the actual reflection.

In order to overcome part of these problems, some students first made a quick diagram of their most important learning points and a possible setup of their showcase on paper. Apart from these basic diagrams, students hardly visually explored relations within their work in order to gain new insight in their learning. There were exceptions: I spoke to a master student who created an extensive diagram on paper, consisting of her topics of interest and aspects of her approach to design that developed over the years (Figure 1.2-3). She used several days spread out over the semester to work on this overview. It helped her to have a better overview of her development and identity, and she identified several characteristics in her development that ultimately led to a more coherent showcase. She explained that although useful, this approach took her a lot of time, time that most students could not find during their projects.



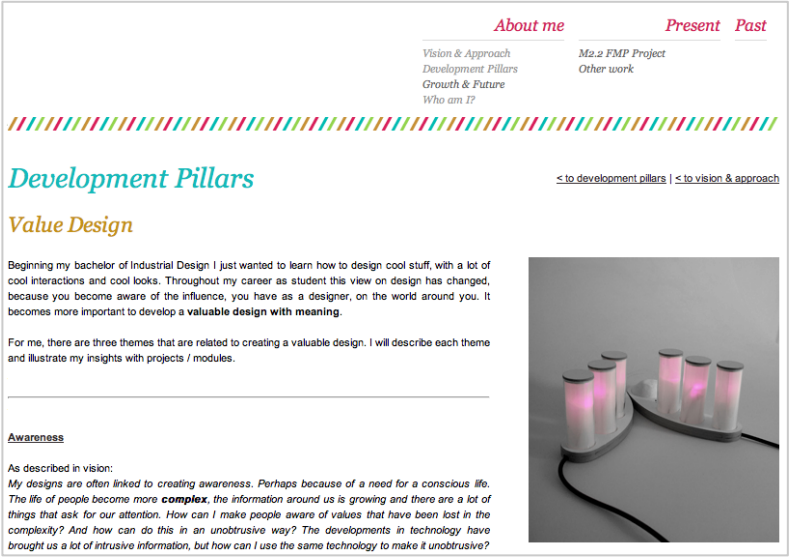


Figure 1.2-3. Showcase and preparation.

Usually students start writing reflections and building their showcase right away, but occasionally students reflect by drawing diagrams on paper in which work, interests and learning developments are clustered and related. In this example a semitransparent sheet is overlaid on the paper to draw additional relations, and post-its are used to mark themes that emerged while diagramming.

1.2.3 Setting up student projects

One of the main advantages of the exhibitions is that students and staff gain overview of all the student work in the department, thereby supporting a sense of community as well as individual identity. Students can for example better compare their own work to the work of other students. For staff the exhibitions provide inspiration and direction for their own work, and a better overview of the educational *theme* that they are involved in.

I coached in the theme *playful interactions*. The content of this theme, and therefore the content of projects and assignments, is continuously developing based on the research interests and personal interests of staff, based on student interests, and based on societal and technological developments. It is therefore not easy to keep overview of what 'playful interactions' comprises. The exhibitions help to gain overview, but are of temporary nature.

As an educational theme, we occasionally had strategy meetings to gain overview of and give direction to the theme. These meetings mainly involved writing down and reflecting on clients, topics, projects, assignments and personal interests. These reflections could then provide a common ground for setting up new student projects and assignments together. Although these discussions were fruitful, considerable time was spent thinking about what existing topics are and explaining existing projects and personal interests to each other. A visual overview of student work and personal work of the staff members was clearly missed.

1.3 Design Research

As the final perspective in this introductory chapter, I briefly reflect on my experiences when starting my PhD research in the Designing Quality in Interaction (DQI) research group, which is part of the same department as discussed in the previous two sections.

My project started very open: In the first phase I tried to relate my own interests to the interests of DQI. During discussions with my supervisors various initial ambitions surfaced, such as to explore how *meaning* could emerge from interacting with collections, to explore how we could experience someone else's *point of view* through a collection, and to explore how to design complex collection *systems* consisting of diverse products and users. These partly overlapping topics were difficult to grasp, and an easy to explore overview of relations between topics, colleagues, students, projects, publications, collaborations and related work could have been a great starting point for further investigation.

We did occasionally create overviews in DQI reflection sessions, during which we for example clustered our topics of interest (Figure 1.3.1). Such overviews were good tools for discussion and collaborative reflection, but the lack of examples of work, such as photos, videos and publications, made them difficult to use as means for further exploration. Additionally, physically clustering topics of interest in two dimensions was hard because almost everything was related to everything. This shows the need for a *digital* overview that can be used for further (individual) organization

and exploration. Such an overview may also help to gain insight in the *process* of designing and researching. Finding a focus, and a proper balance between design and research was far from easy. It would have been helpful to see how other PhD students started their projects, explored various topics, focused their projects, and integrated their design and research processes.

Figure 1.3.1. An overview of topics of interest generated during a DQI group reflection session. First common interests were explored in pairs and written on cards. These cards were then clustered on a big cardboard surface. From these clusters main topics of interest (yellow) were defined and added to the overview.

1.4 Conclusion

Overview, relations and perspectives

In this chapter I used my personal experiences to discuss that reflection is needed in diverse situations, in order to gain overview of, gain insight in and give direction to design work. These diverse situations shared a similar need: A digital *overview* of design work, in order to facilitate reflection. This overview needs to support *diversity* and *integration*, or in other words: It needs to facilitate the creation and exploration of multiple *perspectives*, but also the exploration of *relations* between perspectives.

Examples of perspectives are the many aspects within a design project, the skills, interests or ambitions of a design student, teacher or researcher, the different sections of a students' showcase (learning activities, competencies, identity, development), the topics and projects within an educational theme, the educational themes within our department, the topics and projects within a research group, and finally the perspectives that were used in this chapter: design education, teaching and research.

Integration of contexts and activities

A flexible digital collection system is needed that can be used across activities and contexts. Work and reflections that are collected and organized *during* the design process can later be used for reflecting *on* the process or for reflecting on multiple projects, perhaps of multiple designers in a community. Vice versa, work and reflections collected in dedicated (collaborative) reflection sessions can be useful during design processes. Finally, an integrated collection of work of students, teachers and researchers can benefit the community as a whole, by providing opportunities for collaborative reflection.

2 Foundations, goal and approach

In this research I explore how designers' reflection can be supported by means of their digital collections. I do this using a Research-through-Design approach. I aim to gain insight in this highly under-constrained 'problem' through a holistic process of designing, using, discussing and evaluating interactive prototypes in context. In the next section I first briefly discuss the theoretical foundations of this research. After that I elaborate on my goal and approach.

2.1 Freedom, action, meaning, reflection

My focus on designers' digital collections comes partly from the fact that a lot of content is digital by nature (e.g., photos, videos, work created in software), but also because of the *freedom* that computers provide. They allow for the enhanced storage, distribution, integration, access and search of collections, but also for *active* experimentation in the form of animation, simulation and reorganization. The latter is for example supported by the possibility to easily copy content and undo changes.

Key to this research is the idea that active organization, exploration and other use of digital collections helps designers to give *meaning* to their experience. This relation between action and meaning is central to the philosophical school of Phenomenology. Dourish (2001) describes how for the phenomenologists, meaning is not to be found in abstract reasoning, but in the world in which we act and that acts upon us. Building on their work, he uses the term *embodiment* as '*the common way in which we encounter physical and social reality in the everyday world'*, and argues that this is missing in how we interact with our computers. He therefore makes the case for *embodied interaction*, which he defines as '*the creation, manipulation and sharing of meaning through engaged interaction with artifacts'*. He discusses that meaning is a phenomenon that emerges in interaction. It is found in how a product or system influences our actions. It is not to be found in the *design* of a system, and neither in the *content* of an information system:

> *"[In the context of 'Knowledge Management'] knowledge is pictured as an almost physical phenomenon that can be extracted, transferred, exchanged, stored, indexed, retrieved, and managed [however] practical investigations show that the real cornerstone of organizational knowing is people […] whose role is to understand how the information stored in the repositories can be applied to real problems." (Dourish, 2001: p185).*

Dourish argues that designers of information systems have to look beyond simple action, at *practice.* Practice concerns how action fits into a wider scheme of activity that makes it meaningful. Practice evolves around technologies over time, and within a *community of practice,* that has a shared set of meanings and values. A community *appropriates* technologies by incorporating them in their practice, and by adapting them. He gives the following two guidelines for designing information systems:

> *"… support the improvised sequential organization of action by giving users more direct control over how activity is managed, perhaps by organizing interaction as an informal assemblage of steps rather than a rote procedure driven by the system." (p160)*

> *"… support the process of improvised, situated action by making the immediate circumstances of the work more visible. The insight here is that the setting includes the current state of the system; the system should make information available to the user to guide their activity moment by moment." (p160)*

These guidelines match my ideas that in order to support meaningful interaction, a system should provide freedom in interaction, but also communicate possibilities for action and the results of our and others' actions in a natural way. This can be done by creating different graphical user interfaces (GUIs) that rely less on our cognitive skills, for example by drawing inspiration from our interaction with the physical world, but it can also be done by taking information and interaction out of the traditional computer setup and into the physical, social world.

The latter may be done using various technologies, such as mobile devices, large multi-touch screens or projections, flexible screens, augmented reality, and perhaps holograms. Another option is to represent digital information with physical objects. This is generally referred to as *Tangible Interaction,* which concerns the direct coupling between digital and physical representations (Ullmer & Ishii, 2000). Ullmer, Ishii and Jacob (2004) discusses various types of tangible user interfaces (TUIs): *interactive surfaces*, on which projected images are manipulated through tangible objects, *constructive assemblies*, in which tangible objects are used as building blocks to manipulate digital information, and *token+constraints systems*, in which the movement of tangible objects is constrained by their surrounding physical structure.

However, simply making digital information and interaction physical does not automatically enable meaningful interaction. This is articulated by Djajadiningrat, Frens, Wensveen & Overbeeke (2004), who notice that many TUIs do not really make use of the action potential and inherent feedback of the physical world and mainly address the user's cognitive skills. TUI objects usually represent data and use metaphors and semantics to communicate their meaning. The authors note that as meaning emerges from our interaction with the world, products and systems should address all skills that people naturally use for interacting with the world, including perceptual-motor, social and emotional skills.

In conclusion, meaning emerges from interaction, and therefore requires freedom. Computers can provide freedom by releasing us from the constraints of the physical world. However, freedom also requires attention to the full range of human skills, which are tuned to the constraints of the physical world. This brings me back to *reflection*, which is often discussed in the context of a constructivist view on learning. Pivotal in that view, is that *activity* takes a central role in learning (Swan, 2005). Learning is an active, social process in which learners give meaning to their experience. I discuss reflection and its relation to design in more detail in the next chapter. In the following section, I first elaborate on my goal and approach.

2.2 Goal and approach

Diversity and Integration

In order to explore how designers' reflection can be supported by means of their digital collections, I set out to design a system that allows for active exploration, organization and use of these digital collections. As concluded in the previous chapter, this system should support *diversity* and *integration*, or in other words: It should facilitate the creation and exploration of multiple perspectives, but should also facilitate gaining overview of and exploring relations between perspectives. It should also be useable *during* the design process, to support reflection as part of daily practice, and to let the collection *grow*.

Freedom and Flexibility

The system should be *flexible,* so that it is easy to switch between perspectives on design work, and so that this work can be easily reorganized for or reused in diverse situations. And, as noted in the previous section, it should support *freedom* in interaction: It should not try to impose meaning by structuring or analyzing designers' collections for them, or by exactly defining how designers should use their digital collections in the context of their work. Designers should be able to construct their own meaning by appropriating the system, and by using it in diverse situations in their daily practice.

The importance of freedom as part of tools *for designers* is addressed by Stolterman (2008). Building on a study by Rogers (2004), he discusses that many tools that try to reduce design complexity lead to highly time- and energy- consuming approaches: The approaches themselves become too complex. Successful tools keep the designer's *freedom* intact. They, for example, do not demand a specific step-by-step sequence. He explains that design complexity can also have positive values. It constitutes a challenge, and leads to rich experiences and variation. He further argues that interaction design research aimed at supporting design practice must be grounded in a fundamental understanding of design practice, and not borrow methods from science that aim to reduce complexity.

Research-Through-Design and case studies

This brings me back to my approach, Research-through-Design (RtD), which is holistic by nature. In line with Frayling's concept of RtD I focus on making the right thing, to transform the world to a preferred state (Frayling, 1993). In my case this is a state in which the use of digital collections for reflection, next to or as part of other design activity, helps designers to gain overview of, gain insight in and give direction to their work. It is also a state in which reflection is not a process of abstract reasoning, but a process that is directly connected to design action: Previous (result of) action that is stored as digital collection content, or new action that makes use of collection content.

Following Zimmerman, Forlizzi and Evenson (2007), I aim for a novel integration of theory, technology, user need and context to create a system prototype that can serve as inspiration for the design research, practice and education communities. I opt for evaluating the system using case studies, in line with Shneiderman and Plaisant (2006). They discuss MILCs (Multi-dimensional In-depth Long-term Case Studies) as research method for studying information visualization tools, because traditional methods such as controlled experiments on specific features or gross comparisons of one tool versus the other seem to narrow: Controlling for individual differences seems to be nearly impossible, and specifying tasks seems to contrast the goals of innovation and creativity (and in the case of this project: design and reflection).

The proposed approach implies amongst others that users use a tool in their own environment for their own goals (which may change during the process), that they are encouraged to keep using the best tool for each task (i.e. that they not try to please the researcher by using his/her tool), that researchers work in close cooperation with the users, train them in using the tool, interview them regularly, adapt the tool when required (‘*be flexible*’), document usage of the tool, and document users’ success in achieving their professional goals.

A final note on RtD is that it is situation-specific. It is similar to Research to Practice, which Archer defines as a form of action research that is necessarily situation-specific and usually non-objective (Archer, 1995). It is therefore ‘*difficult and dangerous to generalize from Action Research findings’*, but at the same time it “*may produce insights which might otherwise never be obtained*”, which can advance practice and may provide hypotheses for later testing in more generalizable research (Archer, 1995, p. 12).

Because RtD is situation-specific, it is important to take my personal motivations, the context, and the foundations of this research into account. I have described these in this chapter and the previous chapter. This is a ‘*creative design’* context in which design ‘problems’ are continuously reframed, as opposed to an ‘*engineering design*’ context in which designs are created to meet a specification (Löwgren, 1995). Additionally, it is important to consider the actual design and research *process*, which will be discussed in chapters 4, 5, 6 and 7. In the next chapter, I will first discuss related work concerning reflection, design and collection.

3 Reflection, design and collection

In the previous chapter I briefly discussed theory concerning meaning and interaction, which influenced the approach and goals of this project. In this chapter more specific related work is discussed in relation to the goals (support for integration and diversity) and related starting points for interaction design (freedom and flexibility). First, in section 3.1, theory on reflection and design is discussed. In section 3.2 I focus on designers' digital collections and on related systems and software for visually organizing these collections.

3.1 Reflection and design

I start this section by discussing several general definitions of reflection. Thereafter, reflection is discussed in relation to different views on design: Design as a rational problem solving activity, design as reflective practice, and design as a reflective-transformative process. I continue by discussing different moments for and scopes of reflection (in-action, on-action and on-practice), and a framework that describes conditions for, purposes of, and levels of reflection. I conclude by explaining how the discussed literature relates to my view on design, and consequently to my approach to supporting reflection.

3.1.1 Reflection

The word reflection, in relation to thinking, is not uncommon in everyday language, and usually refers to serious and conscious thinking. The Cambridge Online Dictionary (accessed March 2012) for example defines 'to reflect' as '*to think carefully, especially about possibilities and opinions*'.

John Dewey was one of the first influential thinkers on reflection. He saw reflection as a process of giving meaning to experience, and defined reflective thought as '*active, persistent, and careful consideration of any belief or supposed form of knowledge in the light of the grounds that support it and the further conclusions to which it tends'* (Dewey, 1910, p6).

Boud, Keogh and Walker (1985, p19) describe reflection as '*a generic term for those intellectual and affective activities in which individuals engage to explore their experiences in order to lead to new understandings and appreciations'.* Noticeable here is that reflection is defined more loosely: It is a process of exploration, involving emotions, not only a process of systematic thinking.

Moon (1999, p98) describes reflection as '*a form of mental processing with a purpose and/or anticipated outcome that is applied to relatively complicated or unstructured ideas'.* Noticeable here is that Moon mentions that reflection has a purpose and/or anticipated outcome, even though she also lists '*other outcomes that might be unexpected'* as possible purpose.

Kolb discusses reflection as part of a cyclic process, which he calls experiential learning (Kolb, 1984). In contrast to rote learning, which focuses on memorization and repetition without the use of meaning as basis to store information, experiential learning is learning by reflection on experience. This cyclic process has four stages:

concrete experience > reflective observation > abstract conceptualization > active experimentation

In the reflective observation stage the learner thinks about concrete experiences, and subsequently forms general rules or applies known theories in the abstract conceptualization stage. In the active experimentation phase this new knowledge is applied in new actions, leading in turn to new concrete experiences.

Although there are differences between these definitions, they share the same main idea: Reflection cannot be seen independent from concrete experience. This brings me to design: Design is all about making sense of relatively complicated or unstructured ideas through active experimentation and concrete experience. However, there are different ways of describing how design activity and reflection are related. This will be discussed in the next subsections.

3.1.2 Rational problem solving and reflective practice

Dorst (1997) compares two paradigms for describing design activity: Design as a *rational problem solving process* (Simon, 1969; Roozenburg & Eekels, 1991), and design as *reflective practice* (Schön, 1983). In the former, design is described as a rational search process in which the problem space is known beforehand. The designer has to selectively search a solution space that is defined by the problem space. In this search process the designer makes use of generalized knowledge in the form of design procedures, and this process consists of multiple iterations of the *basic design cycle* (Roozenburg and Eekels, 1991). This cycle, which is used as a prescriptive model for design, consists of the following phases:

analysis > synthesis > simulation > evaluation

In the *analysis* phase the problem is defined and a program of requirements is made, in the *synthesis* phase ideas are generated and combined into a possible solution (or 'provisional design'), in the *simulation* phase an image is formed of the behavior and properties of the provisional design by means of reasoning and testing, and in the *evaluation* phase the expected behavior and properties are evaluated based on the problem definition and program of requirements. In all phases the designer makes use of formalized general procedures, although, especially in the synthesis phase, hard to formalize creativity also plays an important role.

Schön sees the design process not as a problem solving process, but as a process of active problem setting and refining (Schön, 1983). He believes that *the essence of design lies not in generalizable laws of the design process, but in the designer's ability to deal with fundamentally unique problems, or 'situations'.*

These situations are complex and have too many variables (e.g. many possibly contradicting requirements, solutions, technologies, materials, etc.) to be represented in a finite model.

The designer uses his skills and intuition (his tacit knowledge, or his 'knowing-in-action') to create something for a particular situation. This often leads to unexpected results due to the complexity at hand. The designer 'thinks about' these results to form new understandings and appreciations, which he embodies in further action. Schön therefore calls design a '*reflective conversation with the situation*'. According to Schön, this reflective conversation consists of the following activities:

naming > framing > moving > evaluating

The designer *names* relevant factors in the situation, *frames* the problem in a certain way by putting it in a context, makes *moves* towards a solution, and then *evaluates* these moves. Valkenburg and Dorst (1998) further define the reflective conversation as follows: They define a *frame* as a (sub)problem or (partial) solution to explore further on. It is a context for further activities. They define *moving* as an attempt to solve the design problem and as an exploration of the suitability of the current frame. *Evaluation* either leads to reframing the problem, to making new moves, or, if the evaluation leads to satisfaction, to *naming* new issues.

Dorst and Dijkhuis (1995) discuss that describing design as a rational problem solving process is useful in situations in which the problem is fairly clear and existing design strategies can be used, while describing design as reflective practice is especially useful in the conceptual stage of the design process, where the designer has no standard strategies to follow. Additionally, they mention that taking the '*move*' as unit for studying design allows for description of design activity that is much closer to the actual experience of designers. These specific moves inherently *combine the content and process aspects* of design, while rational problem solving focuses on general processes.

In conclusion to a later study on using reflective practice for describing team design activity, Valkenburg and Dorst (1998) notice that stating, modifying and rejecting frames seems to be important in building an understanding of the design problem. A distinction can be made between frames that concern the design task and frames that concern the designed solution(s). *Exploring the design task, rather than immediately searching for a solution, seems to be important.*

3.1.3 The Reflective Transformative Design Process

Hummels and Frens (2008, 2009) discuss that both the reflective practice and rational problem solving paradigms share a sequential approach to gathering information, in which analysis precedes design action. They propose a new process in which *design action and analysis reciprocally give focus to each other* (figure 3.1-1). This *Reflective Transformative Design Process* has an open and flexible nature in order to support their department's focus on highly

innovative systems and societal transformation, a highly person- and context dependent competency centered learning model, and the resulting open character of the projects.

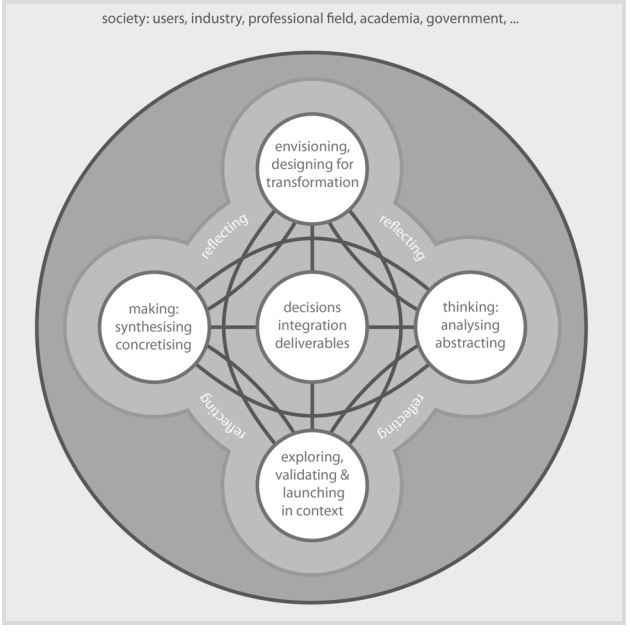


Figure 3.1-1: The Reflective Transformative Design Process.

Hummels and Frens see design as a process of taking decisions based on too little information, and they therefore see design decisions as conditional. Insight into the design opportunity and solution domain is achieved by continuous information gathering.

There are two *drives* for information gathering, which are shown on the vertical axis of the process. The top circle shows a drive for information gathering based on the student's vision. This vision can be more modest and specific to the topic of the project, or can be a bigger general vision about how to transform society that develops over multiple projects. The bottom circle shows a drive for information gathering by exploring possibilities and solutions with users in society. This is necessary because what a meaningful or valuable solution is, is highly *person- and context dependent*.

The horizontal axis shows *strategies* for information gathering. The left circle shows the strategy of using design action as means for gathering experiential information, or knowledge: Students can for example synthesize by making a physical or a descriptive model, and concretize by applying a theory to the specific design situation. The right circle shows the strategy of using academic thinking to produce more formal knowledge: Students can for example analyze the design situation or a system that is designed, and abstract the knowledge gained during the specific design situation into wider applicable theory.

The order of activities and how often is swapped between activities is not fixed. Students decide on this based on their identity as a designer, on the context, or on the phase within the design process. The process therefore supports *flexibility and individuality.* Opportunities for *reflection* occur each time the students *switch between activities*, and therefore students are stimulated to frequently make such switches.

3.1.4 Reflection scope: in-action, on-action and on-practice

As part of his work on reflective practice, Schön described three types of reflection: *Reflection-in-action, reflection-on-action* and *reflection-on-practice* (Schön, 1983, 1987; Schön & Bennet, 1996). Reymen (2003) proposes to use these three types for structuring research on reflection and for categorizing support for reflection and gives more exact definitions of the types of reflection in relation to design. She defines *design reflection* as:

> *'Reflection related to the design process in a broad sense, thinking about the design, design actions, designers, and design context, performed by individuals or teams, during or after the design process, in order to influence future design activities.'*

She defines reflection-in-action as '*thinking about doing while doing it, in such a way as to influence further doing'*. It happens when surprise occurs, it concerns micro-level design process dynamics, and its goals is to gain awareness of design cycle activities in order to decide on the next activities. Examples of questions are 'What are we doing?' and 'How is the design content developing?'.

Reflection-on-action is defined by Reymen as *'thinking about doing after doing, in such a way as to influence further doing'*. It concerns macro-level design process activities and can be planned at for example the end of design sessions, milestones or tasks, or when the team gets stuck. Its goal is to evaluate past and current design situations in order to adjust next situations. Examples of questions are 'What were critical situations?', 'Are the current design strategy and design methods appropriate for the problem?' and "Is the design answering stakeholder concerns?".

Reymen defines reflection-on-practice as *'thinking about doing after repetitive doing, in such a way as to influence further doing'.* It concerns project level dynamics and can be planned at the end of a project, or after several projects. Its goal may be to discover patterns of good and bad practices in order to influence next practices. Examples of questions are "Which patterns in design activities (re)appear?" and "What are recurring neglected design aspects?".

3.1.5 Reflection: Purposes, conditions and levels

Fleck and Fitzpatrick (2010) provide a framework for describing reflection based on a literature overview, and derive guidelines that can help to design technology that supports reflection. In the framework they distinguish *purposes of reflection, conditions for reflection,* and five *levels of reflection*. Although the levels of reflection are developed with respect to teachers' reflective practice, the authors suggest that the general principles of the levels are broadly applicable to other domains.

Drawing on Moon (1999), they name several examples of *purposes* of reflection:

"learning and the material for further reflection; action or other representation of learning; reflection on the process of learning; critical review; the building of theory; self-development; decisions or resolutions of uncertainty; empowerment or emancipation; and other outcomes that are unexpected – images or ideas that might be solutions."

The authors name several *conditions* for reflection: Reflection takes *time*, therefore time for reflection has to be created or allowed. Reflection is a developmental process, which people learn over time and with *support*. Finally, people need a reason or *encouragement* to reflect, because reflection is time-consuming and does not come naturally to most people.

As third aspect of reflection, the authors name five *levels* of reflection. *Revisiting* is level 0. It is not reflective as it only concerns describing events. Level 1 is *reflective description*. This concerns revisiting with explanation, e.g. why specific events occurred. Level 2 is *Dialogic Reflection.* This goes beyond reflective description, as relations and alternatives (e.g. alternative explanations, solutions, perspectives) are explored. Level 3 is *Transformative Reflection.* Here the explorations of dialogic reflection lead to a fundamental change in practice or understanding. Finally, level 4, *critical reflection*, concerns reflection that takes into account aspects beyond the immediate context, such as moral and ethical issues, and wider socio-historical and politico-cultural contexts.

Based on a case study, Fleck and Fitzpatrick mention that there is a certain *circularity to reflection*:

"Higher levels of reflection following from lower levels by making use of the same techniques."

Finally, corresponding to the different aspects of reflection, the authors provide three guidelines for reflection: The first is to define the purpose of reflection. They acknowledge that reflection may lead to unexpected outcomes and new ways of thinking and seeing, but they also state:

"However, key to providing a structure for reflection is being aware of the purpose of that reflection and guiding thinking to that end: having no clear purpose then might limit technology only to (providing time for and) provoking reflection - not to structuring and encouraging it. In this way opportunities for reflection may be lost."

The second guideline is to define (from the previously defined purpose) the reflective behaviors that need to be encouraged (i.e., the levels of reflection), and to define technologies and techniques that match these behaviors. The third guideline is to check if the conditions for reflection (time, structure, encouragement) are being met, as it is not just the technology that needs to be designed but the whole structure around it.

3.1.6 Conclusion

In this project design is seen as a process of *exploration*, and not as a process of problem solving. A flexible, person- and context dependent process, which allows for frequent reframing of the design situation and for many switches between activities, helps to gain insight in the design situation and to actively shape it. However, it also holds the risk of loosing overview. A digital collection system is needed to gain overview of this exploration process and of the developing design situation. Additionally, this system itself can be used for, or as part of, active exploration.

Unfortunately the discussed literature does not provide much insight in the role of reflection in relation to exploration and collection. I do think that a digital collection system can combine the content and process aspects of design, in line with the ‘moves’ of reflective practice. On the other hand, I am not interested in building a system that enforces a sequence of naming, framing, moving and evaluating. I am mainly interested in how construction, exploration and other use (e.g., discussion) of the digital collection can lead to reflection.

Ideally the system supports the diverse scopes, levels and purposes of reflection, as well as their integration. Reflection on practice can benefit from previous reflection on action, which can in turn benefit from previous reflection in action. Similarly, the different levels of reflection are inherently related, as Fleck and Fitzpatrick discussed. Examples of reflection ‘purposes’ that may be addressed are reflection on content, process, development, identity, vision and community, and on their relations. However, reflection may not be the main purpose: Reflection may be part of, or the result of, other activities for which the system is used. It therefore seems tricky to state that *‘thinking should be guided’* by the system. Designers should have the freedom to use the system for their own purposes and according to their own preferences.

3.2 Collection systems and software

The topic of using digital collections for reflection relates to the fields of Knowledge Management, Personal Information Management and Information Visualization. Many frameworks have been developed that describe interaction in these fields. For example, Oliver and Hannafin (2000) discuss the following interactions with knowledge: *seeking, collecting, organizing*, *integrating*, *generating, manipulating*, *communicating* and *scaffolding*. In the context of information visualization, Shneiderman (1996) introduced the 'mantra' *overview-first, zoom and filter, details-on-demand*, and Yi, ah Kang, Stasko and Jacko (2007) discuss more specific categories of interaction techniques: *select, explore, reconfigure, encode, abstract/elaborate, filter, and connect.* Giving an extensive overview of these frameworks is out of the scope of this thesis, because they remain relatively abstract and do not discuss the challenges and opportunities of building, organizing and using digital collections in daily (design) practice. Instead, I focus on more specific literature and examples.

3.2.1 Collections in design practice

Designers keep collections and have various motivations to do so. They use them as reference (e.g. material samples), for inspiration, for archiving their work, or as part of new work (e.g. collages, presentations) (Keller, Pasman & Stappers, 2006). At present, a large part of the collections designers keep is of a digital nature and resides on computers. This is true for new-media design, such as web design, but also for more traditional fields such as industrial design.

Studies on how practicing designers interact with their physical (e.g. tangible models, magazines) and digital collections identify issues with current practice. One study shows that the *reuse of prior design knowledge for reflection purposes is highly valued* but rarely observed during early design activity (Sharmin, Baily, Coats & Hamilton, 2010). This study also highlights that, next to the physical note/sketch book, digital folders were clearly the most used tools for organization. These folders were generally described as 'messy'. Another study shows that for both physical and digital collections, designers find it difficult to remember what they have collected and why (Herring, Chang, Krantzler & Baily, 2009).

Additionally, designers report having difficulties finding previously collected digital content when they need it, and are not encouraged to revisit or explore their digital collections. A third study highlights that browsing physical collections is experienced as a more enjoyable and social activity than browsing digital collections: Collections on computers are often individual, and require users to use their verbal memory (e.g. for the names of folders) rather than their visual and spatial memory (Keller et al., 2006). Finally, there is a need to better integrate individual and collaborative work, as well as physical and digital work (Keller et al., 2006; Herring et al., 2009; Bales & Do, 2009).

3.2.2 Collection spaces and systems

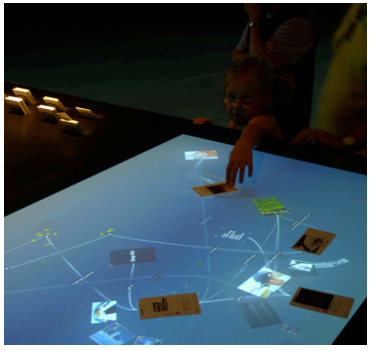
The need to better integrate individual and collaborative work, as well as digital and physical work, is answered by several interactive systems or spaces that aim to support creative group work. *Cabinet* is an interactive table that helps designers to collect and organize digital material for inspiration (Keller, 2005; Keller, Sleeswijk Visser, van der Lugt & Stappers, 2009). Anything that is placed on the table can be easily digitized and placed in the digital collection by means of an overhead camera. Remarkably, the system was intended for the collection and organization of inspirational material only, and not for the integration of this material with the designers' own work. Tests of the system in design practice showed that designers did add their own work to the collection.

AffinityTable (figure 3.2.1-A) is a system that supports affinity diagramming, a collaborative design method applied early in the design process for analyzing a design problem or to create first design solutions (Geyer, Pfeil, Höchtl, Budzinski, & Reiterer, 2011). It combines physical and digital workspaces through digital pen and paper, an interactive table with tangible tools, and a large vertical display. The non-interactive rim of the table provides a personal workspace on which participants can individually create physical sticky notes, which can be digitally clustered on the table. The vertical screen can be used to gain overview of the entire collection.

Also in Maeve physical and digital information are combined (http://portal.mace-project.eu/maeve). By placing physical project cards on an interactive surface, exhibition visitors can summon and explore an organic digital network of projects, people and media (Figure 3.2.1-B). Finally, Lucero presents two interactive workspaces that let designers interact with mood boards using in-air gestures (Lucero, 2009). On the *funky coffee table* designers can organize images and create mood boards, and in front of the *funky wall* (figure 3.2.1-C) they can record their interactions with these mood boards in order to create expressive presentations.

Other systems take a more distributed approach. *Design Teammate* is a system in which individual workstations of designers are fluently integrated with an augmented tabletop and wall display (Martens et al. 2010). *The Library of Skills* (figure 3.2-1:E) is a system of cameras distributed through our department, which enables designers to share knowledge and skills by recording and annotating tutorial videos (by Frens & Kersteman, in: Hummels & Restrepo, 2009). *Noot* (figure 3.2-1: D) is a system for sharing moments of reflection during creative meetings. It consists of tangible interactive clips, which can be used by participants to time-tag an audio recording of the meeting. They can for example be attached to sticky notes, and serve as physical hyperlinks into the audio recording (Van Dijk, van der Roest, van der Lugt & Overbeeke, 2011). Finally, *Traces* (figure 3.2-1:F) is an interactive floor that invites participants of a creative session to be actively involved in discussing insights gathered during the session. An individual selection of content collected during the session is projected around each participant on the floor, and follows the participant while he is walking around and discussing the content with other participants (Van Dijk & Vos, 2011).

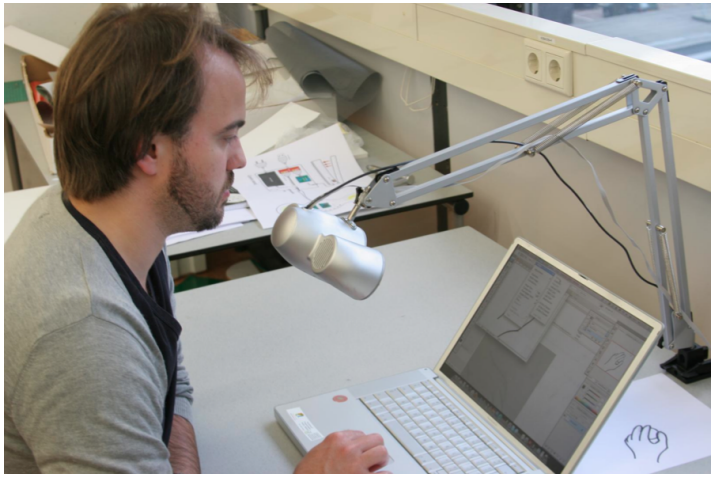
A: AffinityTable



B: Maeve

C: Funky Wall

D: Noot



E: The Library of Skills

F: Traces in Create Spaces

Figure 3.2-1. Examples of systems that allow for tangible and spatial access to digital collections.

Advantages of integrating a digital collection within an interactive space are clear: Reflections and other content can be captured and reused during physical, collaborative activities that designers naturally take part in. However, these interactive spaces may not be accessible to individual designers that do not work in a collaborative design studio, or to designers that work in various locations. Moreover, it is questionable whether these interactive spaces can be used for continuous reflection during the entire design process, including individual reflection. It therefore makes sense to make the digital content that is collected and organized in these interactive spaces also accessible through software on personal computers or mobile devices, and vice versa. In the next subsections I discuss examples of software.

3.2.3 Notes, journals, blogs, forms and checklists

A common way to document the design process is to keep notes and sketches or doodles in a sketch- or notebook. However, the physical nature of these notes makes them hard to archive, reorganize, explore and share. *Evernote* is a software application that aims to support such actions. Notes (i.e. lists, ideas, sketches, images, videos) can be organized using folders, tags, and a timeline view and can be searched and filtered using meta-data (e.g. location, timestamp, tags) and contents (text, OCR-text-recognition). The notes can be accessed through a normal desktop application, mobile devices and a web-application, and are synchronized through a cloud service. Preliminary findings from a case study in which teams of interaction design students used Evernote during the design process, show that the tools works well for regular documentation and for sharing results in the team (Geyer and Reiterer, 2012). Questionnaire answers indicate that the tool is used for reflection, reuse and communication/coordination (e.g. distributing tasks). The authors conclude that the results indicate that Evernote is largely adequate for documenting design processes, but that more physical and spatial information techniques beyond tags and folder might be necessary.

Apart from keeping notes, longer reflections can be captured in a *journal.* Writing regular (e.g. weekly) reflections can however be difficult and time-consuming. Ghaye and Lillyman identify possible concerns with journals, such as "*procrastination, superficial and unreflective entries, waning enthusiasm, and unwillingness or inability to reflect*" (in Ellmers, 2006, p7).

Blogs are similar to journals, but are different in that they are public. An advantage is that the possibility to communicate work, to obtain feedback (e.g. through a comments section on the blog) and to build a community, encourages the designer to create regular updates. For example, MacColl et al. (2005) report that students in undergraduate design studios, in contrast to written journals, embraced the use of reflective blogs and reported regular and continuous use of them. The public nature of blogs also makes it possible to *combine them* in an overview: The *Digital Scrapbook* is an online tool developed in-house in the Interaction Design department of the Royal College or Art (Swan, Tanase and Taylor, 2010). It was developed to enable tutors to gain insight in their

students' design processes, which was difficult because students had troubles with documenting their process. The tool automatically gathers mainly visual content from students' project blogs, online photo sites, and online video sites, and aggregates this content in a minimalistic grid-based interface (figure 3.2-2). The tool is valued by both staff and students for looking at each other's work and for drawing inspiration, for the way it represents the dynamic and haphazard nature of the design process, and for the way it reflects the creative nature of the department as a whole.

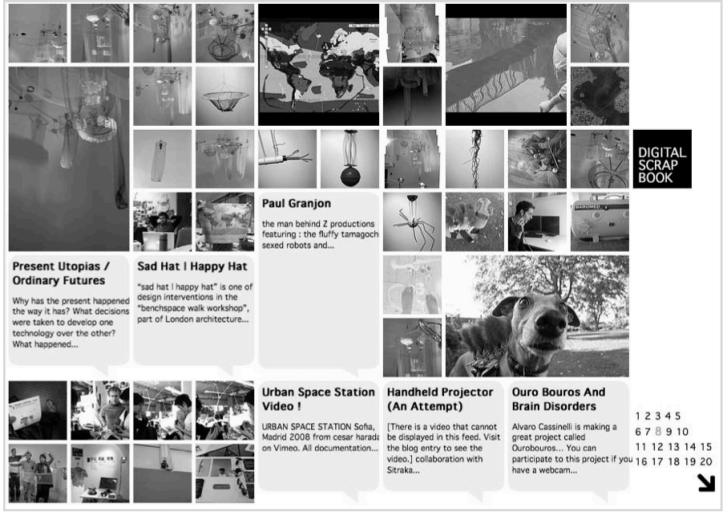
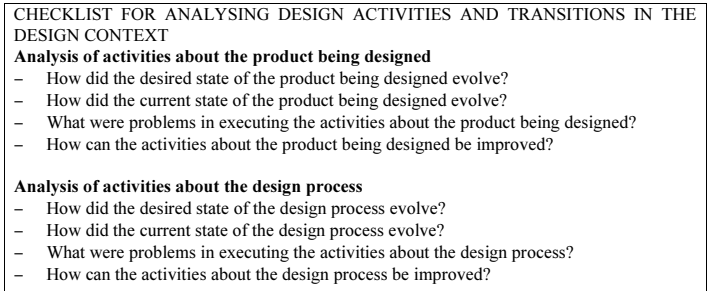


Figure 3.2-2. The digital scrapbook harvests work from students' project blogs and other online repositories, and combines it in a grid-based overview.

Finally, The Process Reflection Tool is a blog-like tool for documenting and reflecting on research-through-design projects (Dalsgaard & Halskov, 2012). Events and sub-events can be documented, and an overview of these events is shown on a timeline. Additionally, notes can be added in order to document more informal parts of the Research-through-Design process. The tool initially had templates for organizing work, but these were dropped as they were too constraining for supporting diverse projects. The authors discuss various challenges and benefits concerning the tool. Challenges concern roles and responsibilities, lack of routines, determining what to document, and finding the right level of detail. Benefits include support for shared reflection and discussion in on-going projects, the development, refining, and reflection upon research questions and scaffolding longitudinal and cross-project studies.

Although the public or shared nature of blogs may encourage documentation and reflection, it also holds a risk. Designers may be less inclined to include raw, intermediate, and personal ideas and reflections. And still, as is the case with learning journals, it can be difficult and time-consuming to write regular reflections, and to decide what to focus on and how much detail to use. Providing guiding reflection questions may lessen such issues. For example, Reymen et al. (2006) describe a model for structured reflection during the design process, as means to improve efficiency and effectiveness. Forms with reflective questions and checklists are provided to designers, which they use to reflect on design sessions (figure 3.2-3).

Feedback of designers on a preliminary version of the model show that it, amongst others, helps to increase awareness of the design situation and helps to bring order in a chaotic process. It also showed that the questions should be more specific to the projects and that care has to be taken that the method is only used as a guideline in a flexible way and that it does not force the designers to use a specific process.



CHECKLIST FOR ANALYSING DESIGN ACTIVITIES AND TRANSITIONS IN THE DESIGN CONTEXT

Analysis of activities about the product being designed

- How did the desired state of the product being designed evolve?
- How did the current state of the product being designed evolve?
- What were problems in executing the activities about the product being designed?
- How can the activities about the product being designed be improved?

Analysis of activities about the design process

- How did the desired state of the design process evolve?
- How did the current state of the design process evolve?
- What were problems in executing the activities about the design process?
- How can the activities about the design process be improved?

Figure 3.2-3. Part of a checklist with reflective questions (source: Reymen et al. 2006)

A problem of templates, checklists and guiding questions, is that procedures that limit freedom may not fit designers' way of working and can be overly time- and energy-consuming (Stolterman, 2008). Rather than as main elements for structuring reflection, reflective questions may be used as a loose reference alongside more unstructured ways of documenting the design process, such as journaling, blogging and taking notes. Still, these techniques provide limited support for gaining overview, and for exploring relations and alternative perspectives. Blogging and note-taking software usually does provide the possibility to reorganize notes based on tags and other meta-data, but this is still a rather formal and cognitive activity in comparison to visual-spatial organization techniques. These are discussed in the next subsections.

3.2.4 Free spatial organization

Many tools for organizing digital collections provide a workspace (i.e. canvas) enabling users to implicitly organize items through clustering, making piles and other ways of spatial organization. The most common example that is a standard part of mainstream operating systems is the *desktop*, which provides more free and spatial organization than a file browser. A standard desktop however still provides little freedom and flexibility: The space is limited (it cannot be zoomed and panned), it still uses folders, and reorganizing items is tedious.

Bumptop is an example of a desktop that makes organization more free and flexible (Agarawala & Balakrishnan, 2006). It uses physical characteristics such as friction and mass so that items can be casually dragged and tossed, and can collide and displace each other, making the '*interaction feel more continuous and analog, rather than the discrete style imposed by digital computing'.* The two main advantages are that users can make use of organization strategies that they employ in the real world, and that they do not have to commit to explicit categorization techniques such as naming and filing (creating hierarchies using folders), which are cognitively difficult.

Bumptop is designed for stylus interaction. Using lasso-selection, items can be selected and 'tidied' (making a sort of cluster) and piled. Piles can be quickly browsed using various techniques such as fish-eye-, grid-, page-turn-, or fan-out-on-a-user-drawn-path browsing. The workspace is not zoomable and pannable, but does provide walls (left, right and back) to place content allowing for semi-3d organization (see figure 3.2-4). Although this gives the user a quick overview of his files in a single view, complex organizations (e.g. representing a large design process) are not possible.

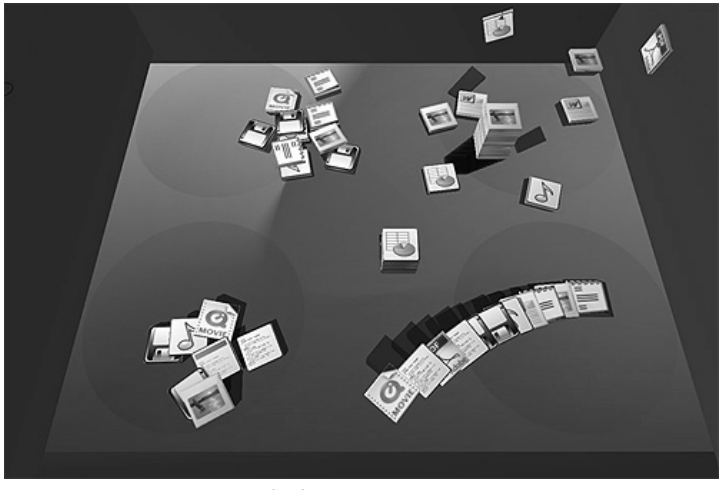


Figure 3.2-4. Bumptop allows for free physics-based organization.

An example of an application that does allow for the creation of large and complex organizations of content is *Prezi* (http://prezi.com). This is a software application that is designed to create zoomable animated presentations. It has web-, desktop- and mobile versions. Its canvas is zoomable, so that major topics can be presented much larger than more detailed topics (figure 3.2-5). To create a presentation, a presentation path has to be generated on the canvas. When playing back this presentation, the application smoothly zooms, pans and rotates across the canvas. Powerpoint slides can be imported and placed on the canvas, and there is a collaboration/meeting mode in which multiple people (represented by avatars) can work together on the canvas in real-time (Laufer, Halacsy & Somlai-Fischer, 2011).

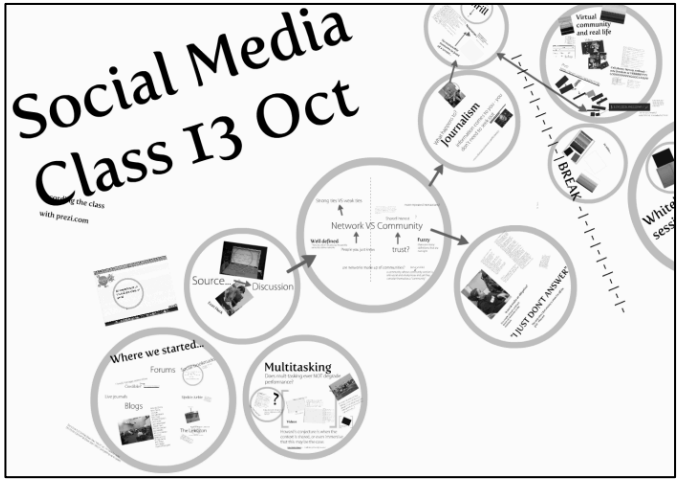


Figure 3.2-5: Prezi, a zooming presentation editor.

I have observed several students at our department using Prezi for creating presentations of their design process. I has potential for documenting and communicating the design process, although too much animated zooming and rotation can make the presentations disorienting. Additionally, although Prezi provides freedom of organization, it is not very flexible: It does not support fast reorganization in order to explore relations and alternative perspectives.

3.2.5 Distance and similarity

Product World is a software application that enables industrial designers to create and explore a collection visually, based on similarity between product samples (Pasman, 2003). A designer enters product samples into the collection by positioning them into a two-dimensional area such that their relative positions (i.e., relative distances) express their perceived similarities regarding a specific criterion. An example of such a similarity criterion is ‘form’. When all the samples are entered, the collection can be explored. In this exploration modus, weights can be set for three similarity criteria simultaneously, and the displayed samples are automatically organized based on these weighted criteria (Figure 3.2-6). Unwanted samples can be removed by dragging them off the screen, and new samples can be retrieved by 'clicking' positions between the other samples. This will initiate a search in the database for an object that 'fits' in this position relative to the other samples.

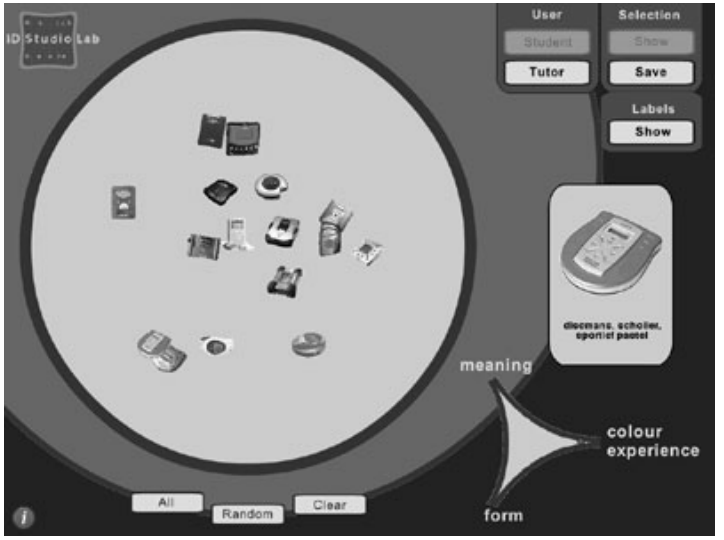


Figure 3.2-6. In Product World collection content can be explored based on a mix of three similarity criteria: ‘meaning’, ‘colour experience’ and ‘form’. (source: http://studiolab.ide.tudelft.nl/dwp/software.html)

Product World can be useful during the design process as an *inspiration* tool. Whether it is useful as an *organization* tool within the design process depends in my view a lot on the nature of the design project. For relatively conceptual projects it might be hard to find useful similarity criteria. Moreover, these criteria might only be discovered through organization rather than being known beforehand. Additionally, even though spatially organizing and clustering items may be a natural activity, comparing items and positioning them on the ‘right’ distance from each other (i.e. defining

weighted relations) may require more cognitive effort than simply associating items with each other (i.e. defining *non-weighted* relations). Moreover, in my experience, the questions *which* concepts are related and *why* plays a stronger role in a much larger part of the design process, than the question *how much*. In the next sub-section, techniques and tools that concern the creation and exploration of explicit but non-weighted relations are discussed.

3.2.6 Explicit relations: Mind maps and concept maps

Mind maps and concept maps are highly similar, and the words are often used interchangeably. Both are diagrams in which words and other content (i.e. images, files) are connected by lines. The difference is that mind maps (Buzan, 1993) are hierarchical, radial trees, branching outwards from a central concept, and that concept maps are graphs that allow for the connection of multiple concepts in more diverse patterns.

Still, the originally intended structure of concept maps is hierarchical, with more general concepts placed at the top and more specific concepts placed at the bottom (Novak & Cañas, 2006). Novak and Canas suggest the following process for constructing good concept maps: They begin with a context, which can be defined by a focus question or problem. For this context several concepts are listed and ordered, which are then used to construct a preliminary concept map in which concepts are connected by links with linking words (e.g. '*results in*'), thereby forming propositions (figure 3.2-7). After that, cross-links may be created, which are links between distant segments of the map, showing relationships between sub-domains. The authors mention that a particular challenge is to identify good linking words, and to select the most useful cross-links.

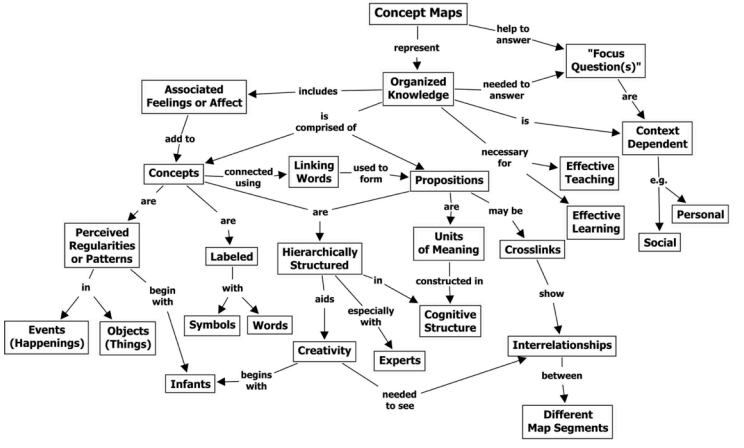


Figure 3.2-7. Concept map about concept maps. Made in CmapTools (source: Novak & Cañas, 2006).

In the Visual Understanding Environment, presentation paths can be created inside a concept map (Kumar & Saigal, 2005) (figure 3.2-8). These presentation paths are different from the paths in Prezi (which was discussed in section 3.2.4), because slides in Prezi are regions of the canvas, while slides in the Visual Understanding Environment are separate entities that are attached to nodes in the map.

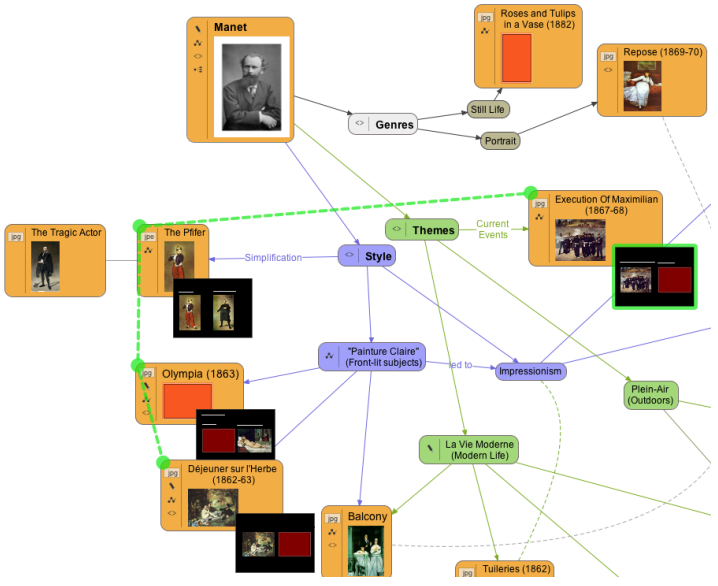


Figure 3.2-8. In the Visual Understanding Environment presentation paths (dashed line) can be created inside a concept map. Slides (black) are attached to nodes and can be edited separately from the map in a dedicated mode.

3.2.7 Self-organizing layouts

A disadvantage of the examples discussed so far is that they do not enable quick reorganization because (selections or groups of) items have to be repositioned individually, or require weighted relations and similarity criteria to be defined first (in the case of Product World). Alternatively, fast reorganization, and therefore the exploration of relations and perspectives, can be supported by means of a self-organizing layout mechanism that uses the links (i.e. relations/lines) between items for positioning them in relation to each other. An example of a mind-map application that features such a layout is *The Brain* (www.thebrain.com). In this application the view can be automatically organized around any node by clicking on this node. This node is then positioned at the center of the view, its child nodes are positioned below it, its parent nodes above it, its sibling nodes at its right, and non-hierarchically related nodes at its left (figure 3.2-9). By refocusing on different nodes in sequence, the user can 'wander' through the collection. At the bottom of the view a history of visited nodes is shown, and at the top of the view shortcuts to any node can be created.

Figure 3.2-9. The Brain features a hierarchical self-organizing layout

Force-directed algorithms allow for a self-organizing layout mechanism that is not based on hierarchy. Such algorithms are usually inspired by physical forces. For example, links between nodes behave as springs and nodes repulse each other as if they were electrically charged particles. The goal is to achieve an aesthetically pleasing result (e.g. minimize link crossings) and the algorithms may therefore deviate from physical laws (e.g., Eades, 1984; Fruchterman & Reingold, 1991).

An example of an application that uses a force-based layout is Vizster (Heer & Boyd, 2005). This is a tool for visualizing and exploring social networks. It represents a network as a node-link diagram and features a force-based layout. Nodes can be expanded and collapsed (i.e. showing/hiding the nodes that are related to a specific node) so that as much space as possible is available for nodes and relations of interest. Expanded nodes are locked (i.e. anchored), so that they are not subject to the force-based layout. The user then has full control over the positions of these nodes.

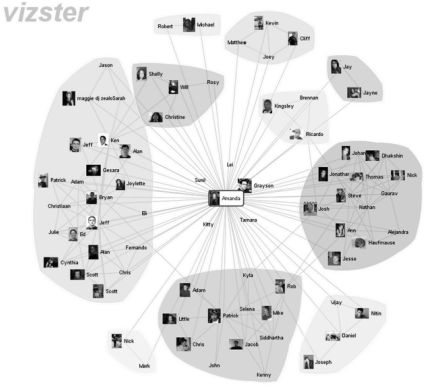


Figure 3.2-10. Vizster uses a force-based layout to visualize social networks. It has a special mode for discovering communities.

Vizster additionally offers special modes for analyzing connectivity and communities (figure 3.2-10). Communities (i.e. clusters) become visible automatically because the more relations a node has the more force it applies to other nodes. This also makes the layout more orderly. Alternative algorithms for reducing visual clutter in node-link diagrams do not adapt the positions of the nodes, but work by bundling the links between the nodes, either based on hierarchy or by letting links attract each other (Holten, 2006; Holten & van Wijk, 2009).

3.2.8 Design rationale and multiple views

A specific kind of concept mapping is argument mapping, also known as rationale management or as creating decision trees. These argument maps are not only thinking tools, but are also tools for passing on knowledge to other or new (design) teams. Research into capturing the rationale of solving complex, ill-defined problems (“wicked problems”, e.g. certain political problems, or design problems) dates back to the work of Kunz and Rittel (1970) who proposed the concept of Issue-Based Information Systems (IBIS). A decision process is represented as a tree of which the top-node is an issue (i.e. question), and of which all other nodes are options (i.e. ideas), pro- or con-arguments, or additional issues (figure 3.2-11).

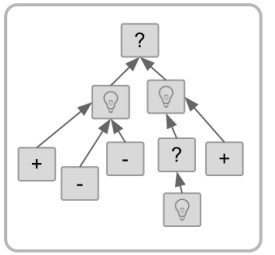


Figure 3.2-11: Abstraction of an IBIS tree

Many derivatives of IBIS have been created, such as QOC (Questions, Options, Criteria, a.k.a. Design Space Analysis), in which options are connected to design criteria, rather than to arbitrary pro- or con-arguments (Maclean, Young, Bellotti, & Moran, 1996).

Compendium is an example of IBIS-based software (Buckingham Shum et al., 2006) (figure 3.2-12). It features list-views, in which content is organized in columns or tables, and map-views, in which content can be freely spatially organized and connected as an IBIS decision tree. Apart from the default IBIS nodes, also *decisions*, *references* (i.e. files, web-links) and *notes* (i.e. miscellaneous comments) can be added. The authors note that one of the problems of capturing design rationale using IBIS-based systems such as Compendium is the prescriptive and intrusive nature of the notations. This obstacle withheld designers from using these tools in their day-to-day practice. Shum et al. call this the 'design rationale capture problem':

> *"How does one acquire input to a rationale management system, without disrupting the very process it is designed to support, or without having to employ dedicated scribes who do nothing but maintain rationale libraries?"*

An additional problem was that the approach does not give immediate value to the user. Value only becomes clear later, when for example revisiting the content. One way of solving (or circumventing) this capture problem was by letting more experienced mappers use Compendium for facilitating meetings (i.e. for '*Dialogue Mapping*'). In such situations there is no overhead because the rationale is captured in real-time, and there is '*immediate value*' because the meeting is documented and structured. In order to make it easier for a third party to understand the (dialogue maps created during the) meetings, a specific 'video map' feature was added to Compendium, in which the map gradually evolves while the video of a meeting is playing.

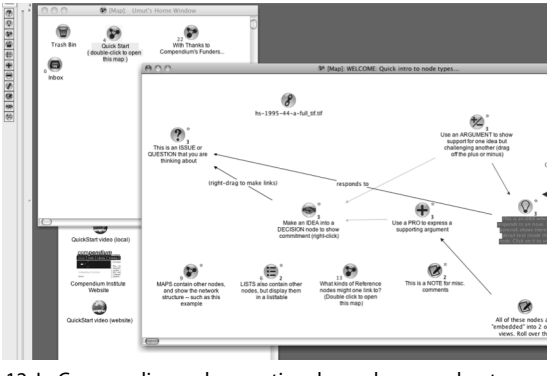


Figure 3.2-12. In Compendium, a large rationale can be spread out over multiple views.

A tool that is highly similar to compendium is *Dred* (the Design Rationale Editor) (Bracewell, Wallace, Moss, & Knott, 2009) (Figure 3.2-13). It is designed to overcome the shortcomings of existing IBIS-based tools, and aimed to be used by designers '*as their designs proceed'*, and not just retrospectively. It is specifically designed for design engineers at Rolls Royce (RR). According to the authors, Dred is a more lightweight tool than Compendium. Instead

of using an underlying database, charts (i.e. maps / views) are stored as separate documents. This proved to be crucial for acceptance of the tool by RR, as it did not have to be installed on company computers and because it could integrate with existing document management systems.

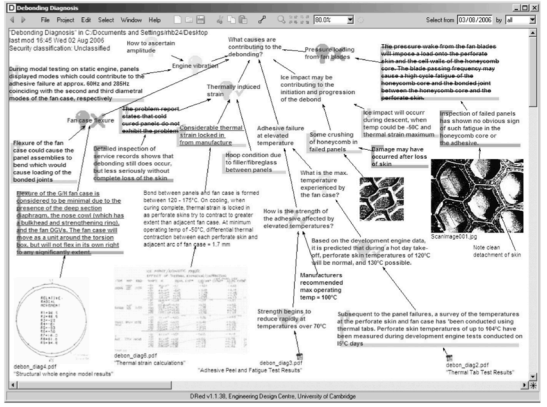


Figure 3.2-13 Dred (image from Bracewell et al. 2009)

Both Dred and Compendium allow for a large rationale to be spread out over multiple views (i.e. maps, charts) in order to make it more manageable. Much has been written about specific types of views, such as *overview+detail, focus+context, master/slave and difference* views (Roberts, 2007) and interaction techniques such as *brushing* (content that is highlighted in one view is automatically highlighted in other views, Becker & Cleveland 1987). However, for this research it is vital to explore how designers *construct their own* views, and how they integrate them.

In Compendium, views can either be linked explicitly by placing a link to another view inside the current view (Figure 3.2-14:bottom), or implicitly by reusing content across views (a transclusive link, Figure 3.2-14:top). The amount of transclusive links of each item is displayed above it. After clicking on this number a popup-menu with links to the other views is shown. In Dred, the same item cannot be part of multiple charts: Therefore, instead of translucent links, '*tunnel links'* can be created (figure 3.2-14:center). This is a link between a node in one view and another node in another view. Little circles with matching integers are shown in both views. When double-clicking on such a circle, the other view is opened and the mouse cursor is positioned at the other end of the tunnel (i.e. on the other circle). Therefore, if the other view is not of immediate interest a new double-click will immediately guide the user (i.e. the mouse cursor) back to the exit point of the previous view.

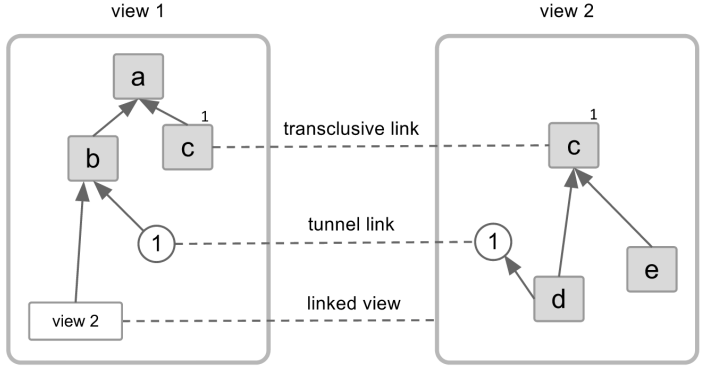


Figure 3.2-14. Different kinds of links between views.

3.2.9 Conclusion

At the end of the previous section I concluded that for me design is all about action and exploration. This fits a flexible design process in which many switches between activities, and regular reframing of the design situation, provide opportunities for reflection. A system for supporting reflection on and in the design process should fit the flexible nature of this process. It should not impose a specific process, or structure of organization, upon the designer, but allow for flexible documentation and integration of multiple perspectives and activities.

Collection and reflection during physical, collaborative activities that designers take part in can be supported by means of interactive surfaces and spaces, but these systems alone may not be enough for supporting continuous and personal reflection throughout the design process. Note-taking and blogging software allow for more continuous and personal use, and make it possible to reorganize a collection based on tags or other meta-data. Defining tags is however a discrete and cognitive activity, and lacks the freedom, implicitness and overview that spatial organization provides. In turn, spatial organization software often misses ease of reorganization and the possibility to create multiple views. Finally, many tools focus on elements that may inhibit free and explorative organization of the collection, such as similarity criteria, IBIS notations, and hierarchical relations. It seems that the desired combination of freedom and flexibility is lacking in existing tools and systems.

4 Finding focus

This chapter concerns the first phase of this project, which was all about finding focus. In section 4.1, I discuss five design concepts and thereafter explain my focus on software. In the second section I describe a first version of the software, called the Magnetic Collage Tool, and reflect on personal use of this tool.

4.1 Five design concepts

In order to gain overview of activities and design opportunities that involve designers' collection and reflection, diverse concepts were created. I started with naming several activities:

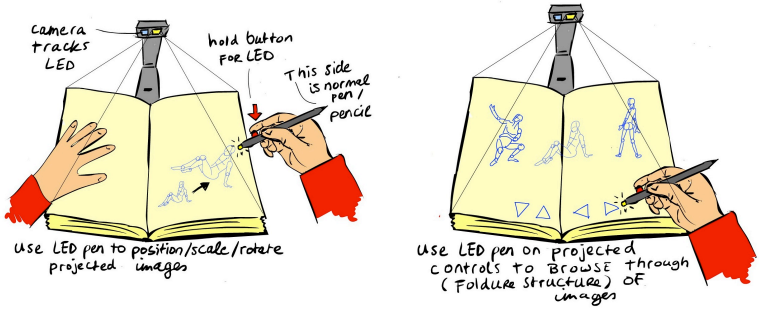
- Individual sketching and note-taking
- Creating a personal overview of work
- Collaborative discussion of work
- Collecting and showing work by means of a mobile device
- Casual, mobile browsing and reflection

From this starting point, I created five concepts. These are discussed on the following pages.

4.1.1 Concept 1: Augmented Notebook

A notebook plays an important role in design. It is always carried along, it keeps work together in a chronological structure, it can be easily browsed by flicking the pages, and most importantly: It allows for the fluent integration of sketching (i.e. scribbling), note taking and diagramming.

The Augmented Notebook integrates the designer's physical notebook with a digital collection. A mini projector and camera are combined in a device that can be connected to the notebook. It enables the designer to capture content from the notebook and store it in the digital collection, but also to project content near the notebook (on table or wall) or on the notebook itself. In the latter case the projection can be physically traced. Relations between digital content and (locations on) the physical pages can be created, so that the digital content, such as notes, images, videos, websites and publications, can be revisited by browsing the notebook.



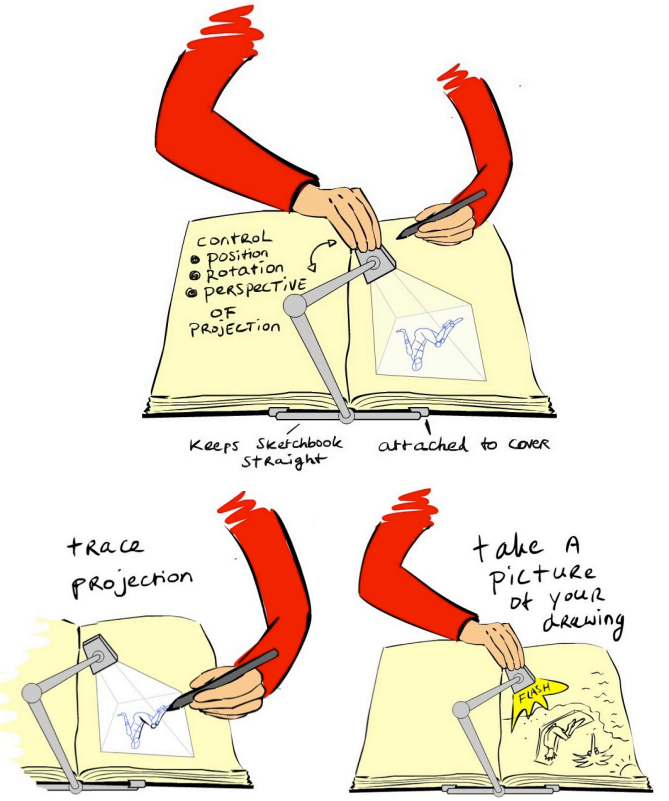


Figure 4.1-1: The Augmented Notebook can be used to add new content to a digital collection, to link digital content with physical pages, to browse the digital collection, and to trace digital content.

4.1.2 Concept 2: Flexible Collection Software

A lot of collection content is of digital nature, such as photos, videos, digital work, websites and publications. However, digital organization tools such as file browsers and blogs impose specific organization structures (e.g. hierarchical, linear) and make it difficult to gain overview of work and to explore relations and perspectives.

The collection canvas can be used to spatially organize design work in various ways. The software allows designers to make quick collages that show relations between work of a single project (e.g. related work, ideas, requirements, feedback) or of multiple projects (e.g. projects, topics of interest, skills). It also allows for the fluent integration of directional information structures such as scenarios, videos, presentations or design processes.

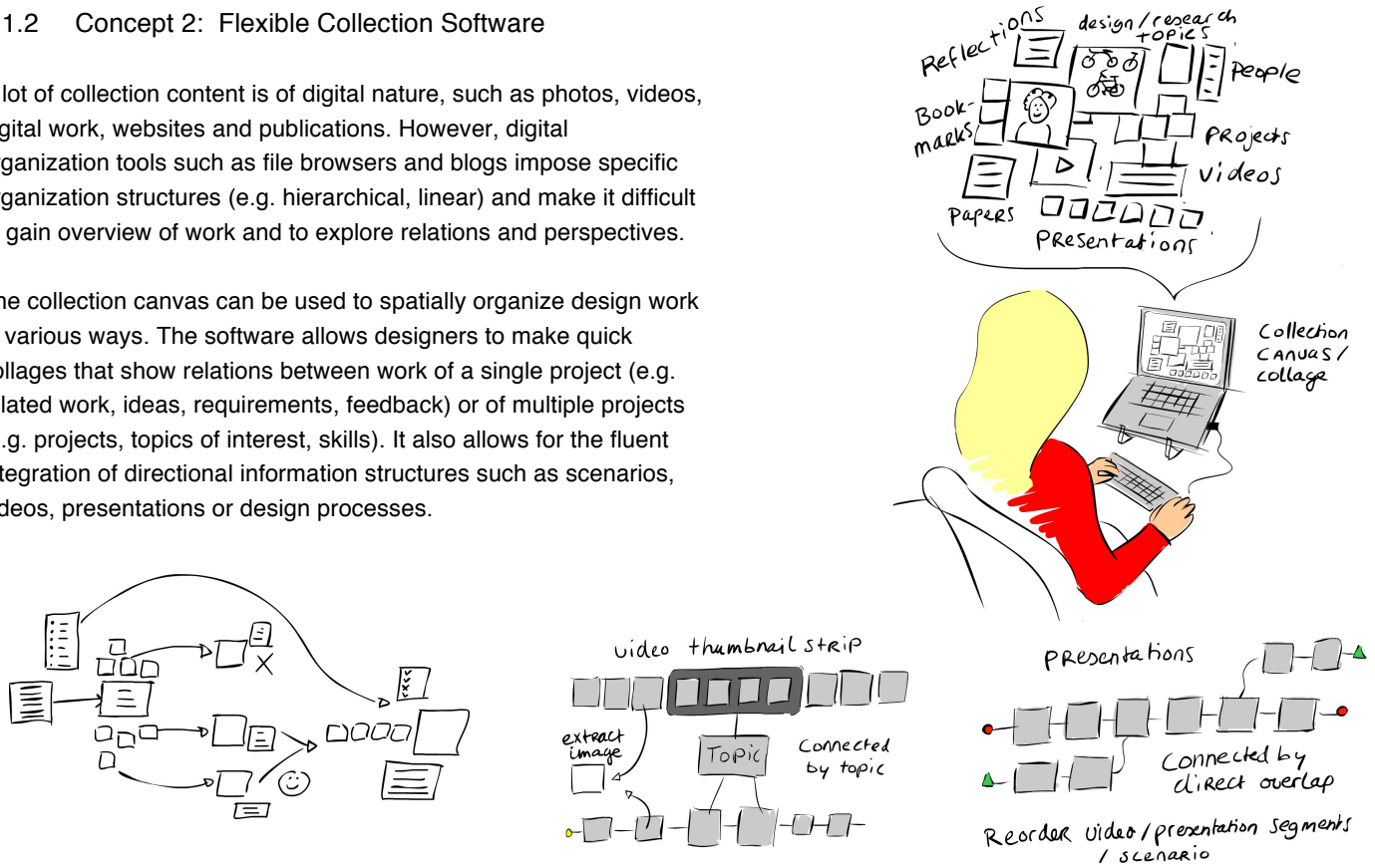
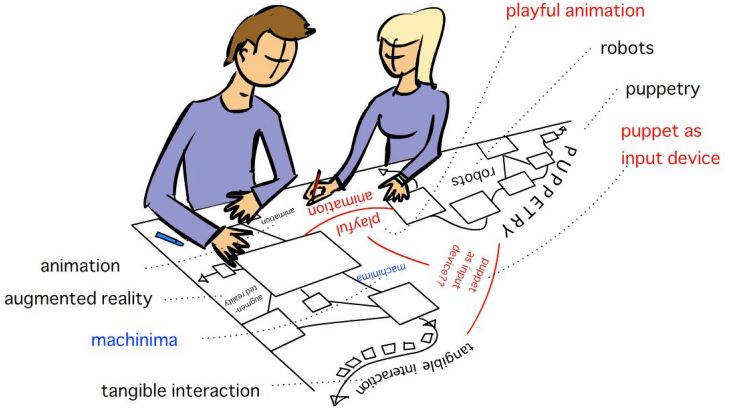


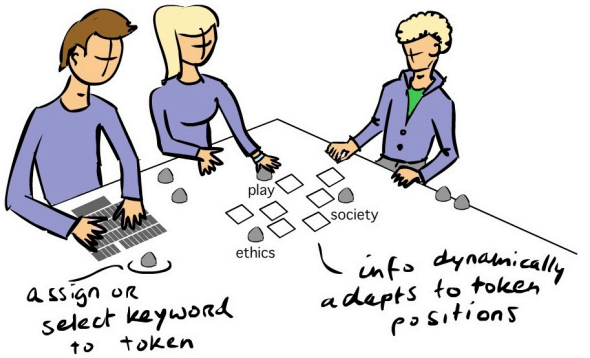
Figure 4.1-2: The Flexible Collection Software enables designers to spatially organize and integrate diverse work of multiple activities, project phases and projects.

4.1.3 Concept 3: Collaborative Reflection Table

Collaborative physical clustering sessions, for example using printed images or sticky notes, are useful to discuss work and to gain overview of it. However, they lack the connection to digital collection content, the freedom to explore relations beyond clusters, and the possibility to easily revisit and restructure the created organizations.

The collaborative reflection table enables designers to spatially organize and integrate their digital collections collaboratively. It has a special dynamic clustering modus in which the spatial organization of collection content dynamically adapts to the positions of topics that are defined and positioned by the designers. The designers may work together in one project, or they may search for relations between individual projects. The table has a central position in the design studio. It can be used during dedicated meetings, but also more informally while individually adding content to the collaborative collection, or while casually exploring the collection during a coffee break.





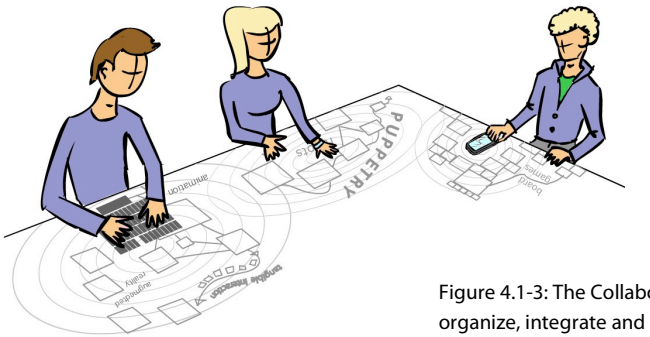


Figure 4.1-3: The Collaborative Reflection Table enables designers to spatially organize, integrate and explore their digital collections collaboratively.

4.1.4 Concept 4: Mobile Collection Explorer

Reflection does not only happen during design work. When a designer is for example travelling by train, there is time for reflection. Additionally, design work may be shown to colleagues, friends or family at a social event or at home. The mobile collection explorer enables designers to explore and discuss their digital collections in such situations. The canvas can be panned and zoomed using the touchscreen, and there is a special modus that allows for full screen browsing of collection content. Pictures can be taken while browsing, so that they are directly added at a desired location in the collection. The device has a mini projector built in so that the work can be shown at a larger size.

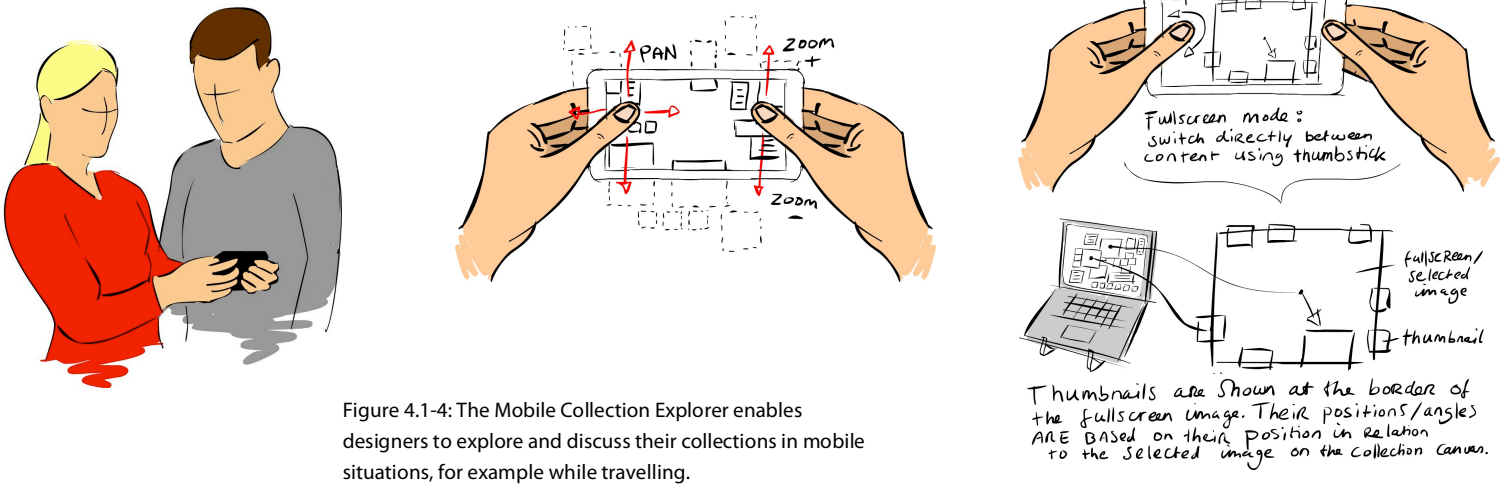


Figure 4.1-4: The Mobile Collection Explorer enables designers to explore and discuss their collections in mobile situations, for example while travelling.

4.1.5 Concept 5: Mobile Path Explorer

The Mobile Path Explorer is a variation of the concept that was discussed in the previous subsection. It is designed for exploring and discussing linear or chronological information structures, such as scenarios, videos, presentations, documents, and timelines. It may for example be used to quickly scroll through multiple years of design projects and zoom in on one of the projects, but also to explore multiple overlapping presentations. The device has a flexible screen enabling the designer to focus on, switch between, scroll and zoom content by stretching, twisting and bending the device.

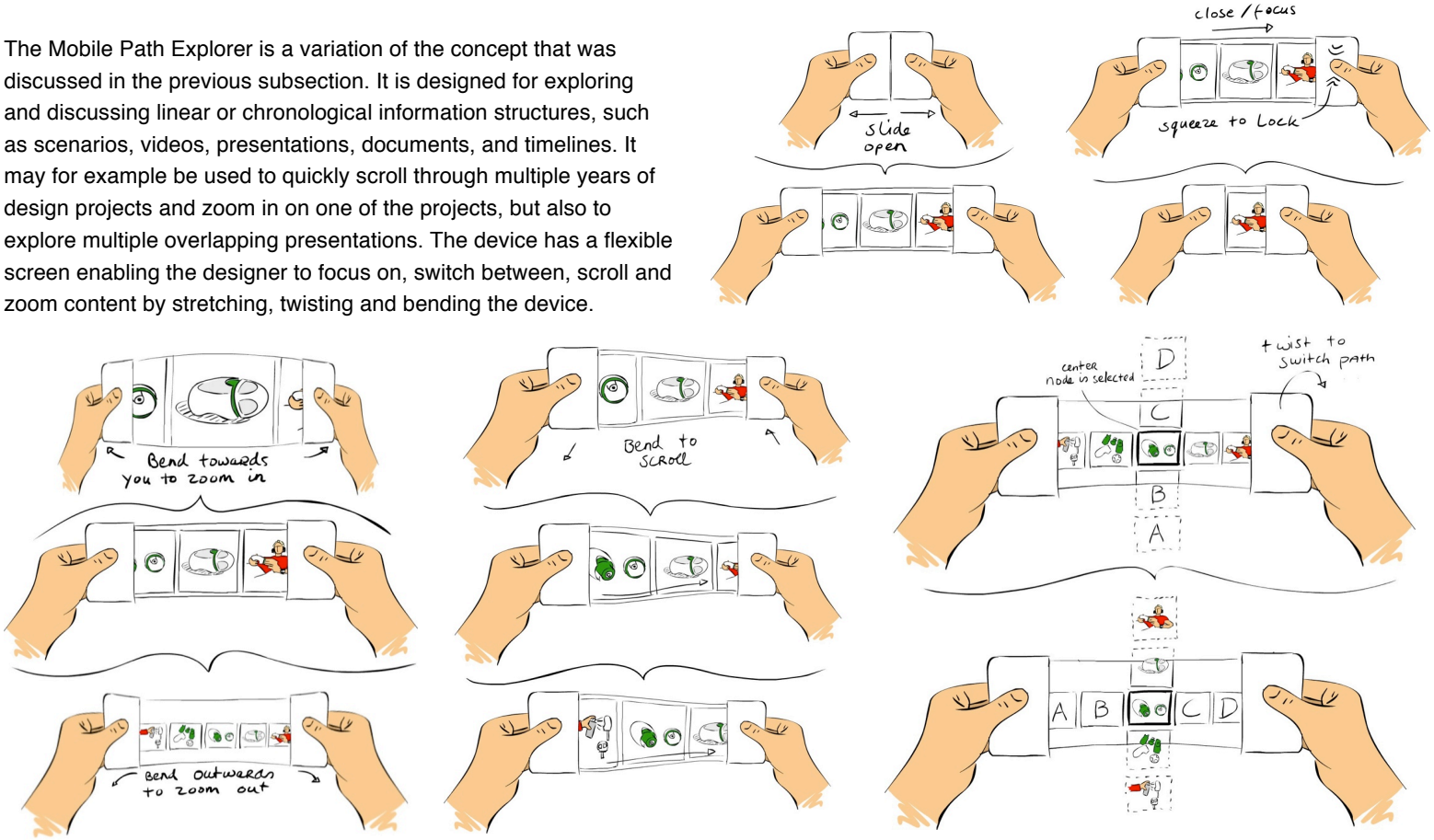


Figure 4.1-5: The Mobile Path Explorer enables designers to playfully and directly explore (overlapping) linear or chronological information structures, such as scenarios, videos, presentations, documents, and timelines.

4.1.6 Conclusion: Focus on software

The concepts discussed in this section can all be connected to the same digital collection, thereby forming a system that allows for diversity and integration. This hypothetical system supports both collaborative and individual work, and various activities such as sketching, note-taking, capturing images, organizing, exploring and presenting. Additional activities may be added, such as capturing videos (e.g. as in the Library of Skills, Figure 3.2-1-E).

This imagined system facilitates the *documentation of* reflection that emerges in the activities, but also *reflection* itself. Previous work (including reflections) can be revisited and reused during various activities in different contexts, which enables designers to see the previous work from a new perspective. They are then *implicitly* exploring relations and gaining overview. The system also allows for an integrated collection to emerge, which designers can use to *explicitly* explore relations and gain overview.

Despite the clear benefits of a systems approach to supporting collection and reflection, creating prototypes for multiple concepts *and* integrating these into a system seemed too ambitious. A decision was made to focus. The choice was first narrowed down to the concepts that individually allowed for the integration of diverse content and activities: The Flexible Collection Software and the Collaborative Reflection Table. The clear advantage of the latter was that it facilitates collaboration, thereby inherently supporting high-level reflection (e.g. new perspectives) due to the integration and comparison of work of multiple designers, and through discussion. Another advantage of an interactive table is that it can be physically present in the workspace, reminding designers of its existence and allowing for the casual exploration or discussion of content while for example having a coffee break. Finally, an interactive table provides possibilities for the integration of digital and physical collections (e.g. sticky notes, sketches), and for designing physical interfaces that can be used for direct expressive interaction on the table.

A possible disadvantage of an interactive table is that it is confined to a single workspace (assuming a non-portable setup) and not always available for personal collection and reflection when needed. It may be too much geared at integration, at the cost of diversity. In contrast, the flexible collection software can be used by many designers individually, whenever they have their laptop available. It ideally allows for *diverse* collections to grow gradually. Therefore, the choice was made to first focus on the Flexible Collection Software, and to focus on collaborative reflection later in the project. In the next section a first iteration of the software, which eventually evolved into Freed, is discussed.

4.2 Magnetic Collage Software

4.2.1 Introduction

In this section, I describe an initial version of Freed, called the Magnetic Collage Software (figure 4.2-1). The main goal of this software was to support revisiting, exploring relations within and gaining overview of design work. I first discuss the tools that I used and the design of the software, followed by a reflection on personal use and conclusions concerning necessary improvements.

4.2.2 Tools used

The software was built using Adobe Flash, because I was already skilled in using this tool, because of its cross-platform nature, and because its integration of drawing, animation and coding functionality allows for relatively rapid prototyping. Additionally its 'display list' (i.e., scene graph) model facilitates managing a hierarchy of graphical objects and their properties (e.g. visibility, 2d location, depth/z-order) and the user interaction with these objects. Adobe Air was used for integration with the local file system.

4.2.3 Design and argumentation

Following, I discuss the main functionality of the software, supported by argumentation.

Spatial organization of images and text

The canvas is the main 'infinite' area for spatially organizing design work. The designer is free to add and organize work without being constrained by canvas boundaries. Images can be dragged (in groups) from a file browser and dropped onto the canvas, and after that freely positioned. Text boxes can be added by double-clicking anywhere on the canvas, or by directly drawing them on the canvas. Their size is automatically increased to fit the contained text, but not automatically decreased so that the shape and size of each textbox are free to define.

Images and text boxes can be scaled and resized to make them stand out more or less. This can be done by dragging scale-handles, or quickly using mouse wheel or track pad while holding the 'S' key. In order to facilitate fast spatial organization, text size changes along when a text box is scaled (i.e., no extra step is required to scale the text). No specific font size can be set.

In order to keep the software 'flexible', and therefore to facilitate the easy reorganization of and the exploration of relations between individual content, the choice was made not to include 'grouping' functionality. Such functionality does make it easy to organize groups of content, but may hamper the reorganization of individual content.

The 'magnetic' layout

The software does not allow content to overlap. This facilitates the fast positioning and scaling of content without obscuring other content. Content that overlaps is automatically pushed apart in such a way that the content just touches.

This means that content can be easily snapped together by dragging it against or over each other, and that content can be easily dragged in-between other content, which will then be pushed outwards. When content touches, a weak 'magnetic' connection is formed. The software tries to keep this connection when content is scaled. The connection is broken when content is dragged apart.

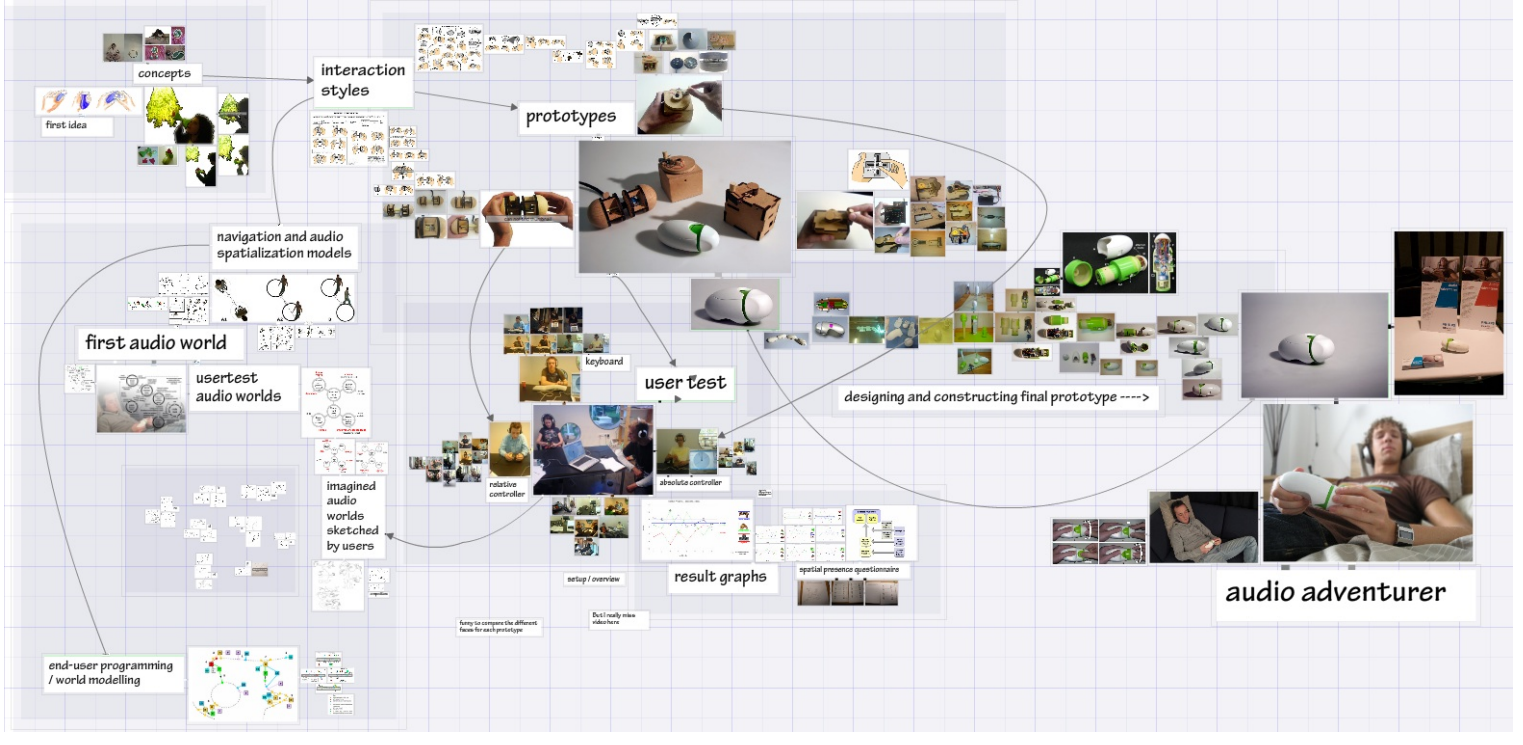


Figure 4.2-1: The Magnetic Collage Software, showing a personal organization of work of one of my previous projects.

Frames

Frames are semi-transparent rectangles that can be created, positioned and resized behind all content. They can be used to subtly emphasize part of the collage and to zoom in on it, but they do not actually hold or group content. Frames can overlap, and smaller frames are automatically placed above bigger frames. In order to keep the software simple, there are no ‘layers’ to interact with.

Connectors

Connectors are curved or straight lines, with or without arrowheads, that make it possible to show a relation between distant content and/or frames. Their end-points automatically adapt when the connected nodes or frames are moved or scaled. Connectors do not affect the magnetic layout mechanism.

Full-screen browsing modus

Content or frames can be shown in full-screen. The application then enters a special full-screen browsing modus with a black background. In this modus, content (e.g. a single image) can be observed in a focused way without being distracted by other content. When the mouse is moved, small images show up at the borders of the screen. These images represent content or frames that are connected (either by direct touch, or by means of a connector) to the content or frame that is currently shown in full-screen. Their positions at the borders of the screen depend on the relative location of the represented content or frames on the canvas. When clicked, the represented content or frame is shown in full-screen.

Zooming, scrolling and panning

Due to the focus on gaining overview, zooming is prioritized over scrolling, thereby deviating from software conventions: Zooming is done directly using the mouse wheel or track pad, and does not require a modifier key to be held. It uses the mouse cursor as center point and is constrained to 10% and 1000% of the default zoom-level, to avoid getting lost. The canvas can be automatically zoomed in order to exactly fit all the content, a selection of content, or a user-defined area on the screen. Mouse wheel or track pad scrolling requires modifier keys. Panning is done by dragging the canvas in any direction.

Grid and alignment

While content or frames are dragged, or while the canvas is zoomed, panned or scrolled, a grid is temporarily shown on the canvas. It fades in and out, and subtly shows the difference between on the one hand scaling and dragging content, and on the other hand zooming, panning and scrolling the canvas. The grid can be used for basic alignment, but there is no ‘snap to grid’ or alignment functionality because this may decrease the flexibility and simplicity of the software.

File and memory management

The collage is saved as an xml file. Images are stored outside of this file, so that saved iterations of the collage file use minimal disk space. Images are automatically copied into a collection folder, to avoid ‘missing link’ issues if the original images are moved or deleted, and to make it easy to backup or move the entire collection. When an image is imported the software generates and stores instances of the image at various sizes. To reduce memory load, the software checks the visibility and display size of each image after each user interaction, and loads differently sized instances into memory if required.

4.2.4 Reflection on personal use

In this subsection I briefly reflect on personal use of the Magnetic Collage Software. I used it to organize work from my graduation project, in which I designed a hand-held device (i.e., controller) and software for playing audio-only adventure games. During the project different controller prototypes and audio world models were explored. The resulting collage was shown in figure 4.2-1.

Flexible, bottom-up spatial organization process

In my experience, the strongest aspect of the software was its flexible bottom-up style of organization. I dropped many images onto the canvas and started organizing and reorganizing them without being ‘distracted’ by advanced diagramming or illustration features, without worrying about overlapping content, and without thinking about the overall structure of the collage. Additionally, I did not have to think about which images to include and which not: I simply added all images, made representative images bigger, and other images smaller. There was no forced selection process. This also made it a relatively fast process, taking me approximately an hour to create the entire collage, although this was also due to the fact that the images were already previously organized in folders.

While organizing I was inspired by the images: I used images to literally build bridges between project phases, and I used the content of an image (e.g. a composition image of multiple prototypes) as inspiration for organizing the surrounding images (e.g. the individual prototypes). The software also allowed me to freely combine categorical organizations (e.g. the different prototypes) and chronological organizations (e.g. the construction process of the final prototype).

Fast switching between detail and overview

Another positive aspect of the software was the ease of switching between detail and overview, which was possible due to the density of the visual information, the size differences of the content (i.e. the larger representative images), and the easy zooming functionality. It for example allowed me to quickly gain overview of all the results from a user test (e.g. sketches made by the participants, graphs of questionnaire results), and to zoom in on the results in order to look at the details and compare them.

I noticed that I mainly navigated through the collage by zooming (while changing the position of the mouse cursor) and not by panning or scrolling. Because the fast switching between detail and overview by zooming worked so well, I did not really need the frames, and I hardly browsed through images in full-screen modus. The full-screen modus was, however, pleasant for studying detailed images.

Revisiting and overview

I mainly experienced the software as useful for quickly revisiting work and gaining overview. Seeing all the work together gave a good overview of how much effort was paid to various parts and directions of the project, and reminded me of previous reflections. For example:

> I was initially too absorbed with aiding free two-dimensional navigation through audio worlds by means of the 'absolute controller prototype', thereby enforcing an absolute top-down perspective on the audio world: I should have earlier explored other navigation models in which the audio world was structured as for example a network of one-dimensional paths, which could be easily navigated with the 'relative controller prototype', allowing for a first-person immersive perspective.

Also a few new insights emerged. For example, while browsing through the photos of user test participants (who used various prototypes for playing audio adventure games), and looking at all the different facial expressions (concentrated, relaxed, laughing), I realized that I should have video-recorded the participants and confronted them afterwards with these videos and the recorded gameplay audio. This could have helped the participants to reflect on their experiences. This also made me realize that I missed the functionality to embed and playback video (and audio) to the collage.

More flexibility needed

Although it was easy to gain overview of and to navigate between various parts of the collage, I still missed the possibility to explore relations between individual content across these different parts. The connectors could be used to *show* relations over distance, but they cluttered the collage and moreover, did not help to *explore* relations by seeing content side-by-side from close up.

What I really needed was the possibility to quickly explore alternative spatial organizations. For example, each user test participant played with three different controller prototypes and three different audio worlds, created drawings of how he or she imagined each audio world, and filled in a questionnaire. This information was now scattered over various parts of the collage (figure 4.2-2). I missed the flexibility to quickly explore relations between drawings, photos and questionnaire results associated with a specific audio world, with a specific controller, or with a specific participant.

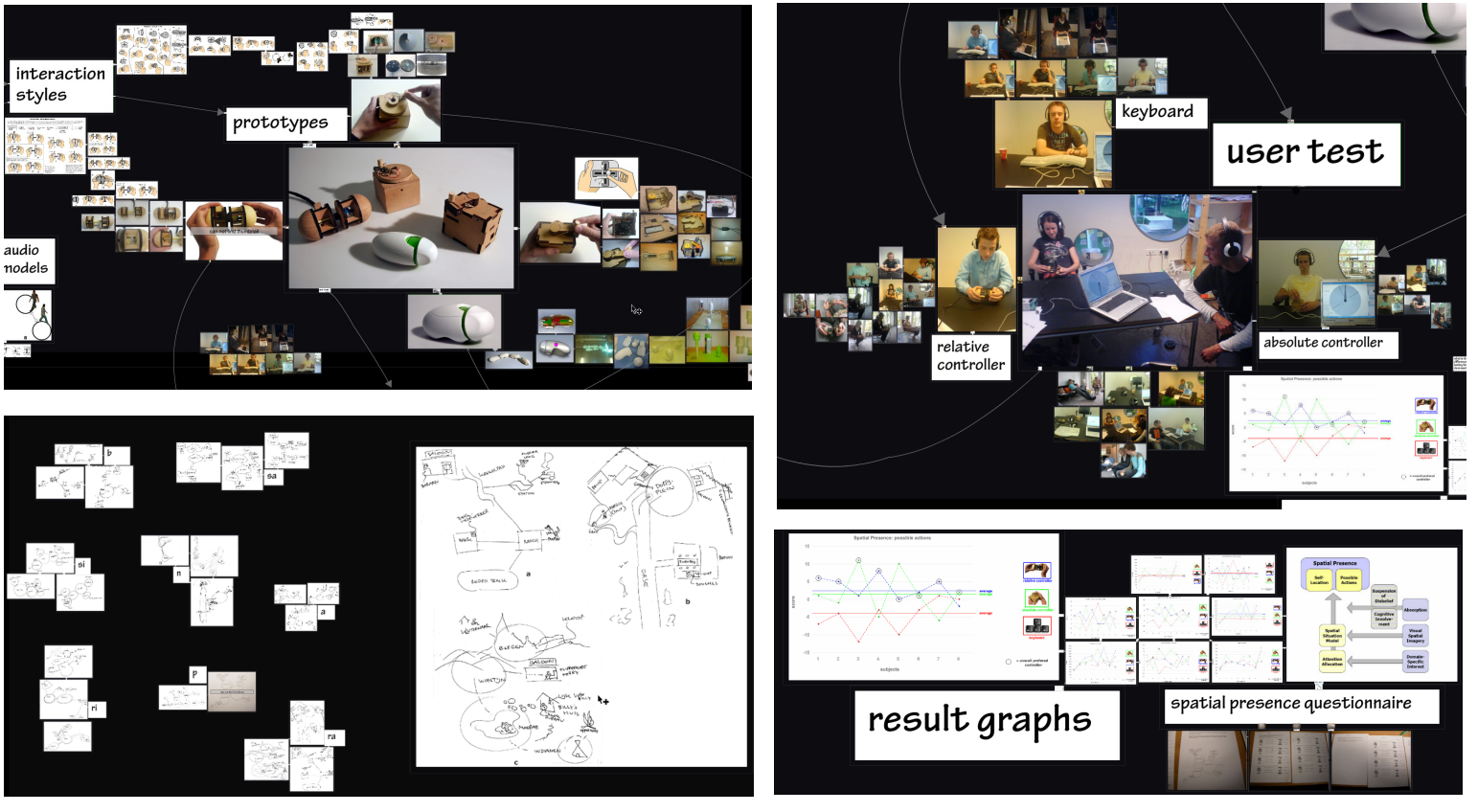


Figure 4.2-2: I missed the flexibility to easily explore relations between different sections of the collage, for example between drawings, photos and questionnaire results associated with a specific audio world, with a specific controller, or with a specific user test participant. Top-left: Various controller prototypes. Top-right: User test photos, organized by controller prototype. Bottom-left: Imagined audio worlds sketched by user test participants, organized by participant. Bottom-right: Graphs of questionnaire results.

Issues with the magnetic layout and clusters

As discussed previously, the magnetic layout and lack of grouping functionality allowed for a playful bottom-up organization style. This (lack of) functionality, however, also caused problems: When scaling, repositioning or adding content, the layout mechanism would pull or push surrounding content in order to avoid overlap and maintain connections. Occasionally, this would affect other parts of the collage, so that separate clusters of content got mixed up (i.e. they merged). This was frustrating, and made me desire more solid clustering or grouping functionality.

4.2.5 Conclusion

Using the Magnetic Collage Tool was a refreshing experience: It allowed for a more flexible and bottom-up organization style than mind mapping, illustration or diagramming software, and the images had a central role instead of a supporting role: They inspired organization and reorganization. The software allowed for fast switching between detail and overview, reminding me of project details (e.g. an idea that I had forgotten about) and high-level reflections.

Still, I felt that the software needed to be significantly improved in order to better support reflection: It allowed me to revisit work, gain overview and see relations, but not really to actively explore relations and perspectives. The resulting collage was too much a representation of the main project phases (e.g. prototyping, user testing). I could have created additional spatial organizations (i.e. new collage files), but I wanted the software to actively facilitate this, preferably *while* organizing and not afterwards. The magnetic layout did not seem to help enough. Additionally, the issues with the magnetic layout and clusters needed to be solved, in order to enable frustration-free reorganization.

All things considered, I decided that a large iteration was needed before evaluating the software. This iteration is discussed in the next chapter.

5 First iteration

5.1 Introduction

In this chapter a first iteration of the software is discussed, as well as two explorative evaluations.

In section 5.2, I discuss the design iteration, which became the first real version of Freed. In section 5.3 I discuss the feedback obtained from four design students that used Freed for organizing their project work. Finally, in section 5.4, I discuss how Freed was used for building a presentation and collection of the work of our research group.

5.2 Freed

5.2.1 Introduction

In this section the first real version of Freed is discussed. It is based on the previous version of the software as discussed in chapter 4, and still focuses on free and flexible spatial organization of design work on an easily zoomable canvas. It, however, uses a different layout mechanism that makes use of explicitly defined relations, and it allows for alternative spatial organizations ('views') to be explored and saved.

In what follows, I first discuss the tools that I used. Thereafter I discuss the main functionality of Freed, followed by a short reflection on personal use.

5.2.2 Tools used

Freed is build from scratch using the Java-based Processing libraries inside the Eclipse development environment (http://processing.org, Reas & Fry 2003). I preferred to continue working in Adobe Flash because of its integrated nature, but it eventually became too slow (in 2008) to render all the images and to dynamically compute the layout. Processing's hardware-accelerated mode (based on JOGL, the Java-OpenGL bindings) is used for rendering all the content on the canvas, and for handling the interaction with the canvas and its content. Swing, a Java GUI (graphical user interface) toolkit, and Jigloo, a visual GUI builder, are used for creating standard user interface elements such as toolbars, dialogs and palettes.

5.2.3 New functionality

Below, I discuss the main functionality of the software. I focus on functionality that differs from the previous version of the software. A description of basic organization and navigation on the canvas has already been discussed in section 4.2.3.

Relations

In Freed, content is organized as a network of 'nodes' (e.g. images, texts) that are connected by relations (figure 5.2-1). In comparison to the previous version of the software, it is not possible to connect nodes by dragging them against each other, or to disconnect nodes by dragging them apart. Relations have to be explicitly created and deleted. Relations are created by clicking on two nodes in sequence while holding the space bar (or using the relation tool). When moving the mouse cursor over a node, related nodes are highlighted. To keep the focus on spatial organization, relations cannot be curved (in contrast to the 'connectors' in the previous version of the software) and cannot be made hierarchical. Text and arrowheads can be added to relations.

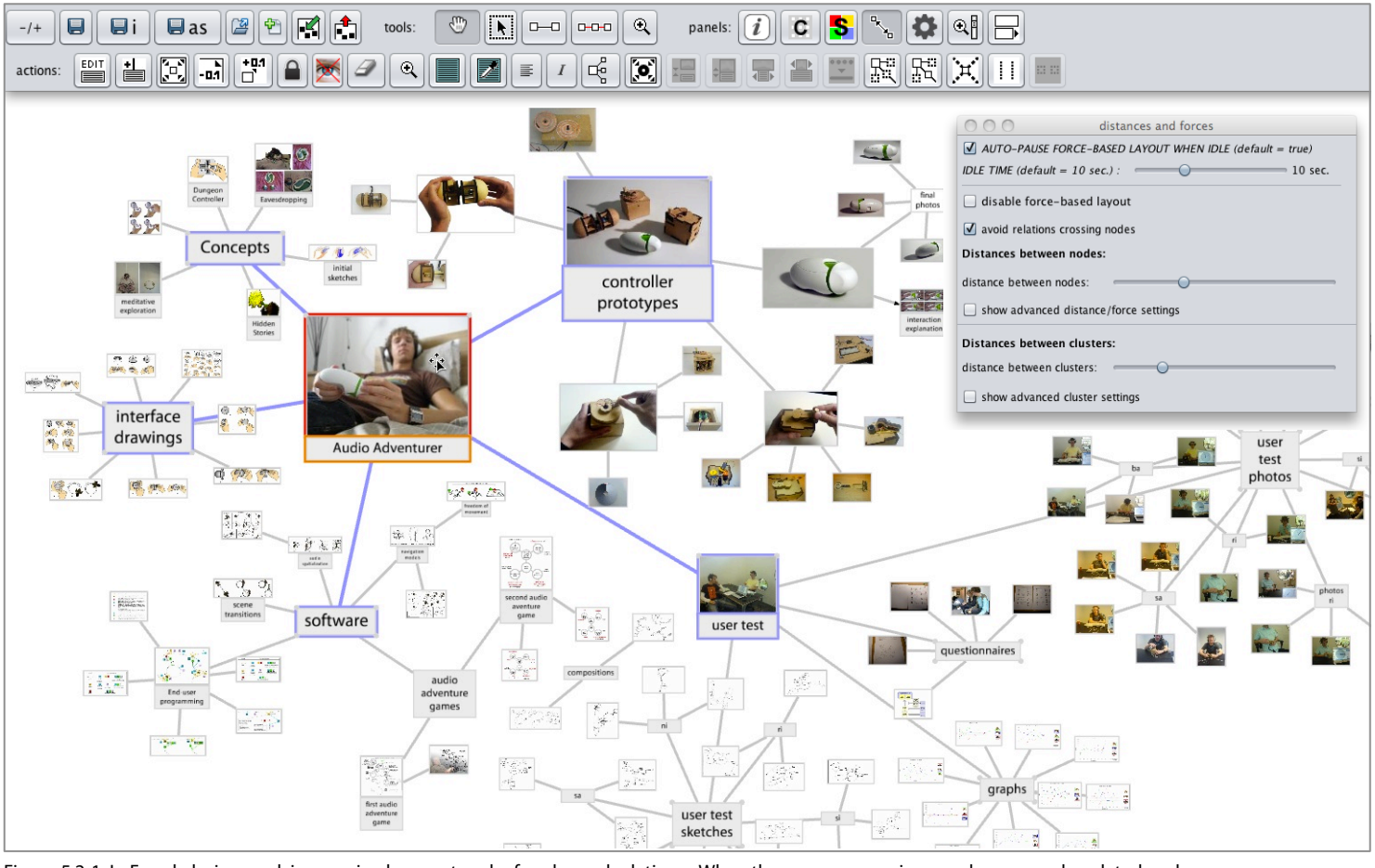


Figure 5.2-1. In Freed, design work is organized as a network of nodes and relations. When the mouse cursor is moved over a node, related nodes are highlighted. The white area is the zoomable, unconstrained canvas. At the top is a menu bar with *main functions* (e.g. save), *tools* which operate on one element at a time (e.g. create relation) *actions* which are applied to all selected elements at once (e.g. delete) and buttons for opening/closing *panels* with more detailed properties, preferences and actions. One panel is open (top-right).

Clusters

Like in the previous version of the software, it is not possible to explicitly ‘group’ nodes. Instead, nodes can be ‘clustered’ by creating relations, preferably by using one node as center of the cluster. The interface is optimized for this process: A cluster can be quickly created by first clicking on the center node (using the relation tool) and then on the other nodes (figure 5.2-2).

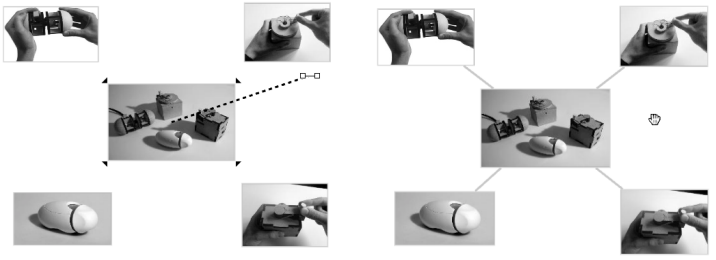


Figure 5.2-2: Creating a cluster. Freed is optimized for quickly creating multiple relations in sequence. Left: First click on the desired center node. Right: Click on the other nodes.

The force-based layout

The relations are needed for the ‘force-based layout’ (FBL) to do its work. The FBL replaces the magnetic layout of the previous version of the software. It causes related nodes to attract each other and all nodes to repulse each other. While nodes are repositioned, resized, created or deleted, or if relations are created or deleted, the FBL tries to optimize the distances. To do this it mainly uses two user-definable *general* settings: ‘Node distance’ and ‘cluster distance’ (figure 5.2-3). The former is the desired distance between each possible pair of nodes (related or unrelated). The latter is a more abstract setting: To compute the distance between clusters, the system uses a similar approach as used in Vizster (Heer & Boyd 2005): Nodes with many relations will be placed relatively far away from other nodes with many relations, and similarly, a node with only one or a few relations will be placed relatively close to its related node(s). Clusters are therefore not explicitly defined, but emerge while creating relations. More information about the implementation of the FBL is given in Appendix 1.

No distances, lengths or forces can be set for *specific* nodes or relations. I experimented with such functionality and found out that it distracted from organization, because of the difficulty that the desired length that is explicitly ‘set’ for a relation (e.g. through direct manipulation) is generally not the same as its actual length (due to competition with other nodes and relations in the FBL).

Locking nodes

Nodes can be *locked* in order to gain full control over their positions. In other words, locked nodes are not influenced by the force-based layout. They, however, do influence other nodes. Locking nodes can be useful to make the organization more orderly. It is for example easy to position a cluster of nodes by locking and dragging the center node of the cluster. Locked nodes have small gray ‘pins’ at their corners (unless disabled in the preferences).

Figure 5.2-3. Various settings of the force-based layout. Top-left: Small node distance, no cluster distance. Top-right: No node distance, medium cluster distance. Bottom: A combination of zero node distance and zero cluster distance gives a collage-like appearance.

Paths

Paths are ordered sequences of nodes. They are created by clicking on nodes in sequence using the path-tool. Paths can for example be used to represent a scenario, presentation, or part of a design process. The nodes that are part of a path can be browsed sequentially in full screen (i.e., as a slideshow). Paths cannot branch. Paths can be compressed or stretched by dragging their ends (Figure 5.2-4).

Figure 5.2-4. A path makes it easy to reposition, compress or stretch a linear sequence of nodes.

The positions of locked nodes are not influenced by a path. Nodes can therefore be locked in order to divide a path in multiple straight segments (figure 5.2-5). Paths can be straight or curved. A curved path blends in with the force-based layout. The curvature of a path can be manipulated by adapting its ‘straighten force’, and a path can be made to stand out more or less from the surrounding network by adapting its ‘space around path’ setting (figure 5.2-6).

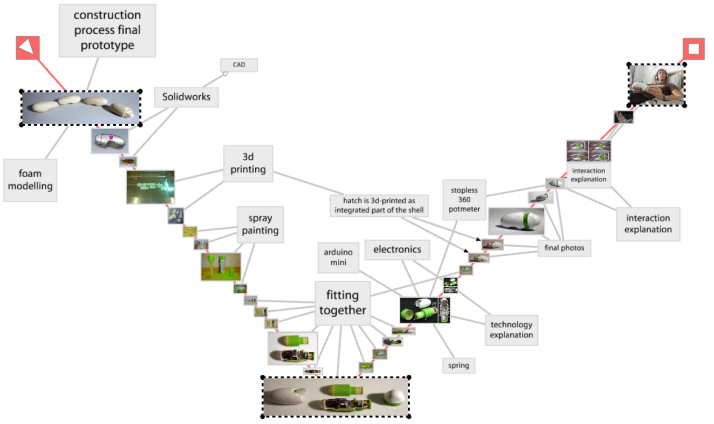


Figure 5.2-5: Nodes can be locked in order to divide a path in segments.

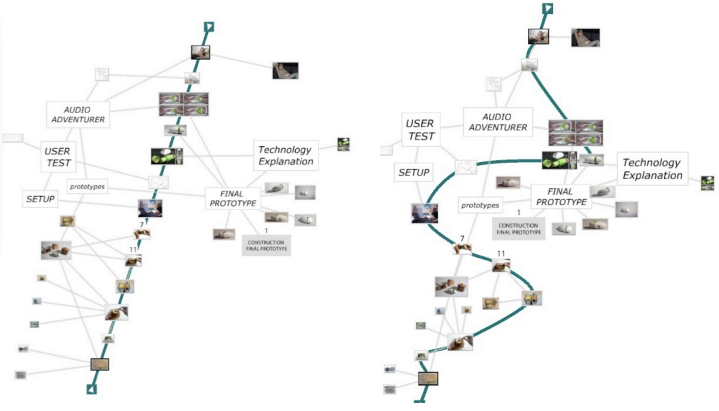


Figure 5.2-6: Left: Straight path with large ‘space around path’. Right: Curved path with zero ‘straighten force’ and default ‘space around path’.

Multiple views

The main purpose of the force-based layout is to make it easy to explore alternative spatial organizations, called ‘views’. New views can be created by cloning the current view, or by starting an empty view. Views can be used to take a different perspective on the design work, or to organize the work for a specific activity or project phase (figure 5.2-7). Views are not separate files. They are stored together in one file, and share the same ‘collection’ of content. This for example means that if specific text is changed in one view, it also changes in all the other views that include that text. Content does not have to be visible in each view. Views are therefore, next to *spatial organizations*, also *selections*.

It is not possible to have multiple views open at the same time (i.e., there are no tabs or windows with views). In the first version of Freed, the user switches to another view by choosing it from a basic drop-down list with view names.

Animated view transitions

Transitions between views are animated. These animations serve to give a quick impression of the differences and similarities between views. View transitions have three stages: First the content that is only part of the first view fades out. Then the content that is in both views is gradually moved and transformed to its new position and size. Finally, the content that is only part of the second view fades in.

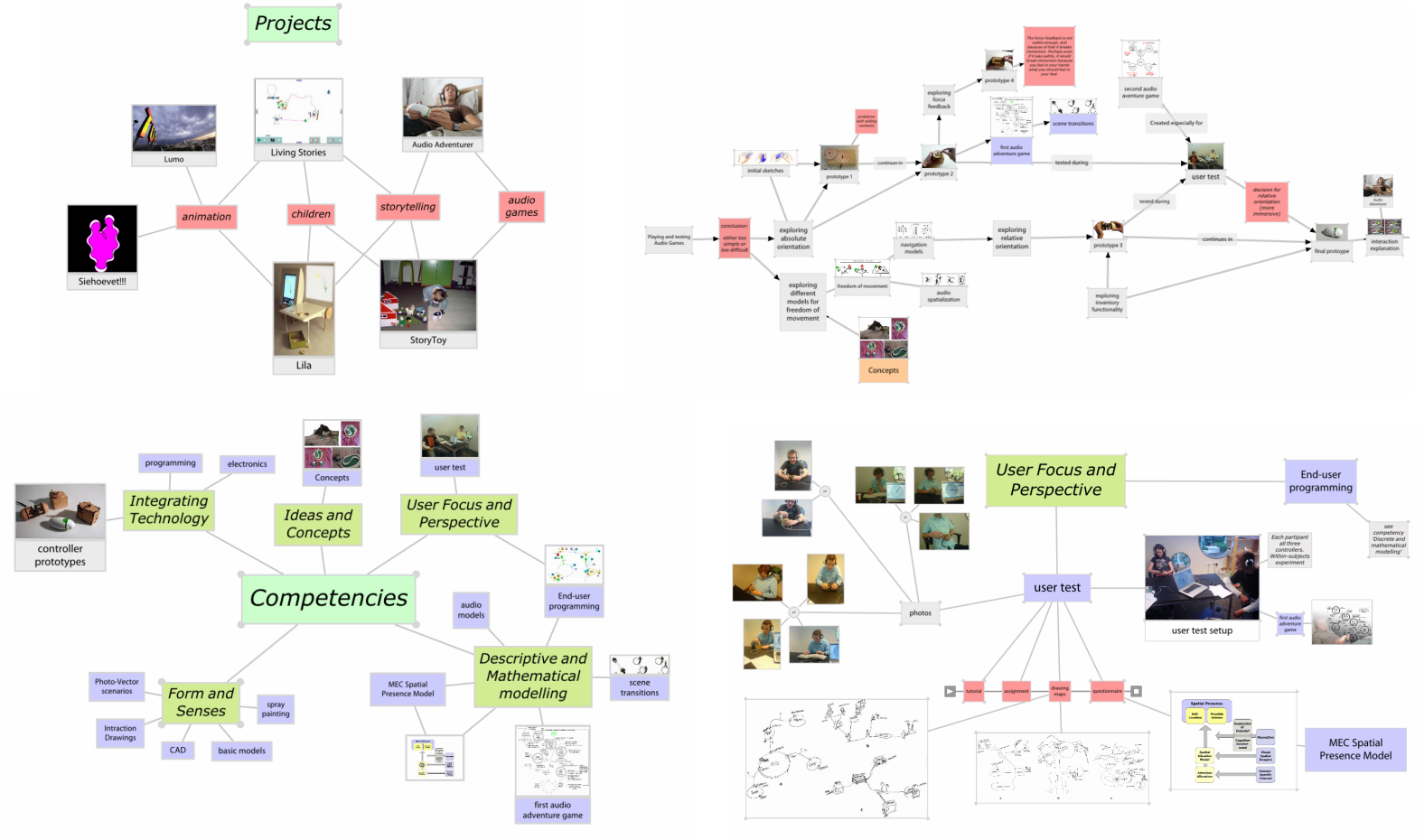


Figure 5.2-7. Four views of the same collection.

Top-left: Multiple projects connected by topics. Top-right: Part of the design process of one of the projects (all nodes locked).

Bottom-left: An overview of competencies addressed in the project. Bottom-right: An overview of project work associated with one of the competencies.

Note: In Freed only one view can be open at a time.

Hiding, deleting and showing content

To only show content relevant to the current view, or to avoid clutter and information overflow, nodes, relations and paths can be *hidden* from the current view. Hiding is different from *deleting*. When content is deleted it is removed from the entire collection, and therefore from *all* the views.

To show hidden nodes or paths (i.e. to add to them to the current view) the user can use the *collection browser* (figure 5.2-8). In this panel the entire collection can be browsed, filtered and searched.

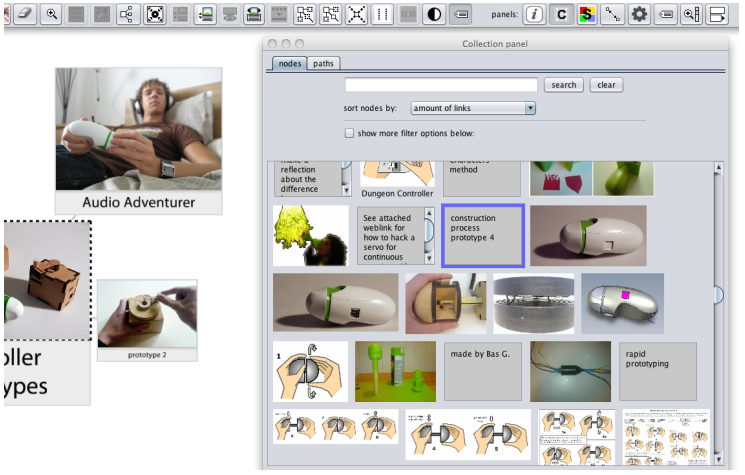


Figure 5.2-8. The collection browser can be used to browse, filter and search the entire collection and to add (i.e. show) existing nodes and paths to the current view.

Alternatively, nodes can be hidden or shown directly on the canvas, expanding or collapsing related nodes that are already visible in the current view. When moving the mouse over such a node, a button is shown above it that toggles between hiding and showing its related nodes (figure 5.2-9). Because there are no hierarchical relations it is not possible to hide or show entire 'branches' of nodes in one click.

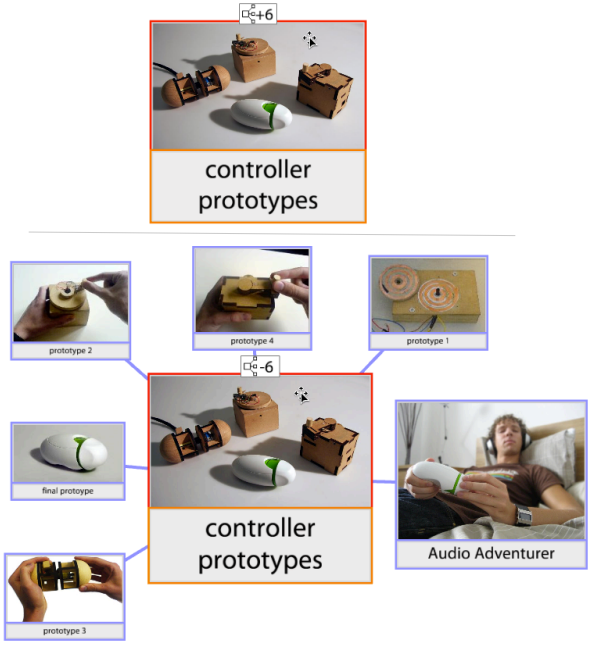


Figure 5.2-9: Showing/expanding nodes by relation. Top: The button indicates that the focused node has six hidden related nodes. Right: After pressing the button the hidden related nodes are shown, as well as the relations between the nodes.

Showing hidden relations

Relations can also be hidden independent of nodes. Relations cannot be shown from the collection panel. In order to show a hidden relation between two already-visible nodes, the mouse cursor needs to be placed over one of the two nodes. Hidden relations of this node are then shown temporarily as dotted lines. These lines can be clicked in order to unhide the relations (figure 5.2-10).

Coordination between views

Some content properties are global (i.e. collection-wide). This means that changes to these properties automatically apply to all views. Examples of global properties are the image, text and relations of a node, the arrowheads and text of a relation, and the content (i.e., the nodes) of a path.

Other properties are view-specific. This means that they are allowed to differ per view. Examples of view-specific properties are the position, size, color and visibility of nodes, relations and paths, as well as the settings of the force-based layout.

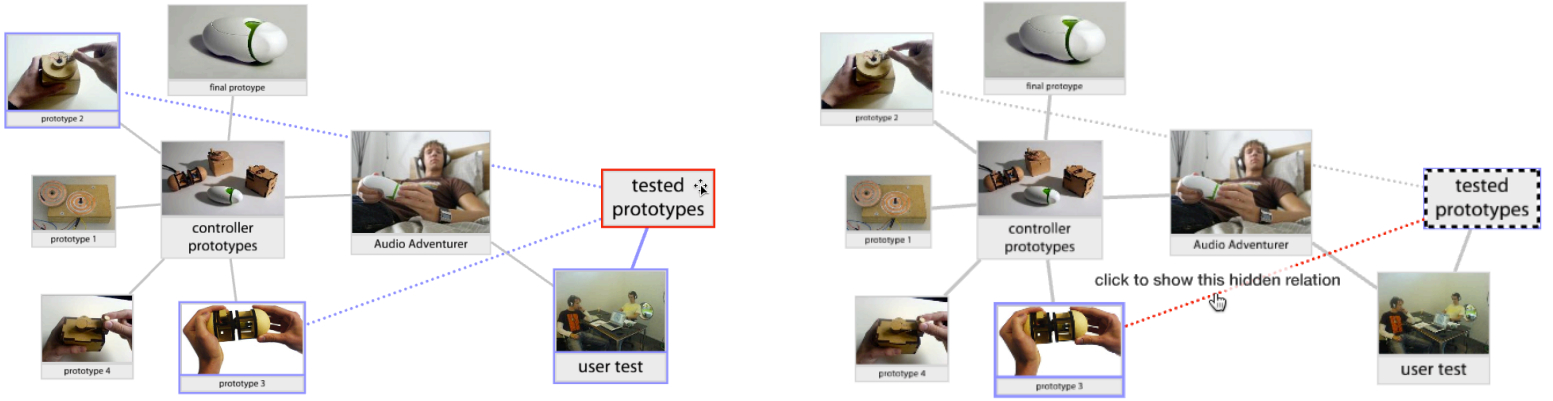


Figure 5.2-10. Exploring and showing hidden relations.
Left: Mouse-over a node to show its hidden relations with other visible nodes.
Right: Select the node and then click on a hidden relation to unhide it.

5.3 First feedback

In order to explore the first reactions to the software and to obtain feedback for improving the software, Freed was used by and discussed with four industrial design students (S1-S4). The students used the software to organize work of their individual semester-long BSc. graduation projects, of which nearly half of the available project time had already passed when the software was introduced. They were not instructed to use the software in a specific way. Near the end of the semester, a loosely structured interview (approx. one hour) was held with each student during which we discussed the views that they created and the functionality of the software. In the following subsections I summarize the main outcome of these discussions.

5.3.1 First impressions of use

Design process overviews

Three students used the software to create chronological overviews of their project work (Figure 5.3-1 and 5.3-2). They mainly clustered images by activity or topic (e.g. ‘concept 1’ or ‘midterm exhibition’). The center-nodes of these clusters were locked and the related content (e.g. different sketches of concept 1) remained unlocked so that it was easy to reorganize the view by dragging the center-nodes. In some cases images were made bigger in order to illustrate their importance or to give overview of their surrounding context.

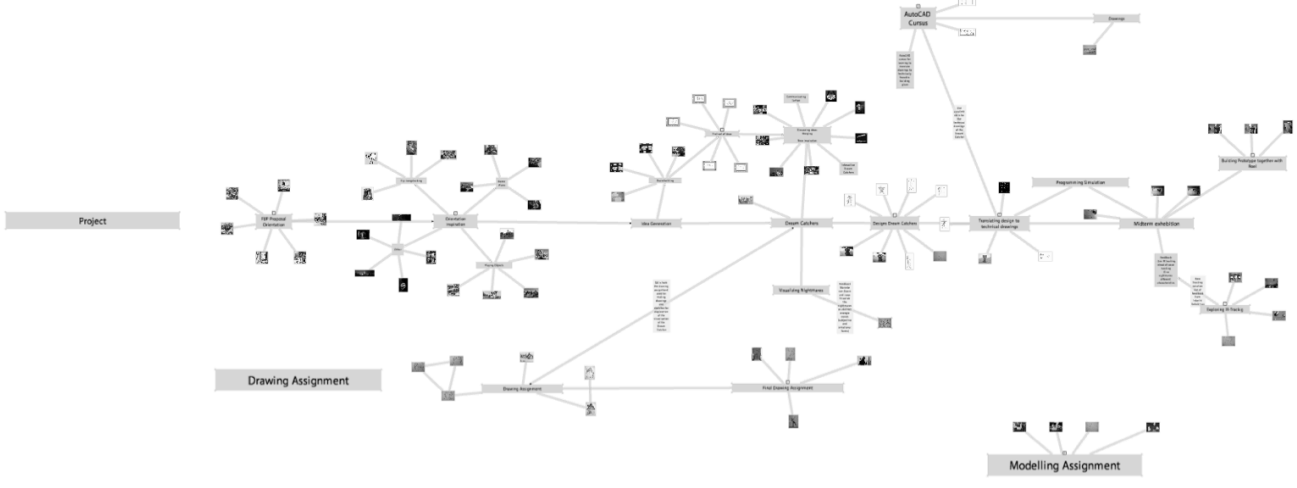


Figure 5.3-1: The main view of S1 shows a visual chronological overview of his project work, connected to work of various assignments (i.e. classes).

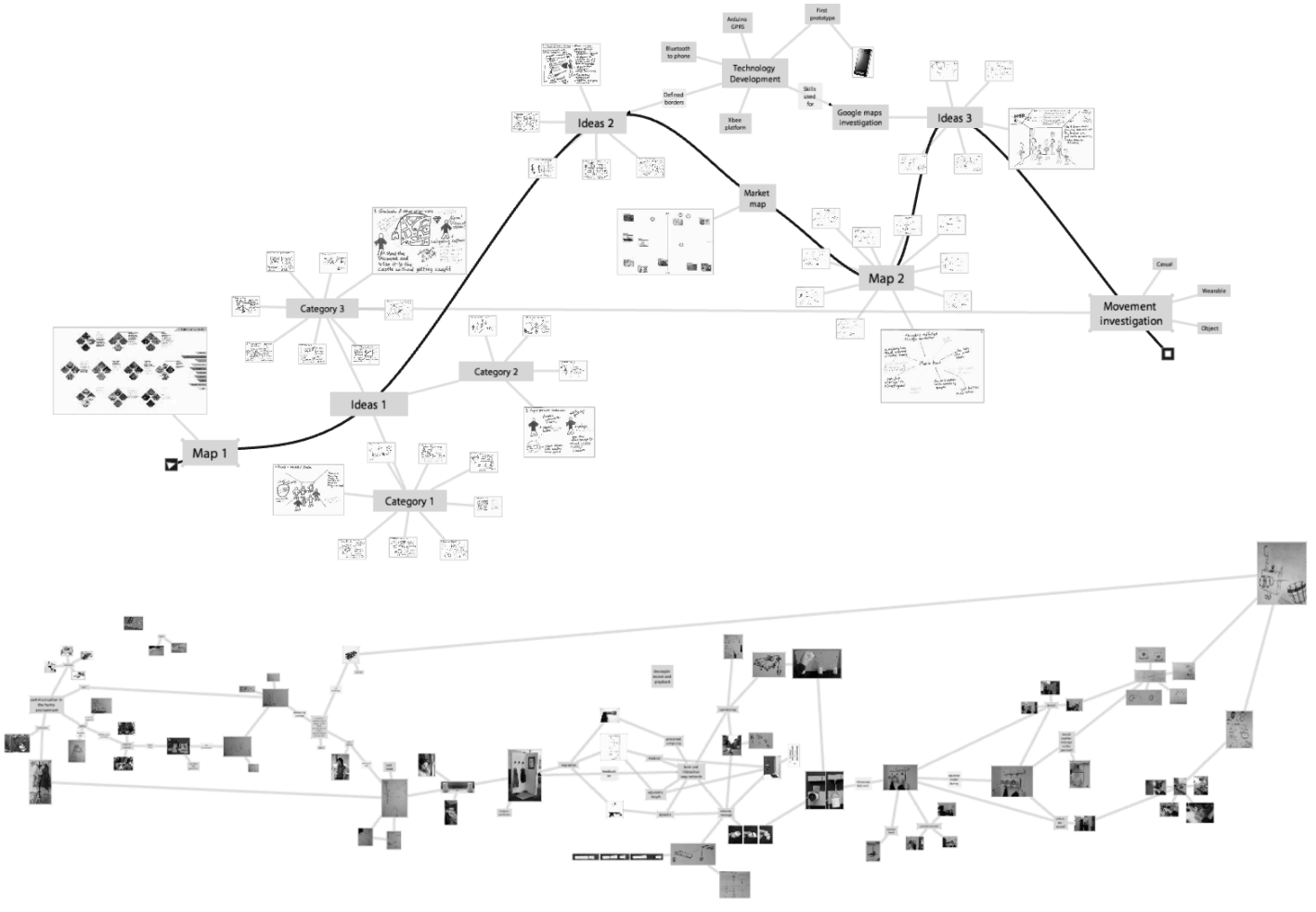
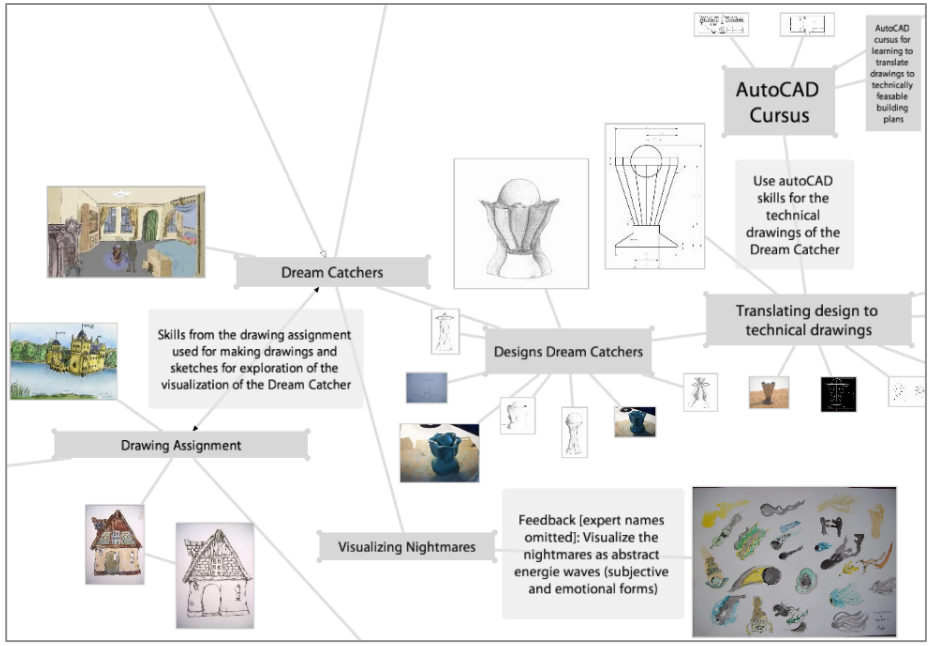


Figure 5.3-2: Top: In his main view S2 has used a path that chronologically connects the main activities of the first half of his project.
Bottom: S3 created a chronological overview of her design process, which uses many related images and less clear-cut phases or activities.

S2 used a curved path to connect the activities in a chronological way. He used the path for its visual properties (a clear thick line) and not for its quick reorganization possibilities (e.g. by using a straight path) or its full screen presentation possibilities. He missed the possibility to create a branching path, in order to show main branches in his design process. He finally used relations to show the branches.

The participants mainly valued Freed for creating a quick personal visual overview, and they did not include elaborate explanations of activities and of the rationale. Occasionally, basic keywords or descriptions concerning the design rationale were added. These for example concerned requirements, feedback of experts, users or exhibition visitors, and skills learned during assignments or courses (e.g. Figure 5.3-3 and 5.3-4).



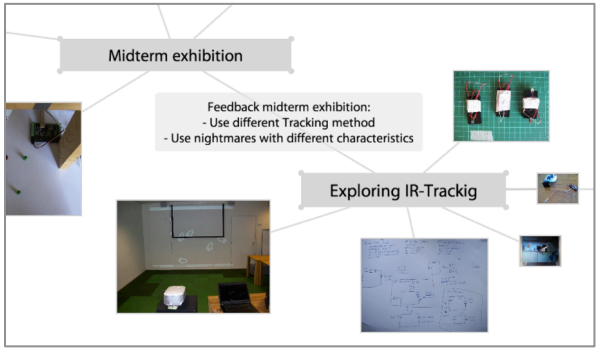
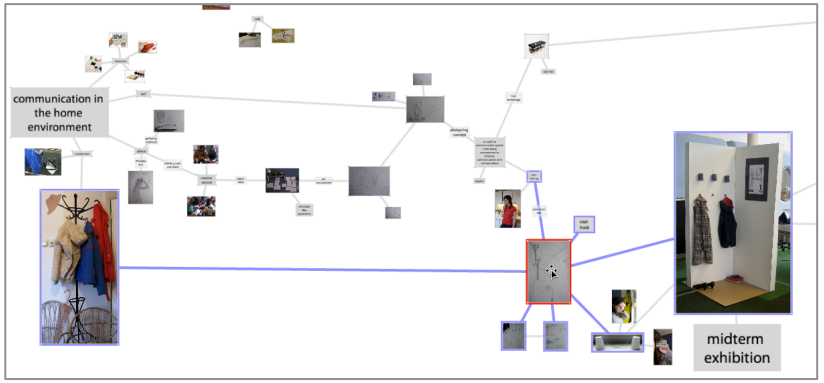
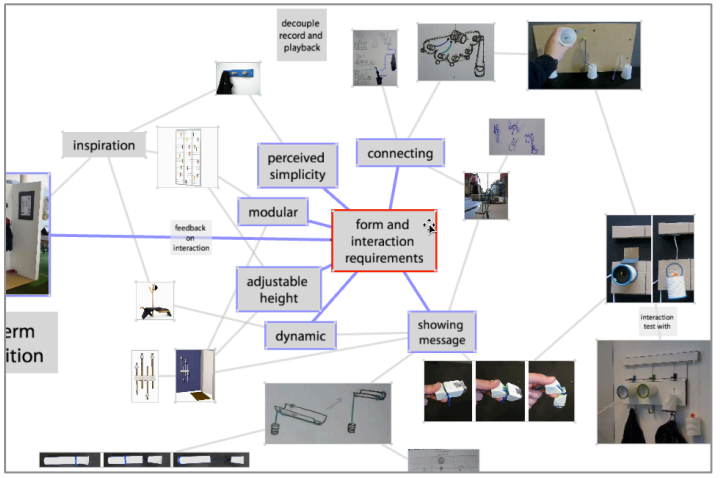


Figure 5.3-3: Examples of relations and descriptions in the collection of S1, who designed an interactive installation that allows children to chase and capture projected dreams and nightmares.

Left: S1 shows how skills from assignments/courses and feedback from experts were used in his design process.

Top: Feedback on his midterm exhibition demonstrator made S1 explore an alternative technological method.





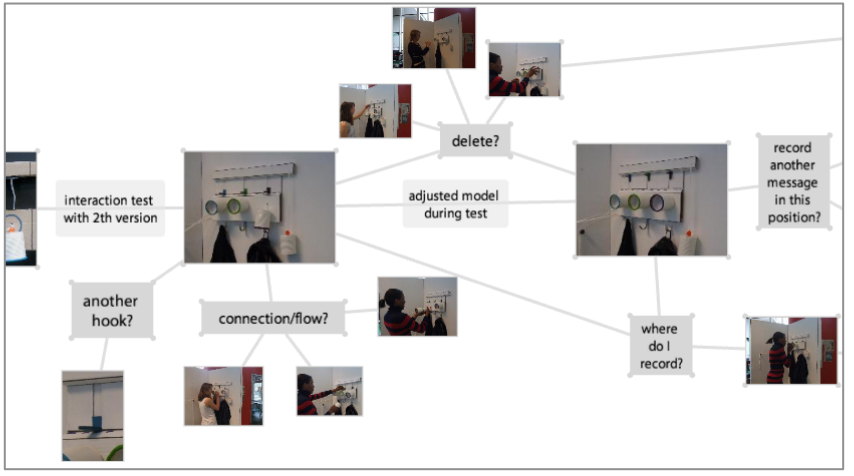


Figure 5.3-4: Examples of relations and keywords/questions in the collection of S3, who designed interactive coat hooks for facilitating in-home asynchronous communication (audio messages).

Left: S3 shows that one of her first ideas (the coat hook) is used in her main concept, but that details of the concept were influenced by other ideas and explorations.

Bottom-left: S3 shows 'requirements' that emerged from feedback obtained during the interim exhibition, and several ideas and explorations that were based on these requirements.

Bottom-right: S3 shows the ideas/questions/issues that emerged while people tested her prototype.

The lack of textual detail in the participants' overviews was contrasted by the detail in terms of images. Many 'raw' images of details of the process (e.g. related work, sketches of ideas, photos of interaction explorations), which are often left out of reports, were included in Freed. Often these details referred to side-tracks or abandoned or underexplored parts of the process, and therefore triggered discussion during the interview, for example about their relation to other project work (e.g. Figure 5.3-5) or about choices (e.g. Why did you not pursuit that idea?) and future work.

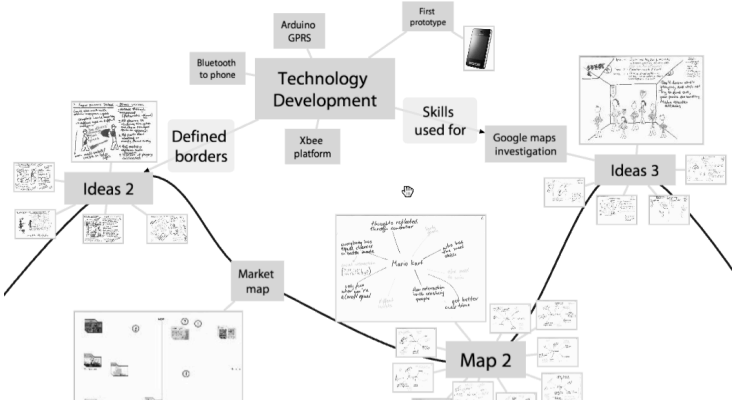


Figure 5.3-5: This part of the main view of S2, who designed an outdoor GPS-based game, triggered a discussion about to what extent his many ideas were supported and /or constrained by technology.

Some of the collected images of related work (e.g. of particular inspirational projects, Figure 5.3-6) were not of main importance for the specific project of the student, but were, for me personally, highly inspirational. These images made me curious and ask for elaboration.

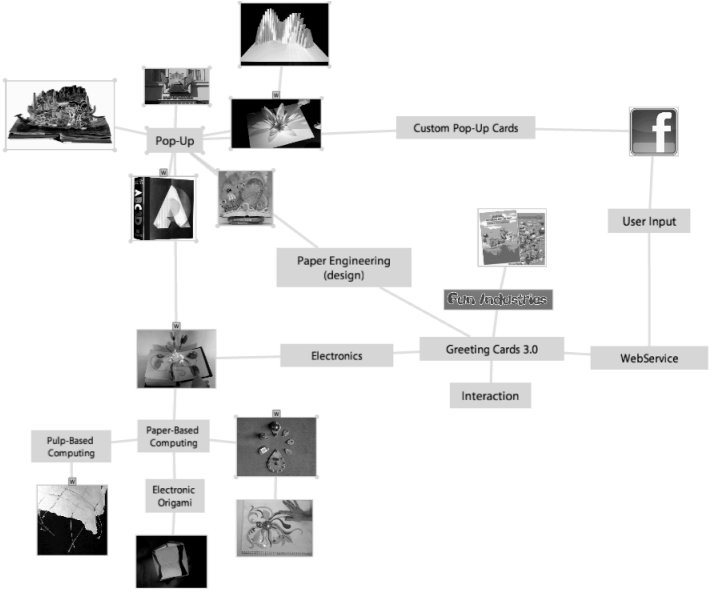


Figure 5.3-6: In this view S4 shows her first ideas for a system of customizable pop-up greeting cards, including examples of inspirational projects and technologies.

S1 and S3 mentioned that they showed their views during meetings with their coach. They used it mainly for giving a quick overview of the past process, and not for actively discussing current project work in detail. They did not add coach comments to their overviews during these meetings. S1 saved multiple iterations of his view and mentioned that switching between views using the animated view-transitions, worked well to show his progress to his coach. He mentioned that this made it easy for the coach to have a quick recap of what they discussed in the previous meeting. Additionally, he created a separate view in which he used a curved path to quickly 'highlight' a selection of work and present it to his coach in full screen (Figure 5.3-7).

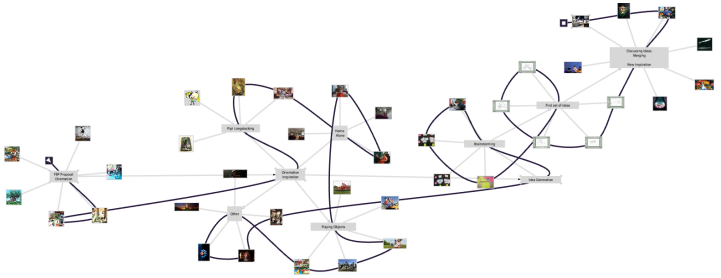


Figure 5.3-7: S1 used a path to quickly present a selection of an existing view to his coach.

S1 also created a poster of his main view and used this during the final exhibition (Figure 5.3-8). His main reason for doing this was to have the process available as reference and evidence for possible discussions with the audience, most notably his assessor.

Figure 5.3-8: S1 showed his main process overview on a poster (in the back) during the final exhibition.

Exploration and reflection

The software was mainly used as a tool for visual overview and quick revisiting, and hardly as a tool for exploring new relations and perspectives. This was partly expected, as the first part of the design process was not part of this evaluation. S1 did create a view in which he explored relations between his project work and competencies (Figure 5.3-9). However, he explained that he mainly did this 'to gain overview' and did not report specific insights.

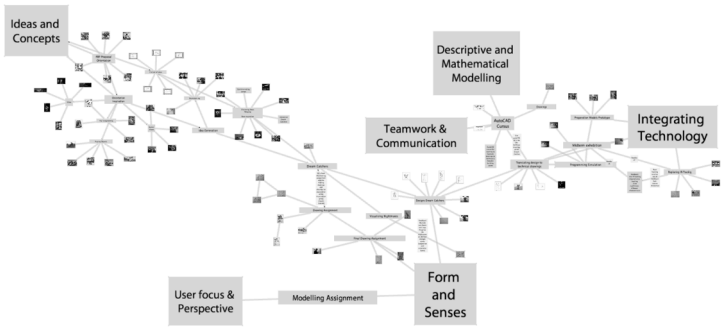


Figure 5.3-9. The competency view of S1.

Feedback on functionality

The force-based layout and the possibility to quickly organize and reorganize content were well appreciated. Still, many feature requests were made: Adding color to text nodes was desired by all participants. As previously discussed, S2 asked for the possibility to create branching paths. S3 mentioned that it may be useful to be have a background layer for drawing background shapes, in order to visually group content and to show project phases. All participants asked for the possibility to import (drag and drop) videos and documents, and S4 wanted to embed online videos inside Freed. Finally S1 and S2 mentioned that it would be useful to have a timeline view inside Freed, in which imported content is organized by time, and which can be used as a starting point for creating relations and for spatial organization.

5.3.2 Conclusion

This explorative evaluation showed promising first results: Freed was appreciated as a tool for free and flexible organization, for gaining overview, and for revisiting work. It also gave a preliminary indication that the inclusion of a lot of detailed visual content (e.g. sketches of ideas, images of related work) helps to paint a holistic picture of the project and process (which is not limited to the main choices and results), and provides rich input for revisiting, explanation and discussion. However, in order to confirm this, and in order to assess Freed as a tool for exploring relations and perspectives within a design project, a more structural evaluation of its role during the entire design process was needed. This evaluation is discussed in chapter 6. First, in the next section, a different use of Freed is explored.

5.4 Group collection and presentation

5.4.1 Introduction

In this section I mainly discuss how Freed was used for creating a presentation of the work, members and collaborations of our research group: The Designing Quality in Interaction group (DQI). Additionally, I give a short impression of individually created overviews by several DQI members.

The presentation was for the research visitation (i.e. research assessment) of our department, which takes place once every five years. The reason for creating the presentation in Freed was threefold: First, it allowed us to explore how free and flexible organization would change the act of making and giving a presentation. Second, we wanted to gain insight in how a collection could emerge from, and be structured through making and giving a presentation. Third, we aimed to get a preliminary view on the possible challenges and opportunities concerning collaborative collection, presentation and reflection, despite that both Freed and the available time did not allow for true group work

In what follows, I first introduce the overall process of making and giving the presentation, and the setting in which it was given. Thereafter an impression of the presentation is given by means of several examples, followed by a short impression of individually created overviews of work by different DQI members. In the conclusion I discuss insights, opportunities and challenges concerning the integration between group collection, presentation and reflection.

5.4.2 Process and setting

Within a time frame of approximately one month, I had regular meetings with the group leader during which we built the presentation. He had already defined the main topics of the presentation in advance, which included an overview of the members of DQI, its research focus and approach, results, integration between research and education, collaboration with other research groups, collaboration with industry, international collaborations, and finally a part about future work and ambitions. During the meetings I controlled the software. In between the meetings, I regularly asked group members for feedback and missing details (e.g. projects, images, collaborations, descriptions) and added required functionality to the software.

In addition to the presentation, an exhibition was organized with posters and prototypes of many PhD projects (Figure 5.4-1). Three of these projects were highlighted and demonstrated, giving the committee information about each specific design process, and the possibility to experience the actual prototypes. After that, the general presentation was given using Freed on a large projection

screen above the exhibition area. The group leader gave this presentation, and again I controlled the software (e.g. switching to a new view, zooming in on content).

Before giving the final presentation, a test-run was done in front of a large part of the research group. This test-run was informal and interactive: DQI members asked me to zoom in on parts of views and gave comments about missing content or relations. I added these comments directly inside the views in context (with a distinct color), so that I could easily revisit them after the test-run. The final presentation to the visitation committee was much more formal, with no time for discussion during the presentation.

Figure 5.4-1: In addition to the presentation, an exhibition was organized with posters, models, prototypes and demonstrations of PhD projects.

5.4.3 An impression of the presentation

An overview of DQI-members

The presentation included an overview of the various DQI-members clustered by function (e.g. PhD candidate, associated lecturer), including the external associations of several members (Figure 5.4-2, top-left). Despite the organization by function, we still tried to give a dynamic, integrated and non-hierarchical 'feel' to the view in order to reflect the situation in real-life (a large part of the members working together dynamically in one space).

Several alternative spatial organizations of DQI members and functions were explored in new views (Figure 5.4-2). This was initially mainly done by playing with the force-based layout and repositioning clusters, but thereafter also by locking content, reconnecting content, changing color and temporary functionality for automatically organizing content on a circle. We experienced these alternative organizations as too orderly, too dispersed or too messy (i.e. too much overlap between nodes or between nodes and relations). Improving these organizations either required too much use of color, or would require additional functionality such as curved relations, auto-arrangement on a grid, or hierarchical relations to automatically generate trees (e.g. a radial or balloon tree). Eventually we chose for the dynamic 'feel' of the original force-based organization.

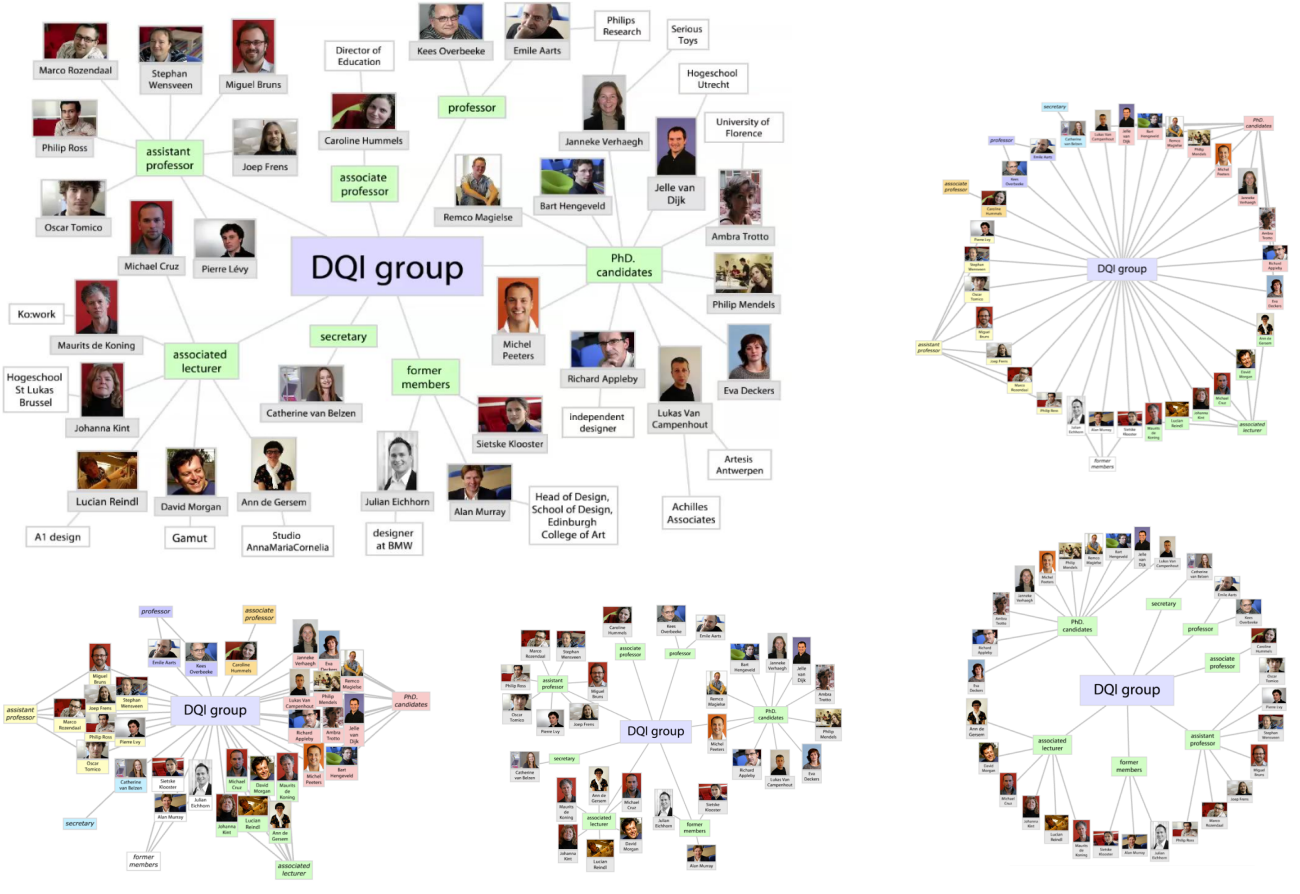


Figure 5.4-2: The multiple-view nature of the software invited to experiment with alternative spatial organizations.
Top-left: The original force-based organization that we finally used.

Another view showed the development of the DQI group in a horizontal tree layout, which was created by locking all nodes and positioning them individually (Figure 5.4-3). Five generations of DQI members were shown and relations were used to indicate who supervised whom. New functionality was added to toggle nodes between their normal state and a 'minimized' state, in which they appear as small dots. This functionality was used to avoid clutter, as it was not necessary to show a description (e.g. 'supervises') at each point were the tree branched. Additionally, the relations between the generations and the members were hidden to avoid clutter (Figure 5.4-4).

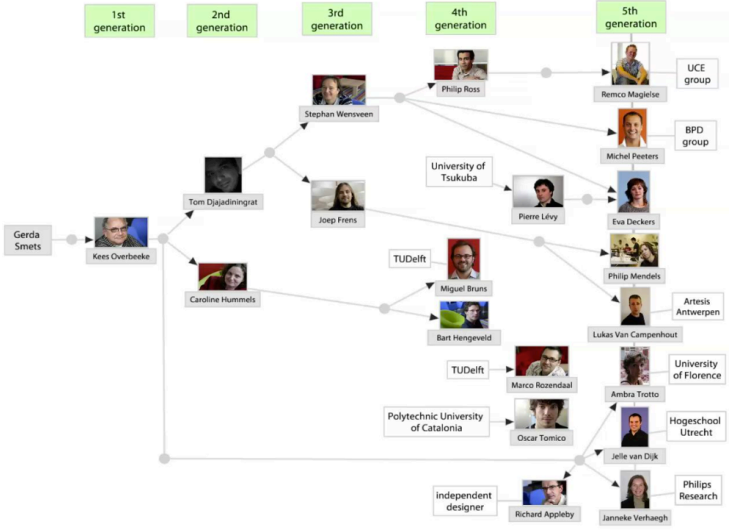


Figure 5.4-3: The DQI generations view, with minimized nodes between members.

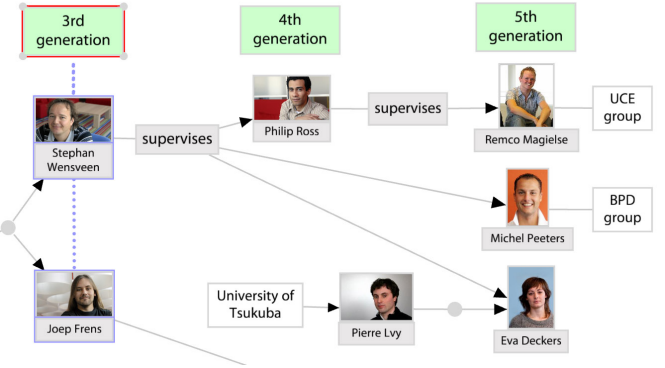


Figure 5.4-4: Part of the same view as shown in the previous figure, but here showing a hidden relation and non-minimized descriptions.

An overview of research

Several views showed the design-research focus and approach of DQI (Figure 5.4-5). A recurring element in these views was the use of examples of DQI members and their work. These examples helped to explain the text and could be zoomed to full screen in order to elaborate on a project. They also served to create overlap between the views (i.e. they were reused in multiple views). This overlap, in combination with the animated view-transitions, helped to show the relations between the views and to keep the 'flow' in the presentation.

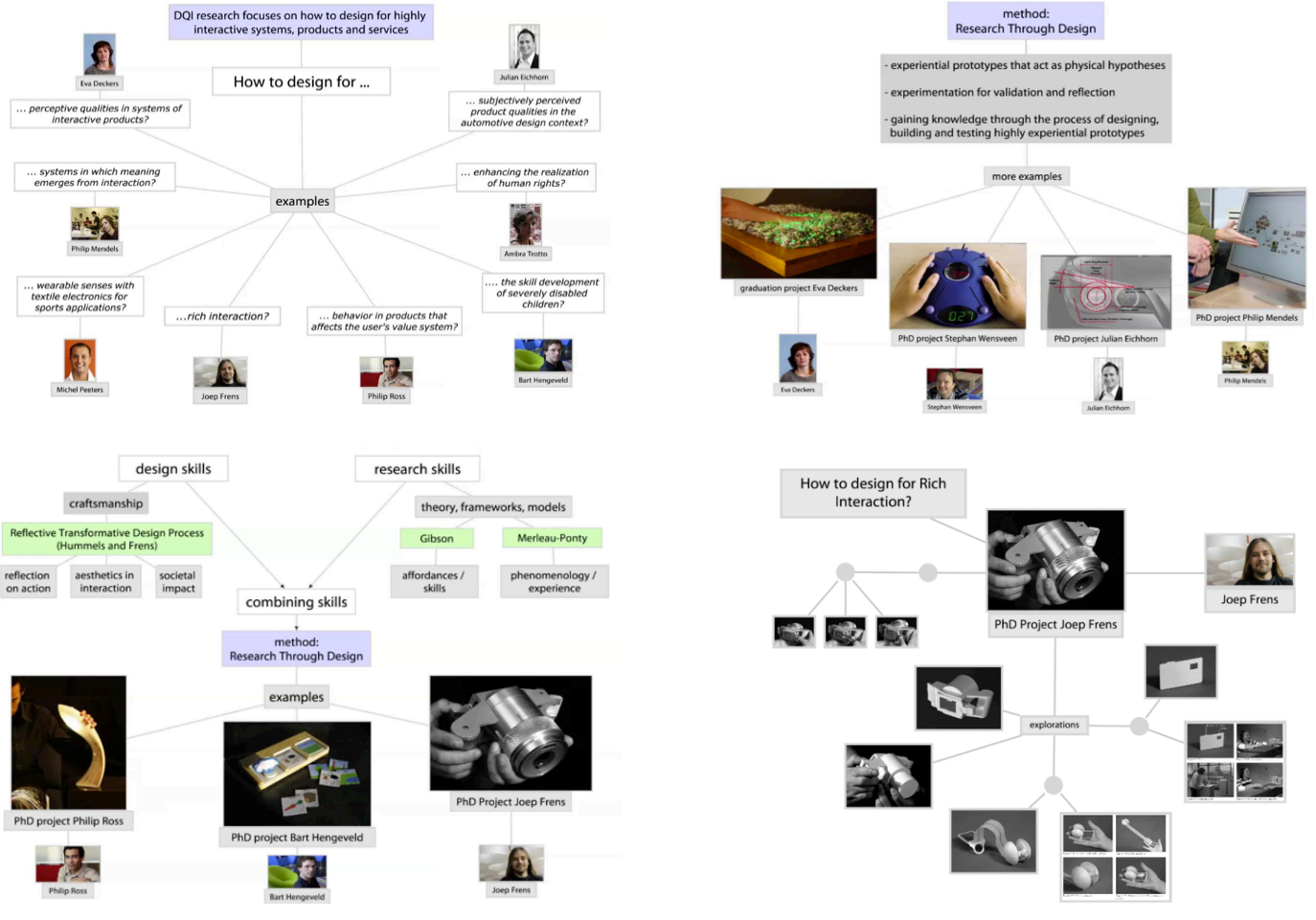


Figure 5.4-5: Four views explaining DQI's design-research focus and approach.
Top-left: Integrated overview of research questions. Top-right: The integration of 'design skills' and 'research skills' in the method 'Research-through-Design' (RtD)
Bottom-left: Elaboration of RtD with additional examples. Bottom-Right: Example of one project to illustrate RtD.

An overview of integration and collaboration

The main part of the presentation was about integration and collaboration, and contained many detailed views that showed examples of and relations between work of DQI, other research groups (i.e. 'capacity groups'), students and companies (Figure 5.4-7).

Because the presentation about integration was relatively long and because the detailed views had a high information-density, we decided to alternate the detailed views with an 'overview-view' (Figure 5.4-6). In this overview-view part of the content of the detailed views was reused and related to each other. Because of that, the animated view transitions helped to highlight the relations between the detailed views.

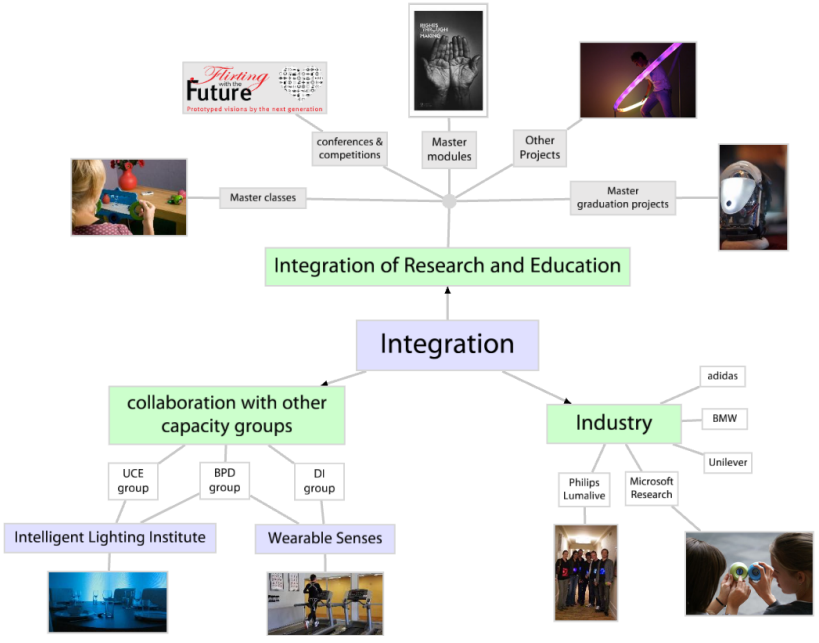


Figure 5.4-6. The 'overview-view' of the 'Integration' part of the presentation. This view was alternated with more detailed views, in order to clarify to the audience how the detailed views were related to each other (i.e. to remind them of the overarching topic).

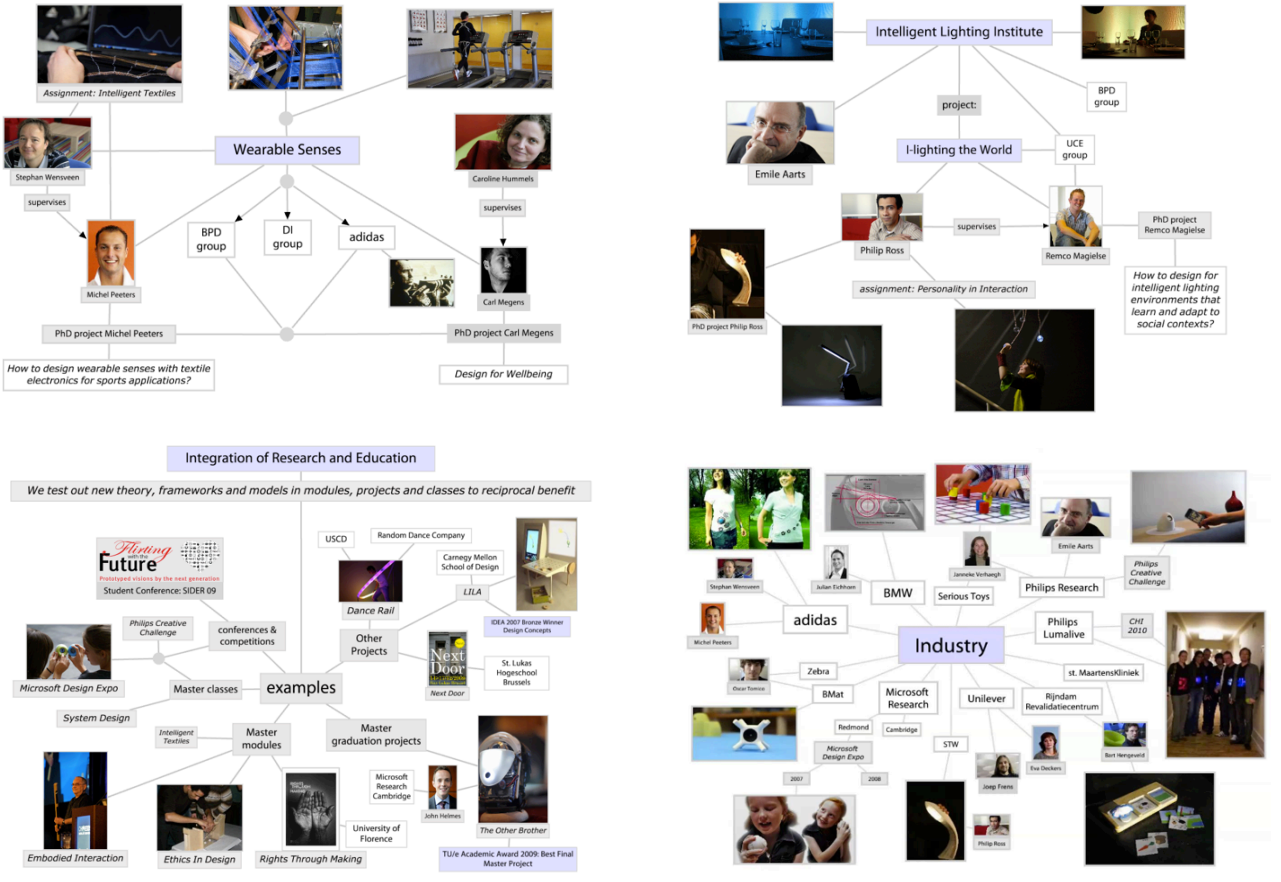


Figure 5.4-7: Four detailed views that were part of the 'Integration' part of the presentation.
Top-left: Overview of people, projects and collaborations with other research groups in the 'Wearable Senses' educational theme.
Top-right: Overview of people, projects and collaborations with other research groups in the 'Intelligent Lighting Institute' .
Bottom-left: Overview of 'Integration of Research and Education', showing various teaching efforts by the DQI group and related examples of student projects.
Bottom-right: An overview of collaborations with 'Industry', showing related DQI members and examples of student and research projects.

Internationalization

The part of the presentation about ‘Internationalization’ contained three views in which examples of international collaboration were laid out on a world map. One view concerned keynote presentations given at international conferences, another view displayed visiting scholars from various countries, and a third view showed international collaborations with universities and companies (Figure 5.4-8). In order to place the world map behind the other content, functionality was added to place a node (e.g. an image) in the background. To create the ‘pins’ on the map minimized empty text nodes were used.

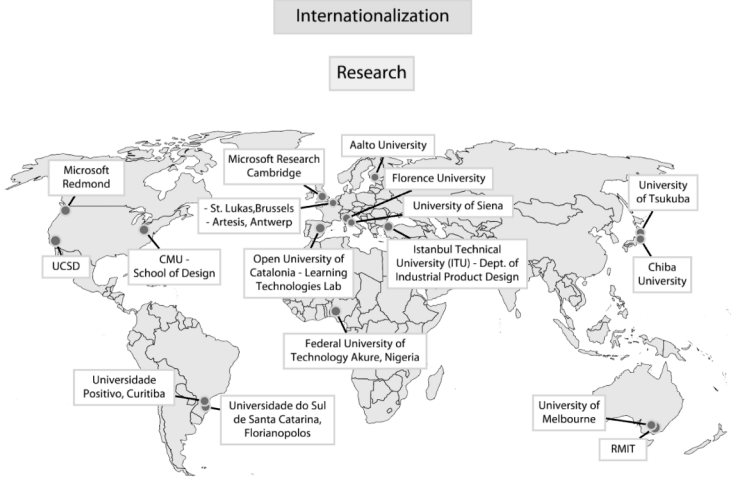


Figure 5.4-8: One of the three views about internationalization.

Multidisciplinarity

The second-to-last view of the presentation showed several focus areas for future work. After that, in the final view, we ‘zoomed out’ again with an attempt to show the multidisciplinarity of the research group: A multitude of ‘skills’ was shown amidst the DQI members (Figure 5.4-9). We considered to relate these skills to the individual members and to the large variation of projects and topics that were already part of the presentation, but finally decided that such relations should emerge from a more collaborative, bottom-up process that required more time.

Figure 5.4-9: The final view of the presentation.

5.4.4 An impression of individual use

Apart from being interested in how a group collection could emerge from creating a group presentation, we were also interested in how a group collection could emerge from combining collections of individual group members. Because creating functionality for merging separate individual collections seemed too complex to implement in the available time, I decided to create one group collection on a shared USB stick that needed to be used in a turn-based manner (i.e. The software could not be used by multiple people simultaneously). Partly due to this decision the individual work never gained a lot of momentum, and eventually no combined efforts were made for exploring relations between the individual overviews. Nevertheless, I do want to give a short impression of these overviews because they point to possible opportunities and challenges concerning group collection and reflection.

The individual overviews showed a lot of variation: One member created an overview of his research, teaching and organizational work, and showed the overlap between these three categories (Figure 5.4-10). This overview in particular would have been useful to have before constructing the group presentation. Other members created overviews of related personal projects, video results of student work from one specific class, examples of student projects related to various knowledge management activities, and personal work related to various topics and meta-activities (Figure 5.4-11). On the one hand, the variation between these overviews is good because it provides rich input for a group collection and for group reflection: The many visual examples and different topics can help to open up new perspectives, for example by discovering new relations between each other's work, discussing nuances and differences, or simply by discovering new topics of interests. On the other hand, the many different examples, topics, and structures may make it difficult to come to an integrated group collection (e.g., it may provide too much clutter and distraction) and may therefore complicate focusing on the topics and relations that matter most.

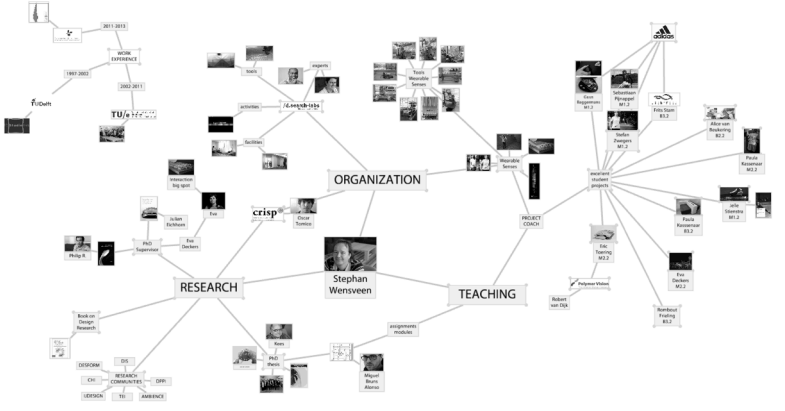


Figure 5.4-10: One DQI member's overview of work relating to organization, teaching and research, including relations between work of these different categories.

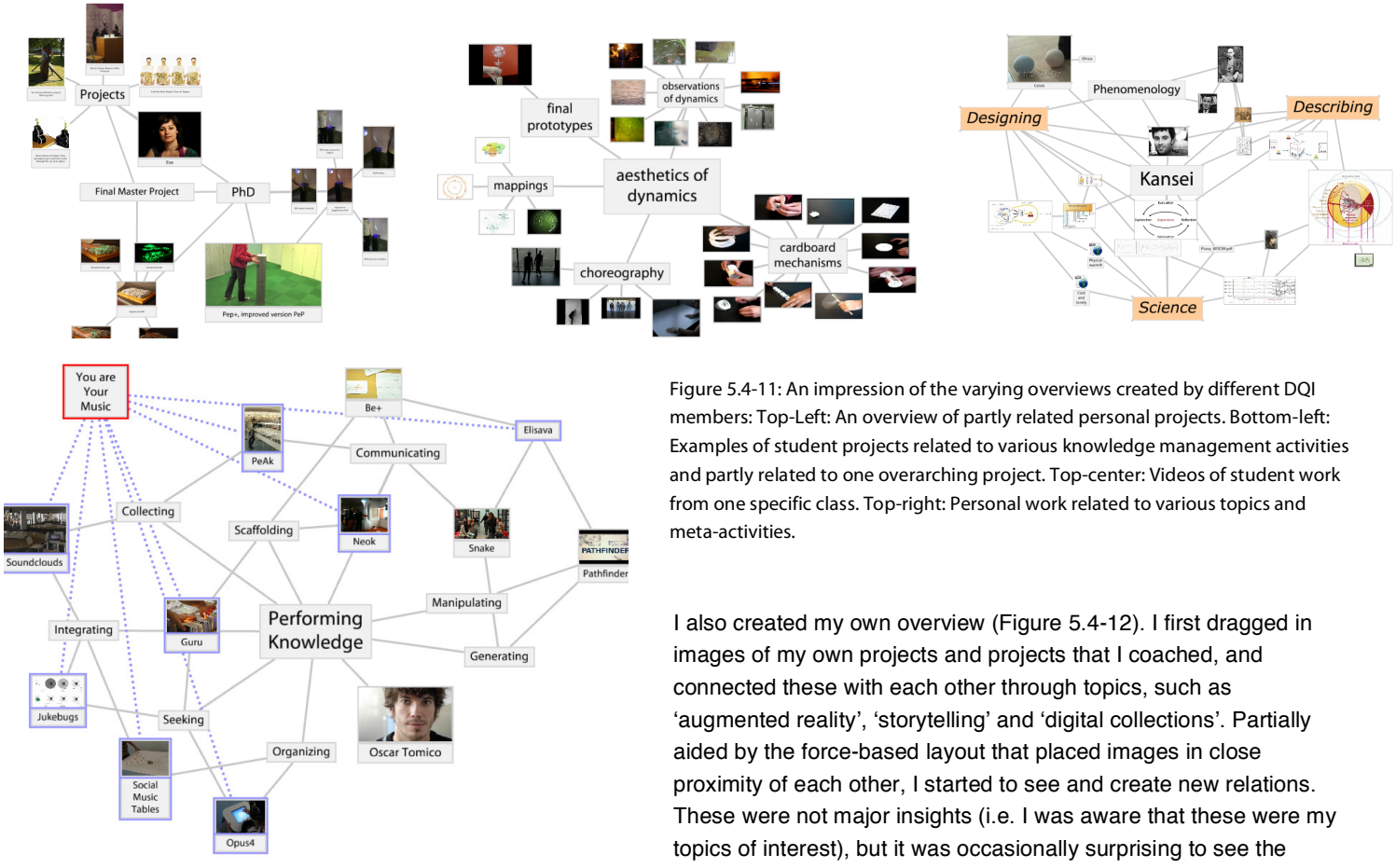


Figure 5.4-11: An impression of the varying overviews created by different DQI members: Top-Left: An overview of partly related personal projects. Bottom-left: Examples of student projects related to various knowledge management activities and partly related to one overarching project. Top-center: Videos of student work from one specific class. Top-right: Personal work related to various topics and meta-activities.

I also created my own overview (Figure 5.4-12). I first dragged in images of my own projects and projects that I coached, and connected these with each other through topics, such as ‘augmented reality’, ‘storytelling’ and ‘digital collections’. Partially aided by the force-based layout that placed images in close proximity of each other, I started to see and create new relations. These were not major insights (i.e. I was aware that these were my topics of interest), but it was occasionally surprising to see the overall picture: E.g, how much content was related to some of the topics, and to see the overlap between projects.

After organizing my own work, I copied content of which I thought it was related to my work from the group presentation and from the individual overviews into my own overview. When doing this I also started to see new relations. For example, I initially related a project about an automated robotic camera to some of my projects involving robotics, but then immediately saw the additional connection to (my) other projects involving digital collections and reflection.

This gives a first indication of the usefulness of having easy access to a collaborative collection with visual examples and the possibility to flexibly organize these examples. However, the real use for group reflection needs to show from how the overviews, examples, topics and relations are used in further group efforts, such as a group discussion session or a new group presentation.

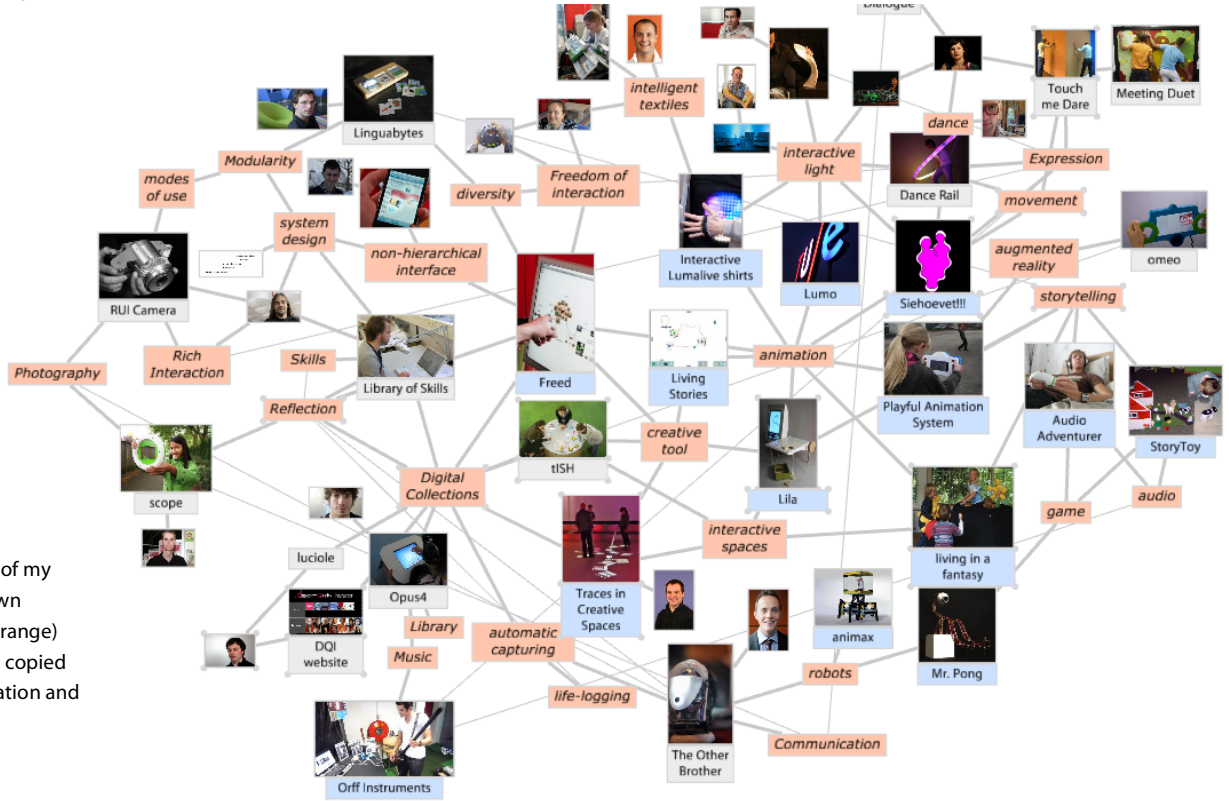


Figure 4.5-12: Overview of my coached projects and own projects (blue), topics (orange) and other projects that I copied from the group presentation and individual overviews.

5.4.5 Conclusions

The integration of presentation and collection

The process of building the DQI presentation was vastly different from building a traditional slide-based presentation. First of all, the zoomable canvas and the force-based layout invited the addition of many examples and relations. Not only did this encourage the creation of visual overviews (e.g. the different overviews of DQI members and their relations) and the visualization of relations between topics, it also empowered a different way of working: Some of the more detailed views were constructed in a brainstorm- or mind map-like manner, and later became even more detailed when asking group members for missing examples or relations. For the final presentation, most of these detailed views were first cloned and then simplified (i.e. nodes and relations were locked or hidden), while still keeping enough detail to show the richness of the topic at hand. In summary, Freed invited a more explorative way of working in which the spatial organization and selection process was more flexible and iterative, and thereby it allowed for a detailed collection with many examples and relations to emerge.

In turn, this growing collection changed the process of building the presentation. Even though it had started out as a top-down process because the majority of main topics were already defined in advance, it gradually became a more bottom-up effort: By expanding nodes (i.e. showing hidden related nodes) or by searching or browsing the collection, we could easily reuse content (e.g. a person, a project, a topic, a research-question) and relations across views, for example to create overlap between the views about ‘integration’ (Figure 5.4-6 and 5.4-7). The resulting transitions between views were useful to keep the flow in the presentation, to switch between detail and overview, and to show the relations between various perspectives on (the work of) the DQI group.

The challenge of complexity: Multiple views and multiple users

Apart from the advantages as discussed above, the detailed, multiple-view collection did not come without its challenges. It was initially very convenient to freely and flexibly organize content without thinking about the overall structure of the collection (e.g. not distracted by hierarchy or categories). However, when starting to reuse content and relations, I noticed that I occasionally preferred a (slightly) different structure, color or textual description in different views. This brings along many questions about whether such properties should be defined on a global (i.e. collection-wide) or local (i.e. view-specific) scale, whether global properties can be overridden locally, and whether changes should be automatically coordinated between views or not.

The main issue is to find a proper balance between structure and freedom, or in other words: Making use of existing content, relations and properties without being too much constrained by them. This issue becomes especially serious in the context of a multi-user collection in which a lot of content and relations are added and in which variation automatically develops due to the more independent

and different use. For such complex situations it may be good to explore the implications of a system in which only images, videos and other files are shared globally and in which relations, text and other properties are defined locally (e.g., in independent files) but can still be easily explored and reused (i.e., copied).

Opportunities for collaboration and reflection

Although the software was mainly used to create the presentation and not to explicitly reflect on the group and its work, clear opportunities for reflection and learning about each other's work in general were observed. For example, while showing the presentation to individual members, but also during the test-run of the presentation in front of a large part of the group, Freed helped to form an active discussion about the content of the presentation: The many examples seemed to inspire people to comment, for example by naming additional related topics, projects or collaborations. This process was further supported by the possibility to easily zoom in on parts of the views, and the possibility to navigate the collection in a non-linear way.

The detailed nature of the presentation and of the overviews of some of the group members gave me personally a lot of new insight about, and a better overview of, activities and collaborations of the various DQI members. Without doubt, this was influenced by my active role in building the presentation and by my personal effort of relating work of other people to my own work. Therefore, more people should be actively involved. It will help if the collection becomes a more integrated part of the workspace, for example as part of a permanent interactive table, which can also be used during group reflection sessions or exhibitions. Ideally Freed will be a multi-user system that allows for the integration of individual work on individual computers (e.g. creating a personal overview of work, or an individual presentation) and collaborative sessions on a collaborative work surface (e.g. a group reflection session, creating a group presentation). This will allow the collection to grow in a bottom-up way during daily practice, while at the same time allowing for relations to emerge by individually reusing each other's content or by collaboratively integrating work of various members.

6 Confronting the design process

6.1 Introduction

The main part of this chapter is a longitudinal evaluation during which eight design students used Freed as part of their design process. This evaluation is discussed in section 6.3. Before the evaluation, the students took part in an introductory workshop. This workshop was accompanied by a questionnaire, with questions about the students' general collection and reflection practice (prior to using Freed) and their expected use of Freed. The workshop and questionnaire are discussed in section 6.2. First, in the next section, a second design iteration of the software is discussed.

6.2 Design iteration

In this section I briefly discuss new functionality that gradually evolved during, and partly in response to, previous use of the software, as described in chapter 5.

Browsing related nodes and paths

Showing nodes by expanding an already visible related node on the canvas (as discussed in chapter 5.2) gives a nice effect and can be useful if *all* related nodes need to be shown, but proved to be inconvenient when only a selection of related nodes needed to be shown or if the related nodes only needed to be browsed temporarily without adding them to the view. Therefore a related-items-browser was added to Freed (Figure 6.2-1). This is a scrollable panel that shows a row of nodes that are related to a specific node on the canvas. It is docked at the bottom of the screen and its height can be increased to see the nodes at a larger size. It is a more contextualized alternative to the general collection browser.

When the mouse cursor is moved over a node on the canvas, several buttons may pop-up above the node, depending on its relations. These buttons can be used to open the related items browser in a specific modus (or to quickly switch to a different modus): One for browsing *all* related nodes, one for browsing all *hidden* related nodes, and one for browsing all *visible* related nodes. The latter are already visible in the current view (i.e. on the canvas), but it can still be useful to see them side-by-side.

A final modus of the related-items-browser shows all paths (represented by their first node) that include the node that is focused on. When clicking on one of these paths, the related items panel switches to a new modus on which all the nodes of that particular path are shown.

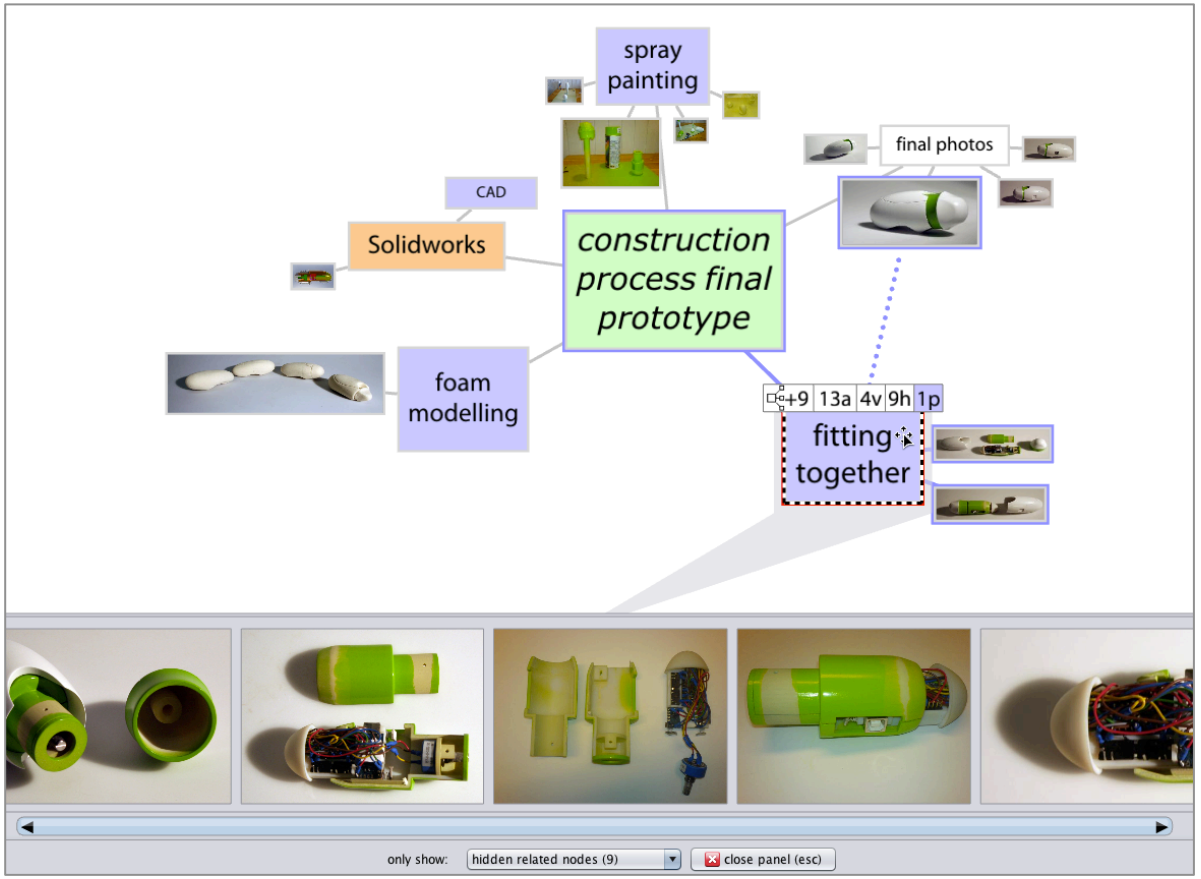


Figure 6.2-1: The related-items-browser at the bottom of the screen shows the hidden related nodes of the node that is focused on the canvas. The buttons above the focused node indicate, from left to right: +9: Expand 9 hidden related nodes (i.e., add them to the current view). 13a: Show all 13 related nodes in related items panel. 4v: Show 4 visible related nodes in related items panel. 9h: Show 9 hidden related nodes in related items panel. 1p: Show path that includes focused node in related items panel.

Styling

In order to facilitate coordination of visual properties between nodes, and across views, styles were added. A style is a specific combination of properties, such as text background color and font style. Styles are not used to 'paint' nodes a single time, but are actually linked to nodes. This means that if the style is changed, all nodes that are linked to that style also change.

Styles were originally only applicable as a global (i.e. collection-wide) property of a node, but this was experienced as too constraining because the meaning of a node occasionally differed across views. Therefore the possibility was added to overrule the global style property of a node with a view-specific style, or with individual view-specific properties (Figure 6.2-2 left). Also the global settings of a style itself could be overruled with view-specific settings (Figure 6.2-2, right).

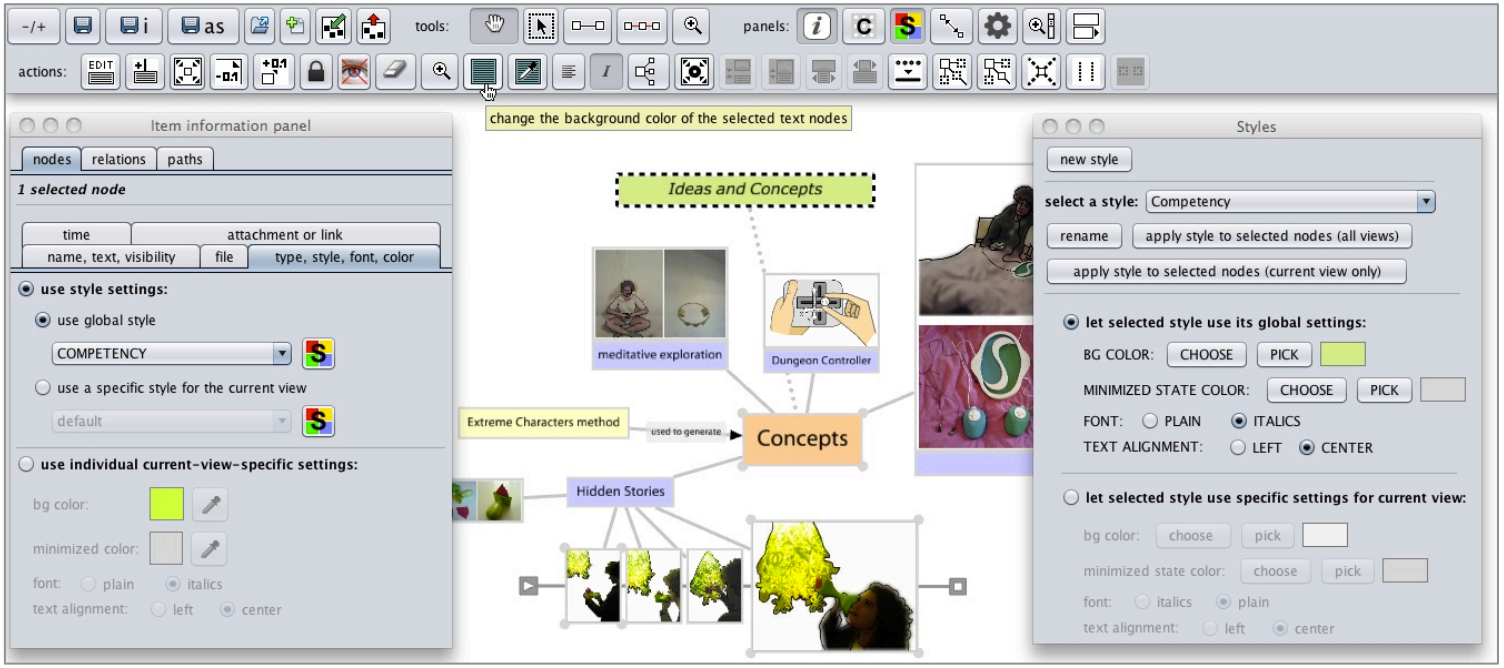


Figure 6.2-2. The interface for styling content in Freed is too complex. Left: Panel for setting visual properties (including style) of selected nodes. Right: Panel for creating and adapting styles. Top-center: In the actions bar individual view-specific visual properties of selected nodes can be directly set.

Interface problems

All these additions, of which many were implemented rather hastily while building the presentation for the research visitation (which was discussed in section 5.4), made the interface too complex. There are too many panels, nested tabs and options, which makes it difficult to find important functionality that is of immediate interest (e.g. changing the color of a node without thinking about styles) and which distracts from the direct interaction on the canvas. Too much attention is drawn to the global structure of the collection, instead of local interaction in the current view. I elaborate on this in the final chapter. Finally, reorganizing and improving the indirect interface proved to be more challenging than expected. The GUI builder that I used and in which I was 'locked in' became increasingly slow and unstable, which eventually forced me to focus on other aspects of the software that also required attention.

Files, websites and videos

In response to student requests, support for importing (i.e. dragging and dropping) videos, web links and additional file types (e.g. PDF documents) was added to Freed. Functionality for rendering/embedding websites (e.g. YouTube videos) and documents inside Freed was desired, but no straightforward way to implement this was found. Instead, file or web icons are displayed. When these are clicked, the associated file or website is opened outside of Freed.

Video files can be played back directly on the canvas, or in full screen. During playback snapshots can be created which become new image nodes on the canvas. These image nodes are by default related to the original video node, and they are part of a path, ordered by time.

Force-based timeline (discontinued)

During discussions with the students that used Freed the point was raised that it may be useful to have a timeline of content that can be used as an initial foundation for further spatial organization. In response to this feedback, a timeline modus was added to Freed. In this modus, which can be turned on or off for each view, the timeline is visible at the bottom of the screen. The timeline is part of the canvas (it can be zoomed and panned). By default, relations are hidden and the nodes are organized by time. However, relations can be shown and added in the timeline modus, after which the timeline blends in with the force-based layout, depending on the strength of the *time-align force* (figure 6.2-3).

During the workshop (which is discussed in the next section), many problems concerning the timeline surfaced. Apart from some bugs, the main problem was that timestamps of images were not always correct. As a result, students spent more time 'correcting' the timeline than using it as a foundation for insight or further organization. Therefore the timeline modus was disabled and discontinued.

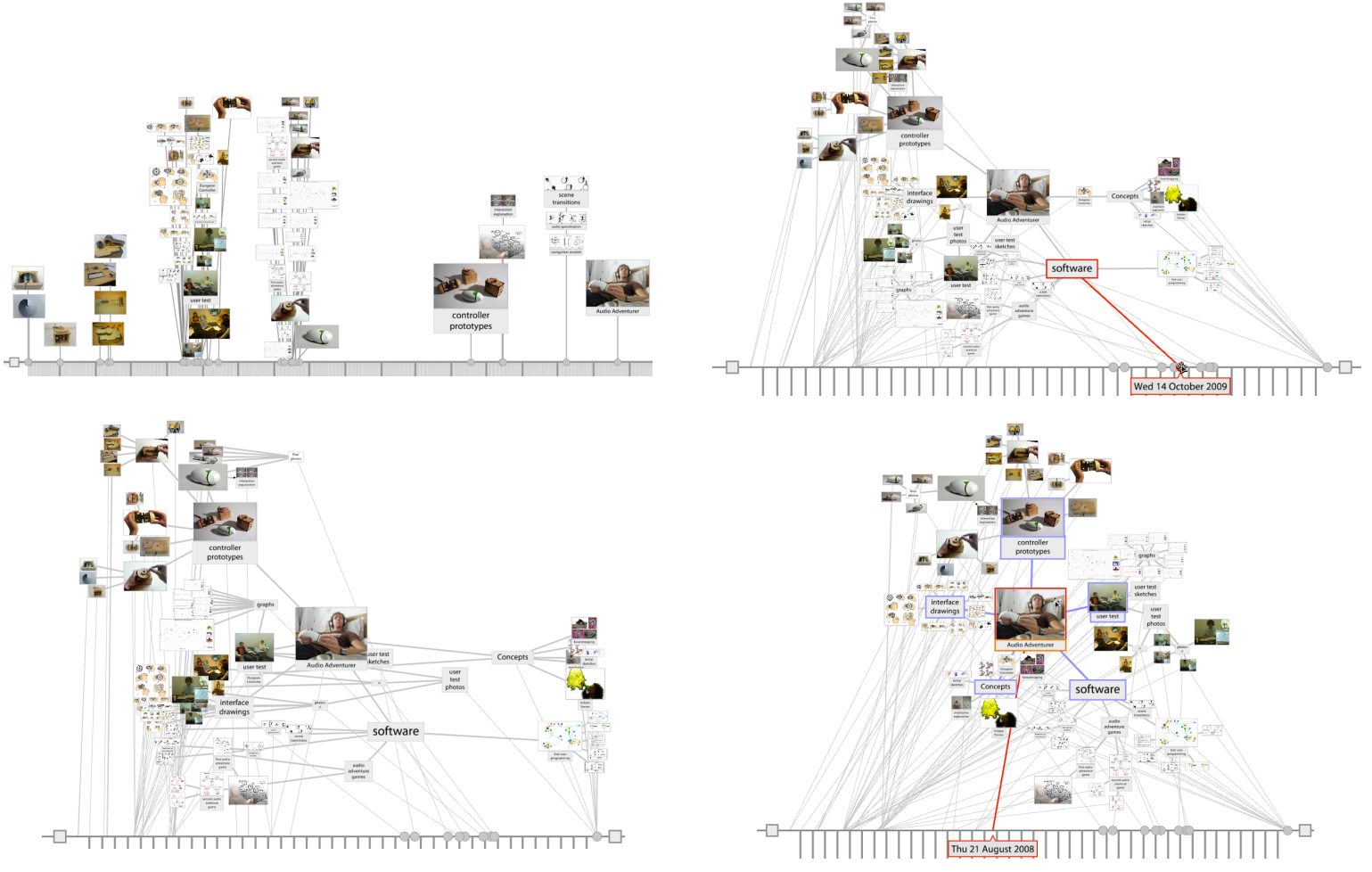


Figure 6.2-3. The force-based timeline (discontinued). Top-left: Default modus: Relations are invisible, nodes are organized by time. Bottom-left: Relations visible, high time-align force. Top-right: Relations visible, medium time-align force. Bottom-right: Relations visible, no time-align force.

6.3 Introductory workshop and questionnaire

6.3.1 Introduction

In the beginning of September 2010 a three-hour workshop was held with fourteen industrial design students. This workshop was followed by a questionnaire (appendix 2). The main goal of the workshop was to introduce the students to the software, and to inspire them to take part in an evaluation during the entire semester. This evaluation is discussed in section 6.4. The main goal of the questionnaire was to gain insight in students' general collection and reflection practice (independent of Freed) and in their expected use of Freed.

In the following two sections I briefly discuss the participants and the workshop. Thereafter I discuss the questionnaire answers concerning the participants' collection and reflection practice, followed by a section on their expected use of Freed. In the conclusion I summarize the main insights.

6.3.2 Participants

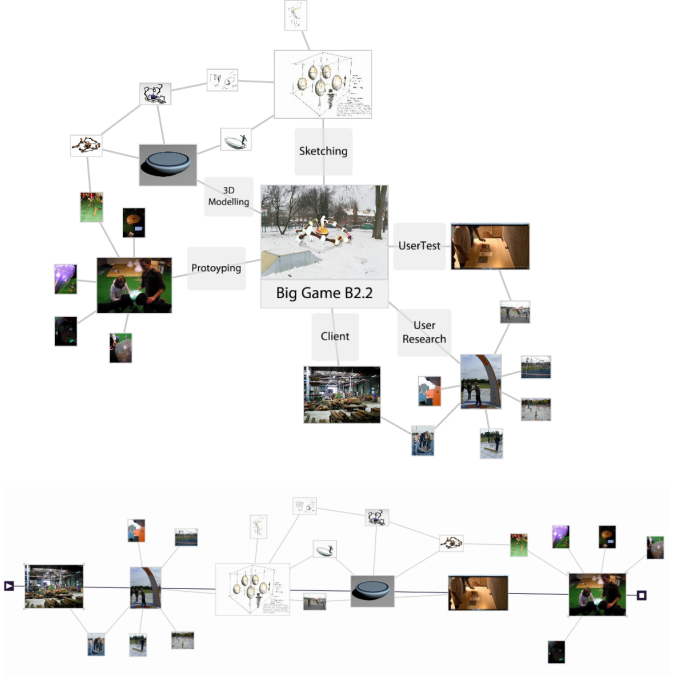
Seven participants were Bachelor students in their final year (three female: P2, P8, P10 and four male: P7, P9, P11, P12). The seven other participants were Master students in their final year (one female: P3 and six male: P1, P4, P5, P6, P13, P14). One workshop participant did not return the questionnaire (P14).

6.3.3 Workshop

During the 3-hour workshop, the participants were provided with the software, explanation videos of the main functionality, and an example collection that they could explore. This example collection was also used to create the explanation videos, and included an overview of some of my projects connected by topics, and several views of my graduation project. The students were asked to bring as much digital content as possible from previous projects and their just-started current project, and to experiment with creating multiple views and the integration of multiple learning activities (e.g. multiple projects). They worked individually and used their own laptops (Figure 6.3.1).

Figure 6.3-1: The workshop mainly consisted of individual learning and work, occasionally interrupted by a demonstration/explanation in response to a question.

Because the workshop was mainly introductory, I will only give a brief impression of how Freed was used: All participants but one experimented with multiple views. Some created multiple views for a single learning activity (e.g. a project, Figure 6.3-2-left), others created one categorical overview of learning activities and separate views for the individual learning activities, and some created multiple overviews of learning activities with different categorizations (e.g. Figure 6.3-2-right).



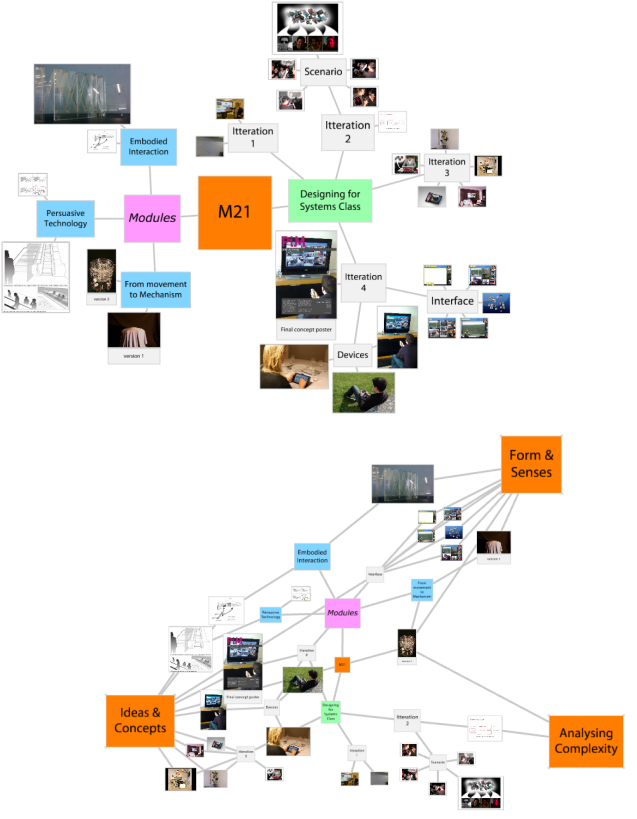


Figure 6.3-2. The participants created different combinations of views:
Left: Two views of P10. The top view shows the main activities of one of her projects, and relations between these activities. The bottom view shows the same activities in a chronological way.
Right: Two views of P5. The top view shows an overview of content and learning activities of one semester of Master education(M21). In the bottom view competencies are added and related to the content.

The participants were mainly focused on exploring the software and creating an initial collection, and reported that more time was needed for exploration and insight to develop. For example:

P7 explains in relation to figure 6.3-3:

> *"[I did not really get new insights]: I think I should spend more time exploring new views and including more graphical content. I did found it interesting to see all my prototyping activities aligned in a completely new way."*

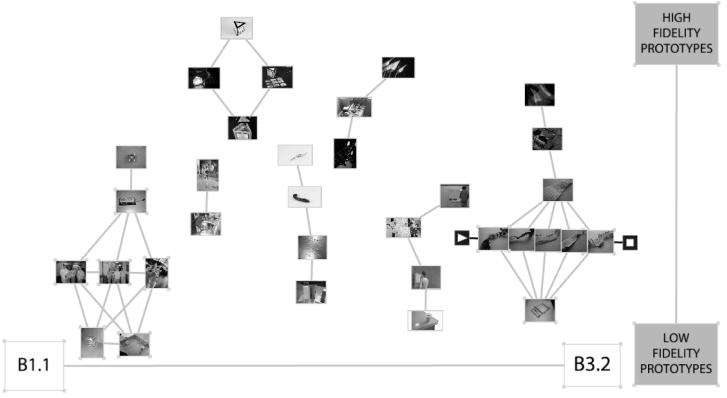


Figure 6.3-3: P7's prototyping view. The horizontal dimensions represents three years of bachelor education. Several design/prototyping processes are mapped to the vertical dimension, which represents the quality of the prototypes

P1 explains in relation to Figure 6.3-4:

> *"[Interesting clusters did not emerge, but] the process of organizing makes sure you get to know the set and think about it (it was not my own work)"… I was busy getting to know the software. Really thinking/reflecting takes a more relaxed environment."*

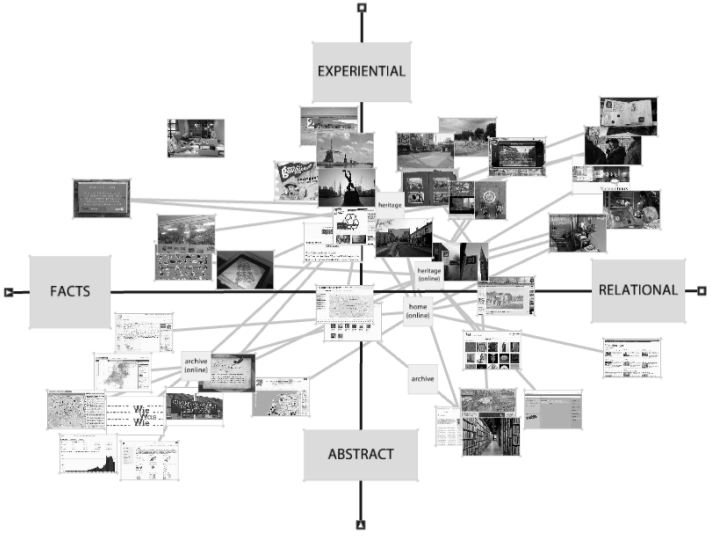


Figure 6.3-4: In this view P1 mapped a collection of related work of his current project along two dimensions.

Participants did mention insights of a more general nature, such as becoming aware of the importance of visual documentation and being inspired to use new methods or styles for visual presentation. For example:

P9 explains in relation to Figure 6.3-5:

> *"During the process, I got inspired by the option of multiple views. While I was going through my collection, I realized that in different situations, you need different 'views' on your collection. In my case I figured that there are situations where you want to present your specific skills as a designer and there are situations where you want to focus more on your projects."*

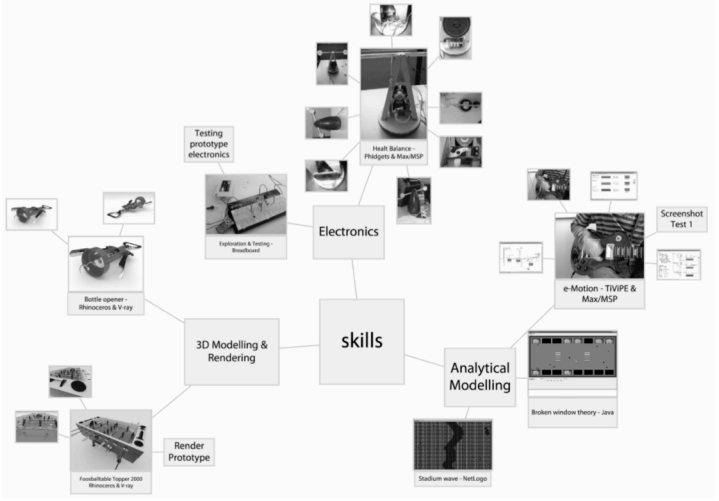


Figure 6.3-5: P9's view about skills

6.3.4 Existing collection and reflection practice

In this subsection I summarize the participants' answers to the part of the questionnaire about their collection and reflection practice. I first discuss how they document their work, how they create and communicate overviews of their work, and how they reflect. I conclude by discussing reported issues concerning documentation and reflection.

Documentation

A digital *file browser* (e.g. Windows Explorer) is the participants' main tool for managing their digital work during the design process. They create folders with the main activities or project phases. Some organize these chronologically by numbering them. P8 once used a *blog* to document his work and to communicate to his team and client. P12 had just started to use a *video log*, because he had difficulties to express himself in writing (and accordingly to motivate himself to document his work). Three participants keep a simple text file as a *project log file* in which they keep track of what they have done. Such a file is also used as a basic *planning* and *to-do list*, or as *learning log*. For example:

> *P4: "During the work often interesting notes pop up. I immediately write these (short) in a file named whatlearned.txt at my desktop. Later I review this file and elaborate to complete reflections."*

All participants use their physical notebook for taking notes and making scribbles, sketches and diagrams (e.g. small mind maps, concept maps or combinations of the two). P2 additionally keeps a physical A3-sized *'inspiration book'* in which she actively collects photographs and samples of work, and for which she also prints out digital images. Some participants mentioned that they use separate sheets of paper next to their notebook. One of them specifically mentions the feeling of *being in control* and the *feeling of progress* as advantages of using separate sheets for documentation:

> *P1: "The ongoing process of meetings, small planning, TODO etc. is all on ever-changing A4 papers that get refreshed all the time. When stuff becomes irrelevant, I transfer the left issues to a new paper and destroy/throw out the old paper. This gives me the feeling of being in control (clear what is still relevant and what isn't) and progress (as stuff also goes away)"*

In contrast, P6 pointed to the disadvantage of using separate papers, as they are often *'stacked and forgotten'.* Finally, P4 explained that he uses binders to organize his paper materials.

Overview and communication

The participants regularly create overviews of work of specific process phases. Some mention that they print out digital material in order to create physical overviews of related work, inspirational material (e.g. mood boards), ideas or designs. These serve for communication, inspiration and overview in the physical design space. Also *digital* overviews of work are made, but no participant creates an overview of work of the entire design process:

> *P9: "During the design process, I use Adobe Illustrator and Adobe InDesign often to create a file which combines work of a specific design phase (e.g. research or concepts)."*

> *P8: "In the beginning of my process I start with mapping related work and topics, first on paper, and then I put those into schematics within OmniGraffle [diagramming software] so it is more clean and digital".*

Other files that are created during the design process and that contain collections of digital work are *posters, reports* and *presentations*. One participant elaborates specifically on the role of presentations for gaining overview:

> *P1: "Presentations are also a way of organizing thought in my mind. I sometimes create presentations even when I don't need to give one."*

Reflection

Most participants do not write elaborate reflections and do not organize or integrate their reflections until the end of the semester when they have to create their showcase on which they are assessed. Different techniques are used for structuring these reflections. For most participants reflection is mainly a writing process: They revisit work and documentation per learning activity (e.g. project, assignment) and reflect on the main points of the process, such as goals, requirements, decisions, iterations and insights. More high-level reflections follow from comparing and

integrating reflections of individual learning activities, but also simply from describing the individual activities. For example:

> *P3: "[I reflect by] describing the process, usually in writing, then adding comments to points I would like to highlight (positive or negative) in that process, bringing me to realize higher level reflections as general conclusions."*

Four participants mentioned that they reflect by clustering work, competencies, and reflections, both physical and digital. For example:

> *P13: "I reflect on my work by creating a paper based overview of what I've been doing in the semester. Clustering the different competencies. Furthermore I use tools like illustrator and flash to create visual overviews of my work."*

All participants think that it is important to keep an organized digital collection during the design process. Most mention that it is important to collect work for inclusion in their report and showcase, but three students specifically discuss the use of a collection for reflection: They mention that a digital collection is important for revisiting work in order to understand why and when *decisions* were made, to gain overview of a complex *process* (e.g. parallel explorations, iterations), to check if the project is heading in the right *direction*, and to explore or visualize the work from different *perspectives.*

For example:

> *P5: "I think it is very important to keep AND organize a digital collection during the design process. Having a properly structured overview of your activities helps me to see what I have done so far and if I'm heading in the right direction. An advantage of a digital collection is that I use the same objects/sources/images in multiple ways, one time it is to show my overall process and another arrangement can focus just on the technical development within a project."*

Documentation and reflection issues

The main reported issues regarding the documentation of work are *lack of time*, *forgetting to do it, inability to step out of the immediate design work* and *lack of motivation* (i.e. procrastination). For example:

> *P9: "I do think it is important to keep an organized digital collection of my design process and work. However, this is quite time consuming in my opinion. Especially when there is time pressure during the projects, the organization of my collection becomes messy and chaotic because my priority then lies with the project. In the end [of the semester] this can be frustrating as this makes it more time consuming to keep my portfolio up to date or to make my showcase."*

> *P12: "My problem mostly resides in the actual documenting because I am never able to step out of my everyday work to take a picture of something."*

These issues are also mentioned with regard to reflection. For example:

P9: "I don't reflect (enough) during the projects and process itself, but only at the end. This can result into superficial reflections."

P1: "I keep record really bad. The report is a nightmare in the end.… [The problem is] remembering all the why's and why not's of when you took certain decisions. (and the lack of time to clear your mind and really reflect...)"

Another issue that was mentioned by most participants concerns *lack of overview:*

P10: "Because I do not have the overview if everything is documented I sometimes miss information at the end. This is partly because there is no software which is easy in use to create an overview of the design process with all the activities and the documentations of it."

P13: "[The main problem for reflection is]: Creating the overview and creating a coherent story/reflection out of feedback, work, reports, etc."

These issues concerning lack of overview are closely related to issues concerning *lack of integration* and efficiency. For example:

P3: "It is a pity that [reflection] does not flow naturally from creating the collection in the first place and that I have to perform all this [reflection] while looking at such an unattractive overview: a folder list [in which] each document has the same weight"

P7: "I preferably would want to organize my work in a personally created 'showcase-compatible' platform. This prevents me from doing double work (organizing the same graphical content two times)"

Five participants mentioned *lack of support for exploration* as a problem with current software. For example:

P5: "The various representations of my output are tedious to produce as most of the time it involves recreating part of a previous representation. The differences between these kind of representations are key to gaining insight however the representations of the current software I use (OmniGraffle, Photoshop, Visio) are too static."

Remaining issues that are mentioned are the time and effort required for *digitizing physical material*, for *printing and cutting digital material,* and for *version management*. Finally, three other issues specific to reflection are mentioned: One concerns reflecting *too much on a meta-level* and may be related to lack of overview:

P3: "I often reflect on a meta level on my work too soon. Which means that I have not clearly seen the reflections on the practicalities in the process (lower level reflections) which are interesting in itself. And that my meta-reflections seem not grounded because they lack the practical reflections to underpin them. I 'zoom out' too quickly because I try to cover the entire big bunch of the collection in one go."

Another issue concerns *information-overflow*. For example:

P2: "[The problem with reflection is]…information overflow, seeing too many links and connections between reflections, and not being able to structure them in one way. (reflections can relate to each other, to competencies, to activities, to the past, the present, the future etc. everything is related...)"

And a final issue concerning reflection is more related to *writing* in general:

P11: "I have to turn thoughts and philosophies into words. I sometimes can't describe the reflections properly."

6.3.5 Projected use of Freed

In this subsection I summarize the participants' general impression of Freed and their thoughts about using Freed as part of future work. Most participants considered Freed to be of added value, mainly mentioning its use for organization (structuring), reflection, and communication. Remarks related to organization concern speed, freedom and flexibility. For example:

P9: "The freedom is very useful. You can just throw in all your material and collect it in every way you want. I consider the multiple views feature to be the most important feature."

P3: "Important is that Freed is a straight 'mind-to-computer' tool for which you do not need preparation on paper."

P5: *"The forced-based layout is useful when trying out various criteria for sorting a collection."*

The participants saw Freed as a useful tool for gaining overview of their design process, and in particular the first phase:

P11: "I would use it during the idea generation phases and the idea selection phases, because I can add my ideas to the web, but also all kinds of supporting evidences/papers/other research. I can cluster ideas on several different levels in the same visual presentation."

Two participants specifically mention that Freed would be useful to gain overview of parts of the design process that are not clearly visible in the final result:

P3: "It also helps me document choices that I ruled out over the course of the process and why."

P6: "I mainly want to use Freed to gain overview of design-decisions and various activities of a project that did not directly lead to the result of the project, but that did contribute to it.

Freed was also considered to be useful as a tool for communication during the design process:

P4: "Perhaps Freed is useful to show coaches content of what I did (as they tend to quickly forget small things you did, because they coach many more students)."

P9: The force-based layout makes the collection more dynamic. I believe this works well for informal meetings (e.g. coach meetings!), to show your work or to show relations etc. The locking nodes function however is very convenient as it allows you to structure your collection in a specific way, suitable for more formal presentations or exhibitions.

Apart from the design process, participants wanted to use the software for reflection on various topics, such as their *vision/identity* and their *development.* For example:

> *P7: "[I would use Freed for] exploring my vision/identity by mapping my personal content with that of reference projects/work from the internet."*

Several participants mention that Freed may be used as a flexible foundation for their showcase (the portfolio with work and reflections on which the students are assessed).

> *P1: "Maybe [I would use Freed] for reflection, but I'm not sure. It could be a nice way to postpone writing [reflections] while still working on the portfolio."*

> *P9: "I believe it is very useful for creating an 'unofficial' portfolio, mainly for myself as a base and structure for my real portfolio."*

Drawbacks, doubts and intentions

The participants were also asked about possible negative consequences of using the software. Two participants indicated that Freed might make designers spend too much time organizing their work. Four others mentioned that Freed may hamper the exploration of new directions, or force the project too much into a direction:

> *P4: "Perhaps too much focus is put on the work that is done. It might limit the new directions for the designer (e.g. I did all this, I don't want to waste that work now)."*

> *P7: "I can imagine that you start verifying design decisions based on arguments that are grounded by 'Freed-reasoning'. E.g. you want to explore a certain direction because it makes your process looks coherent / structured, while it is not, it only looks structured because that's the way Freed presents it."*

Other possible dangers that are mentioned are not keeping an ordered file structure due to using Freed as only file-organization tool, and trying to use Freed for building rather than preparing the final showcase, thereby using it too much as a visual design tool rather than as a tool for exploration.

When asked about their intentions of using Freed, some participants expressed doubts, such as that they may prefer physical organization and communication, and that they may not be motivated to digitize enough visual material only for organization and exploration in Freed. According to another participant, this latter issue could also be a virtue:

> *P5: "[Freed] makes you think more about the output of your work, is it rich enough to be used in the software. It might 'force' me to better document my process visually (a good thing)"*

Finally, nine of the thirteen participants indicated that they intended to use Freed during the semester. In the end, eight actually did.

6.3.6 Conclusion

The need for a tool that offers free and flexible organization was confirmed by the issues that the participants reported concerning their current collection and reflection practice: Issues concerning *Lack of overview, lack of integration, and lack of support for exploration* stood out strongly. This need was also confirmed by the participants intentions of using Freed for diverse activities, such as organizing, communicating and reflecting on project work, as well as on multiple learning activities, development and identity.

General issues such as *lack of time* or *inability or lack of motivation to step out* of the immediate design work in order to document and reflect, might be partially addressed by Freed: A direct integration of visual and textual documentation and reflection can save time, and the possibility to easily gain overview and to explore relations and perspectives can motivate to document and reflect.

Finally other general issues during reflection and possible drawbacks of Freed were mentioned, such as *information overflow*, *spending too much time* on organization and exploration*, fixation on previous work*, and *being too much directed* to explore or visualize relations or perspectives in order to make the process look structured in Freed. Because Freed is all about freedom and flexibility, the possible benefits and drawbacks (e.g. gaining overview versus information overflow, fixation versus exploration) will depend for a large part on how the tool is used. In the next this use is discussed as part of the design process.

6.4 Individual student projects

6.4.1 Introduction

Between September 2010 and February 2011 a qualitative semester-long evaluation was held with eight industrial design students. The main goal of this evaluation was to gain insight in the use of Freed during the design process. A secondary goal was to gain insight in how this use could aid reflection, during the process as well as after the process.

6.4.2 Procedure

Twelve students who had previously joined the workshop were offered 100 euro for using Freed during the semester (17 weeks) and for taking part in regular meetings and a final interview. Eight joined the evaluation. Of the eight participants three were doing their BSc. graduation project, three were doing their MSc. graduation project, and two were preparing their MSc. graduation project. These latter two students each followed four short specialized curricular activities called ‘modules’ (one or two weeks per module) next to their project.

The participants were asked to document their design work and process using Freed. They were not specifically asked to use it for additional activities (e.g. communication, reflection), they were not instructed to use the software in a specific way, and they were free to use other tools or software next to Freed. During the semester I had several individual meetings with the participants to discuss possible issues with the software (bugs, usability problems, feature requests) and to observe and discuss how they had used the software thus far and how they wanted to continue with it. At the end of the semester a one-and-a-half hour semi-structured interview was held with each participant individually. The participants were asked to bring all their digital and physical documentation and visualizations of their design work and process to this interview.

During the final interviews the participants were first asked to explain their project and process with the help of pen and A3-sized sheets of paper. This exercise was done in order to have a basic point of comparison for discussing the functionality of and interaction with the software. Next, the participants were asked to discuss their work and process using Freed on their own laptops (Figure 6.4-1). After that, the participants were first asked to describe Freed, and how they used Freed or other tools for documenting, organizing, revisiting, communicating and exploring. Thereafter they were asked how they used Freed or other tools for reflection, and how they thought that reflection was related to the previously mentioned activities. A final part of the interview focused on how the software could be improved to invite more use in general and reflection in specific.

Out of the eight cases I have selected five that approximately cover the different ways in which the software had been used and experienced. These examples are discussed next. Thereafter I conclude with a more general discussion of how the software was used and experienced by all participants.

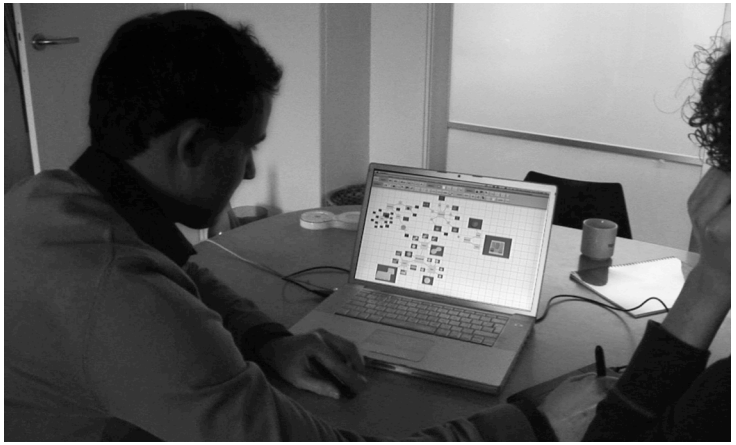


Figure 6.4-1: The setup of the final interview.

6.4.3 Five cases

Participant 1

P1 (male, individual MSc. grad. project) was doing a project about cultural heritage. He aimed to design a system for raising historical awareness among residents of a city. He was initially inspired by visual material (e.g. old photographs, landscapes), which mainly led to ideas that involved the use of *visual* historical information. However, through a combination of literature research, user profiling, idea generation and benchmarking of related projects he gained a *'better understanding of heritage'*, and developed a more specific goal (*'vision'*) for the project: A system that leads to a sense of belonging and societal participation by giving strong immersion into historical content, but that also triggers interest in and does not distract from people's physical surroundings (the city itself).

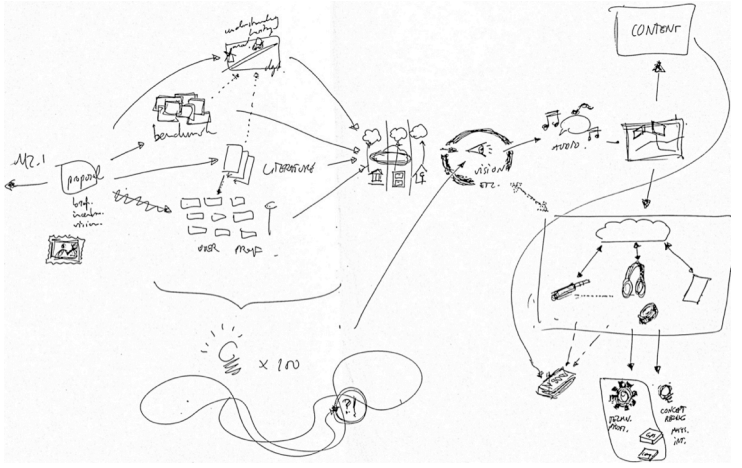


Figure 6.4-2: The process sketch of P1

This vision led to the concept of an '*audio explorer system'* consisting of various types of audio content (e.g., audio tours) which could be accessed through different products by diverse people in various situations. At the time of the final interview P1's project was not yet finished, and he was busy prototyping the individual products of the system. During this implementation phase he was stumbling on many questions and *'disadvantages'*, which made him realize that he did not yet have a complete overview of (all the functionality

of and interactions within) his system. He planned to create this overview later when writing the report, and to reflect on it in relation to his project vision.

P1 created two views. His first view showed the first part of his process up until the focus on an audio-explorer system, and the second view continued with the elaboration of this focus and work that still remained to be done. In his first view P1 visualized a process (Figure 6.4-3) that was more linear than his actual process. He explained that this was due to using a path (which cannot branch), and that he in hindsight would have preferred a more parallel organization of activities such as in his process sketch.

However, in contrast to this sketch and associated narrative, his main view did include various '*insights*' that were related to his initial activities. Examples of insights were that the *'city is its own museum'* (insight from investigating cultural heritage of a specific city), that *'small stories'* are an important part of cultural heritage and tell a lot about general history (insight from benchmark), that there is a lack of integration between physical and digital collections (insight from benchmark), that historical awareness can lead to societal participation (insight from literature research), and different examples of motivations for engaging with heritage (insight from user profiling). Despite the fact that these insights were not visually connected to later (i.e. resulting) content and activities, they did allow P1 to explain in a much clearer way what his project vision was and how his initial activities had contributed to this.

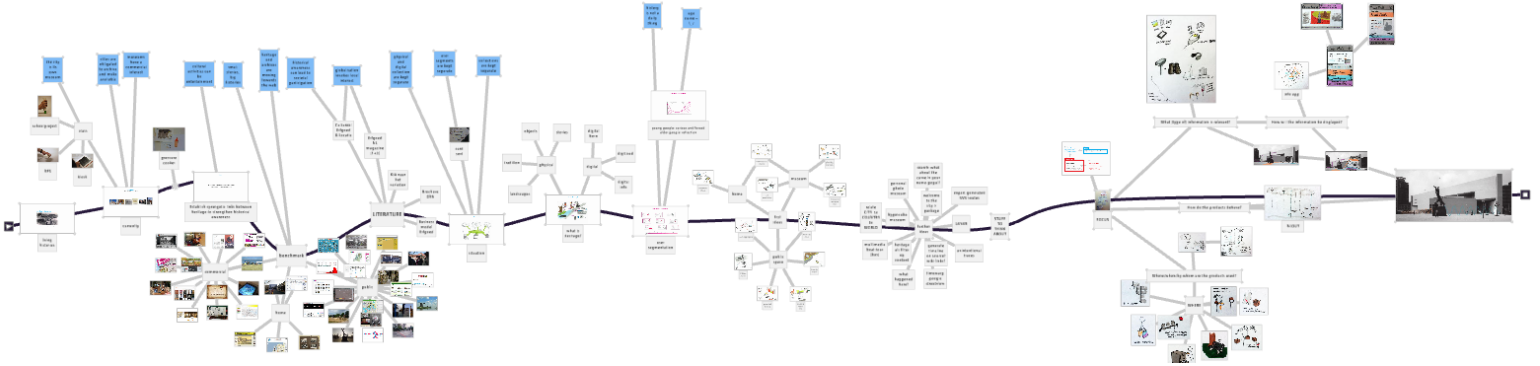


Figure 6.4-3: The first view of P1. The 'insights' from his initial activities are the blue nodes at the top-left of the view.

P1, who classified himself as both a visual and analytical designer, created a lot of sketches on separate A4-sheets of paper during his design process, collected these on a pile on his desk (figure 6.4-4:left), and occasionally pinned some on the wall. He explained that these sketches were tools for thinking and communication. They did not only address specific ideas or questions, but they sometimes also contained compositions of multiple topics, ideas, questions and insights.

P1 included most of these sketches in his process overview in Freed, and organized them in different ways: Some of the overview sketches were included as individual items in the process (e.g. a 'landmark' to show the end of his orientation phase), sketches of initial ideas were mainly organized by context (e.g. home, museum, public space, some related to multiple contexts), and later sketches were organized by means of the more specific questions that they addressed (e.g. '*How will the information be displayed*,' Figure 6.4-4:right*).*

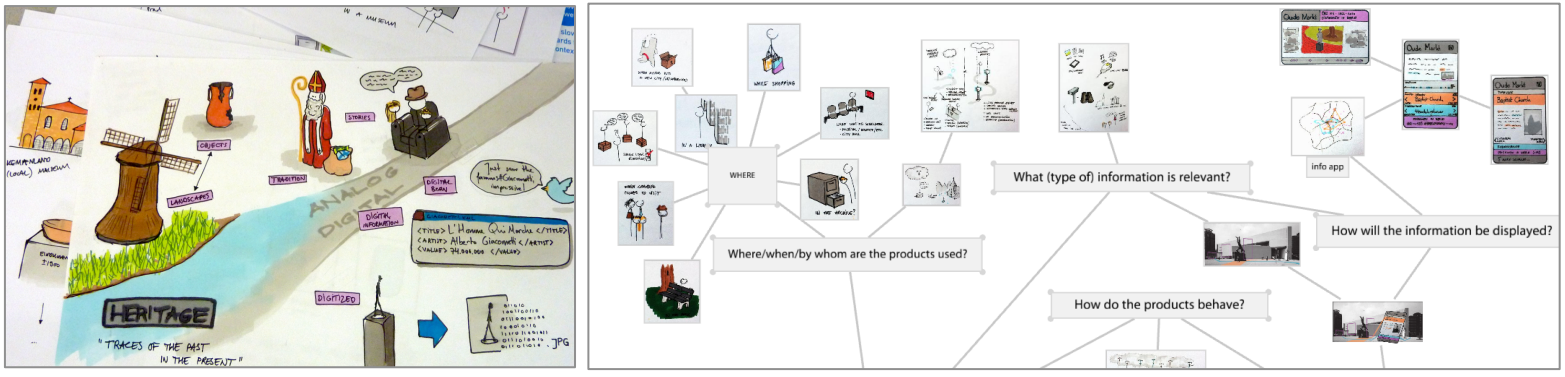


Figure 6.4-4. The sketches of P1.

Left: During the design process, P1 created a lot of sketches on separate sheets of paper.
These sketches were both thinking and communication tools, and concerned specific topics as well as overviews.

Right: In Freed, P1 organized part of his sketches according to the 'questions' that they addressed.

P1 also regularly combined sketches into an overview using Adobe Illustrator, a vector-based illustration tool. He explained that creating such an overview takes him approximately an entire day, but that it is generally worth the time because he enjoys making '*nice compositions'*, and because he can use them in his report. Additionally, they helped him to think about the more detailed aspects of his work (e.g. Figure 6.4-5).

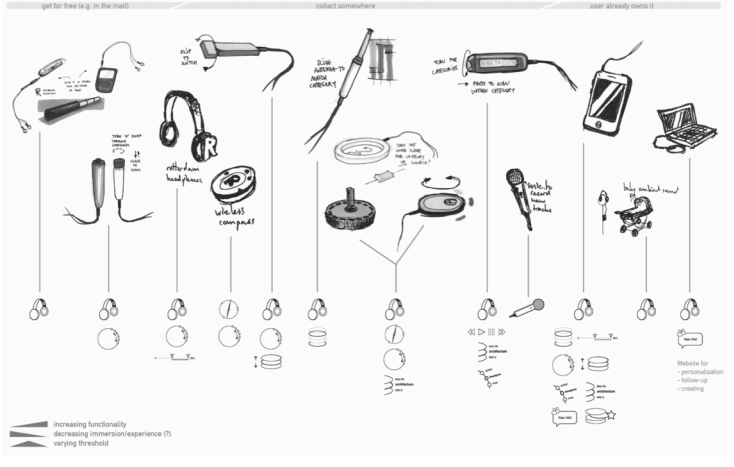


Figure 6.4-5: An overview visual that P1 created in Illustrator that shows various ideas for products/components of his final system, and possible functionalities/interactions that could be associated with each of them. This helped him to think about the amount of functionality in relation to the threshold for acquiring the products and the amount of immersion that they provide.

When asked about the added value of Freed in relation to Illustrator, P1 replied that Illustrator was useful for explaining (the relations between) very specific selections of content, but that it was useless for gaining overview of and showing the richness of the entire project. Additionally, he explained that Freed allowed him to quickly document and revisit his process, in order to '*get a grip on the situation and to immediately think about new steps'.* He supported this by showing some small mind maps and an elaborate to-do diagram (Figure 6.4-6) that he created in Freed as part of his process overview.

P1 mentioned that Freed gave him more '*freedom*' than other applications such as mind map applications ('*too hierarchical*') and diagramming applications (e.g., '*Visio: too textual*'), which he mainly attributed to the possibility to quickly import (clusters of) visual content, the force-based layout that automatically spreads out images right after importing, the possibility to quickly add and reorganize text and relations, and the infinite and zoomable canvas. He did mention that despite its usefulness for initial organization, he might prefer the force-based layout to be off by default, in order to have more control over the positions of content. Additionally, although he explicitly did not miss 'hierarchy' during the initial organization, he did miss it when showing hidden nodes by relation (e.g. to show only the 'children' of a node rather than showing everything at once).

P1 explained that it should be easier to style content and relations, as well as to auto-arrange it (alignment, circle, grid). He did add that there should not be too much functionality for creating advanced graphics: He was of the opinion that Freed should focus at quick organization and overview and that advanced visuals should better be made in a dedicated application such as Illustrator. He concluded that export functionality from Freed to such applications might be useful.

P1 did not regard Freed as an application for explicit reflection, and explained that apart from some to-do items, ideas and standing issues, he mainly used the software for documenting and organizing existing questions, ideas and insights. However, documentation was a means to an end: *'I often updated my process in Freed specifically to gain overview'.* He therefore classified Freed mainly as an application for gaining overview of the process (past *and* future), and mentioned that the integration of images and text helped him to easier revisit and understand the text (i.e. keywords) that he had put in Freed.

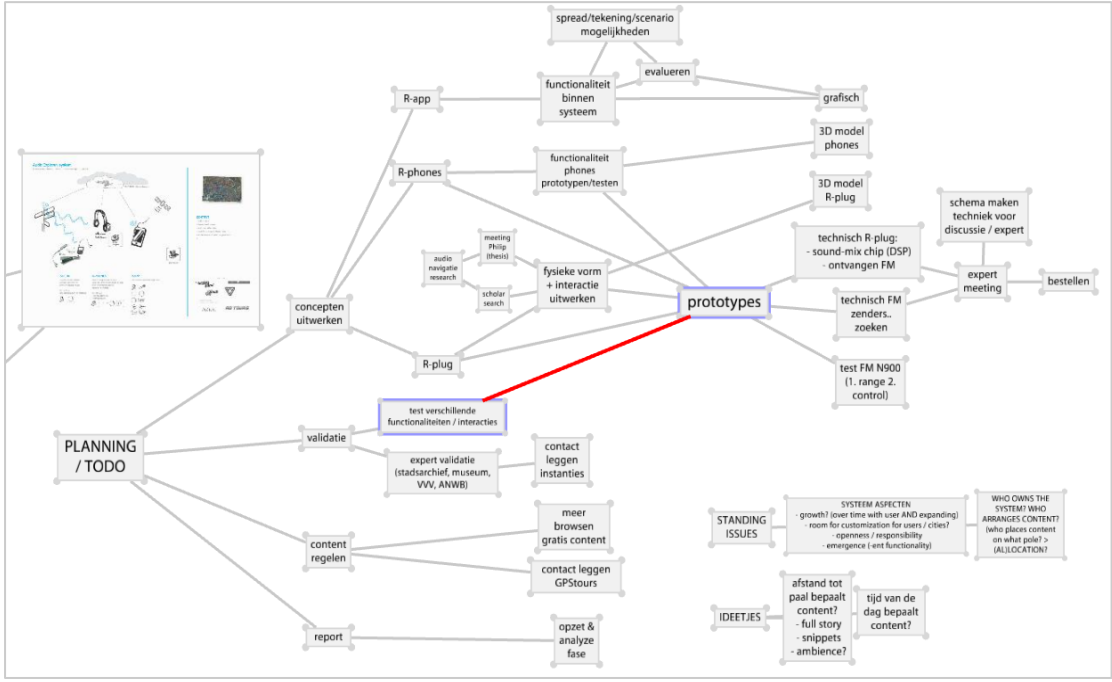


Figure 6.4-6: P1 highlights a relation while explaining his to-do diagram, which was part of his second and final view. At the bottom-right are 'standing issues' and ideas that may not be solved/implemented during the project, but that do need to be addressed later in his report/reflections.

Participant 2

The project of P2 (female, individual BSc. grad. project) was about 'Growing Value'. She aimed to design a product that would change through use, thereby gaining emotional value. During the process she focused on designing for expats in temporary housing (which benefits from personalization), and on the '*abstract concept'* of creating a personalized in-home light experience. This concept went through various iterations and resulted in a prototype of a lamp that could be controlled by deforming its fabric housing.

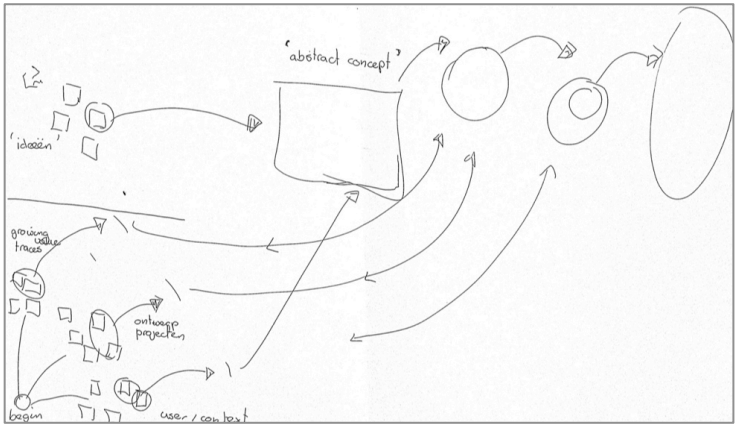


Figure 6.4-7: The process sketch of P2, with at the top-left her ideas, at the top-right her 'abstract concept' evolving through various iterations, and at the bottom-left three separate exploration tracks/topics that interact with the main design iterations.

A major part of the process consisted of collecting inspirational examples. P2 created many photographs herself, collected many images, and collected physical material samples. She consciously divided this inspiration and exploration process in three separate process tracks: Exploring *users and context*, exploring *use-traces in products*, and exploring inspirational *design projects*. She wanted to keep these tracks separate as long as possible in order to avoid fixation, but mentioned that this decision did lead to occasional discussions with her project coach who was of the opinion that there was initially too little integration between the separate process tracks.

The collection of P2 consisted of nine views, of which each one was associated with a different topic, or part of the design process. She created views about related previous work of herself that helped shape her current project, related projects by others, photos of use-traces in products, photos of users and context, initial ideas & sketches, materials, her prototyping process, and photos of interaction with her final prototype. Each time when she finished working on a topic or project phase she created a new empty view and imported a selection of images. Most views included clusters of locked images without relations and text, and were mainly used for '*documentation*' and *'overview'*. An exception was a view in which she clustered related projects, which helped her to think about different ways of creating use traces in products (e.g. conscious vs. unconscious, temporary vs. permanent). She later translated these clusters to Illustrator in which she added text and created a more orderly visual for her report (figure 6.4-8).

Figure 6.4-8: Top: Initial overview of clustered related projects, as shown in Freed. Bottom: Part of the final overview created in Illustrator, which was part of the report of P2.

The reason that P2 created a separate view for each phase was because this matched her process (she explored topics separately) and because this would allow her to clearly see at the end which content was added in which phase. Her plan was to create a large view in the end for exploring the integration between all the individual phases and to show her design process, but she did not find the time for this because of the deadlines at the end of the semester. It therefore remained relatively vague how her explorations had interacted with her main design iterations.

P2 explained that she was perhaps less motivated to document her process in Freed because she already had her own system for visual documentation and communication: Her A3-sized 'inspiration book' (figure 6.4-9). She used this next to her normal notebook for collecting inspirational material (photos, images). This book also included notes and simple sketches, sometimes on semi-transparent sheets overlaid on the photos.

Although not being used as main documentation tool, P2 still thought that Freed was good for clustering and gaining overview, and she did not have many suggestions for improving it. She did mention that an annotation layer (similar to the transparent sheets in her inspiration book) might be useful, for example for drawing a boundary around a cluster of images.

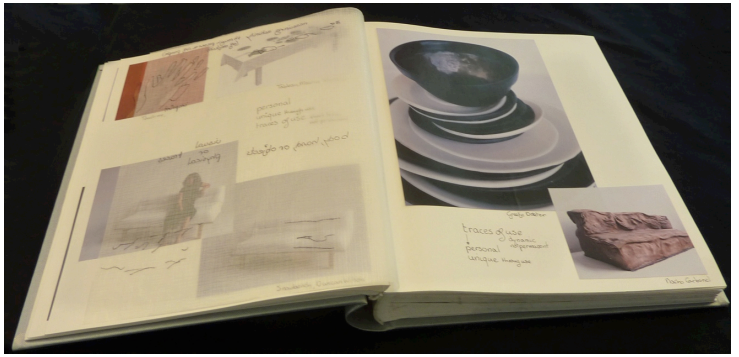


Figure 6.4-9: The inspiration book of P2, containing inspiring photos and related thoughts and ideas.

Participant 3

P3 (female, orientation semester before individual MSc. grad. project) was broadly exploring the area of '*intelligent textiles'* (i.e. textiles and electronics) from a business-, a user- and a technology perspective. She was also improving her skills and knowledge in this area through various modules. She initially had troubles to integrate and focus all these endeavors into a specific goal for her coming graduation project because she '*wanted to do too much'.* Eventually she partnered with a client, which helped her to focus on photonic textiles. Several application areas were possible, of which she chose for interior lighting and decoration, mainly because this best fitted her own interest in the '*tactile aesthetics'* of intelligent textiles.

P3 created various views of specific phases of her process: An initial mind map for exploring project directions, a view containing a lot of photos of small textile and technology experiments, a view containing a mind map of large European research projects related to textiles and technology, three views in which she clustered many related design projects and several views that were associated with a business module in which she explored how to promote intelligent textiles to the design community. She also created several views in which she prepared a screenplay for a module that was not related to her project.

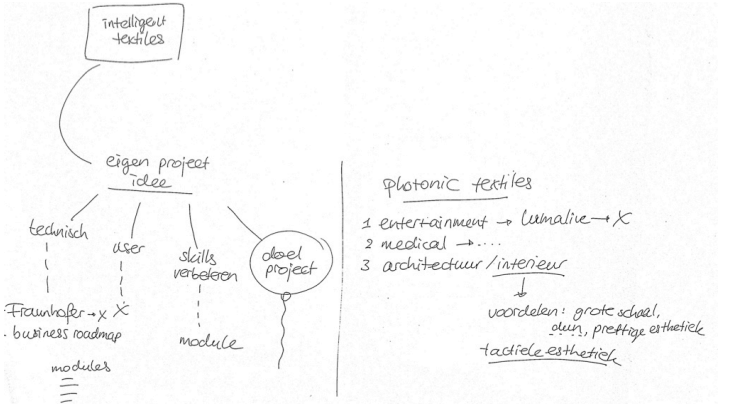
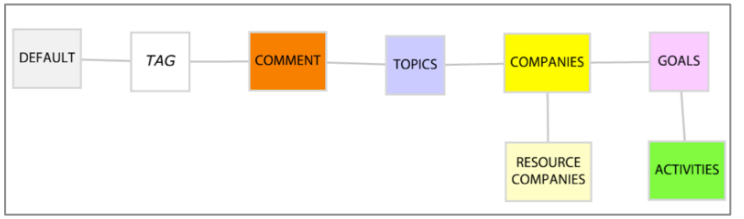
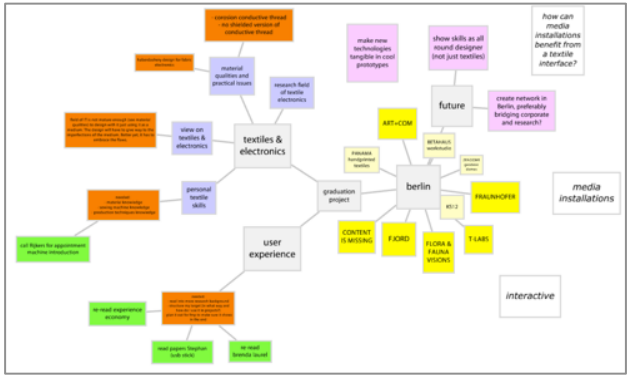


Figure 6.4-10: The process sketch of P3.

The first view of P3 was a '*mind map'* (figure 6.4-11). This mind map helped her to think about the possible directions that she wanted to explore and things that she wanted to learn in the semester. While explaining this view she stumbled on an early direction that she '*totally forgot to mention'* because it was abandoned during the project, but that was still important for future work and projects: She initially wanted to combine her interests in *'media installations'* and intelligent textiles, and did research on companies in Berlin (where she wanted to work after her graduation project).

She explored various relations between these companies and her main project interests (intelligent textiles, media installations, user experience design). She hid these relations in order to retain her main mind map structure and to keep the view orderly. She then highlighted nodes to temporarily show the hidden relations for when presenting the mind map to others (her coach, her assessor and me). P3 used this technique in many of her views, and also explained that the styles (e.g. color) helped a lot to keep the overview in specific views and across views





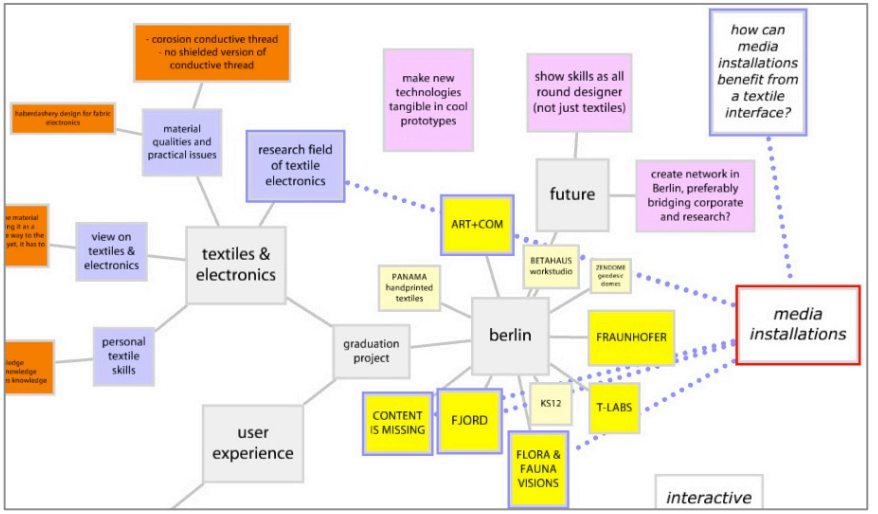


Figure 6.4-11: The mind map that P3 used to think about her project directions and 'future' directions.

Left: The entire mind map.
Bottom-right: P3 shows a part of the hidden relations in her mind map by highlighting one of the nodes.
Top-right: P3 created a separate view that shows a legend of the styles that she used in various views.

Three other views, in which P3 clustered the same related projects in three different ways (Figure 6.4-12), helped her to position her own project: She for example identified that she wanted the functionality of her product to be accessible through the tactile and interaction qualities that are inherent to the textile materials. Also the different views that she created for the business module (figure 6.4-13) were considered as useful to gain overview of the situation and to think about future activities. In these views she created a '*value ladder'*, which helps to think about a product from various perspectives ('*functional properties'*, '*functional benefits'*, '*emotional benefits'*, and '*values*') and about how these perspectives are related.

P3 very much valued the freedom that the software gave her to create different kinds of spatial organizations (in contrast to a predefined mind map or value ladder template), and the flexibility to try out alternative spatial organizations of the same content. She for example first used the force-based layout to create mind maps for each layer of the value ladder, and then created new views in which she locked the content to orderly show the relations between the different layers.

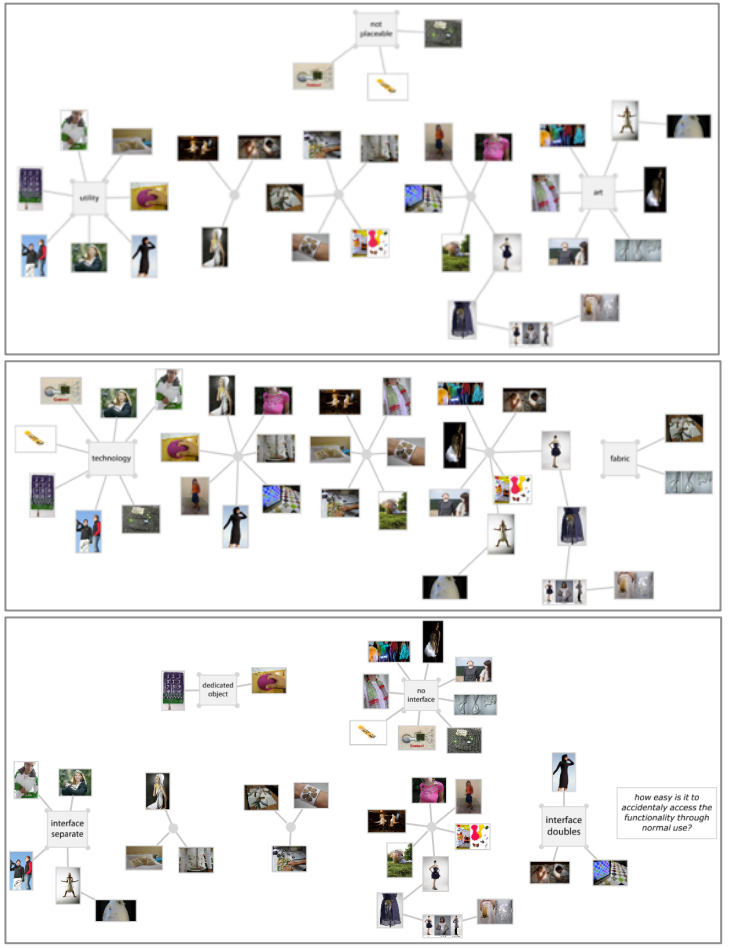


Figure 6.4-12: Three views in which P3 clustered the same related projects in three different ways. Each view approximately defines a dimension.

Top-left: Utility ←→ art.
Top-Right: Technology ←→ Fabric.
Bottom: Separate interface ←→ inherent/integrated interface.

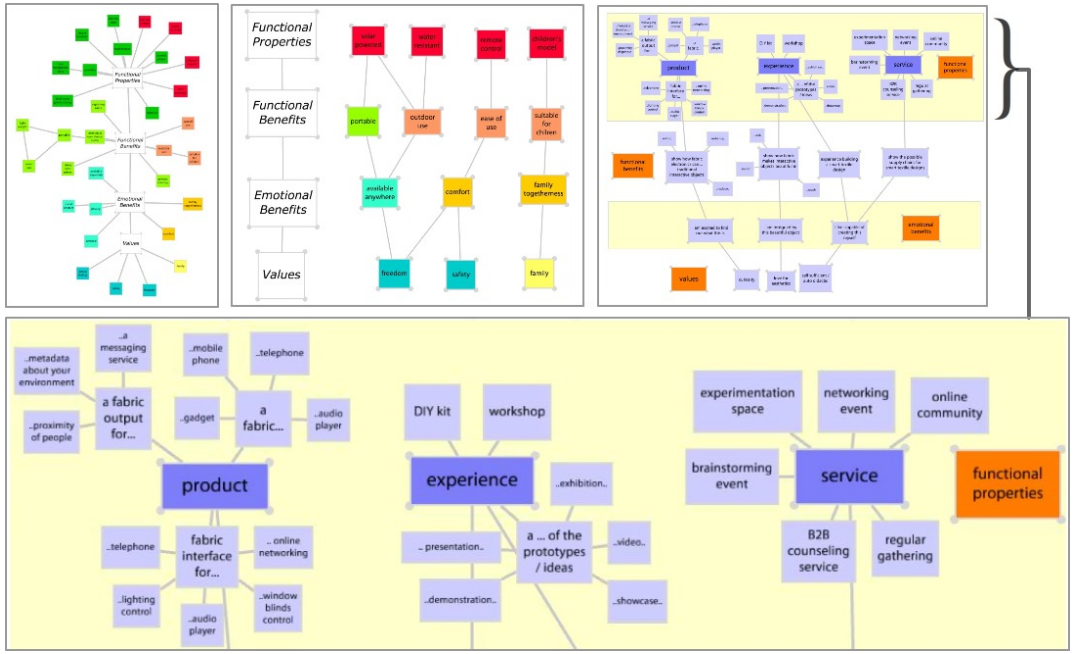


Figure 6.4-13: Examples of value-ladders that P3 created.

Top-left: Brainstorm about separate parts of the value ladder.
Top-center: Value ladder.
Top-right: Combination of brainstorm and value ladder.
Bottom: Excerpt from the top-right brainstorm/value-ladder.

P3 integrated most of her views with her main process view (Figure 6.4-14). This process view initially grew out of her first mind map, and was later extended by adding selections of the other views and by adding new content directly. She used a lot of minimized nodes (the small gray dots) because this allowed her to show that there was a lot more to see (in the other views) while still having a relatively clean process view. She created various iterations (*'snapshots'*) of her main process view so that she could see and show how it had evolved. P3 thought that it was useful to be able to integrate her specific views (e.g. mind maps, clusters, value ladders) into a process view in order to gain overview, but mentioned that it should be easier to access (i.e. switch to) the individual views from within the process view.

P3 explained that updating her process helped her to quickly revisit previous work and to think about how new work related to previous work. She for example showed how the final part of her process (after radically refocusing the project and collaborating with the client) was still related to her initial explorations. Still, P3 did not regard documentation of and reflection on the process as major reasons for using Freed: She explained that creating relations between the project phases sometimes *'felt a bit forced'* (making the project look more streamlined or linear than it actually was), and that at the end of her project she did not really need to look into the details but preferred to reflect on a more abstract level. She sometimes supported this with more abstract process visuals created in Illustrator. She also mentioned that she might use the software more for documentation of and reflection on the process if it became better integrated with (or replaced) her file browser. For example, she would like it to automatically help her to look at her folders *'in various ways'.* In conclusion, she mainly appreciated Freed for being a *'flexible mind mapping tool'.*

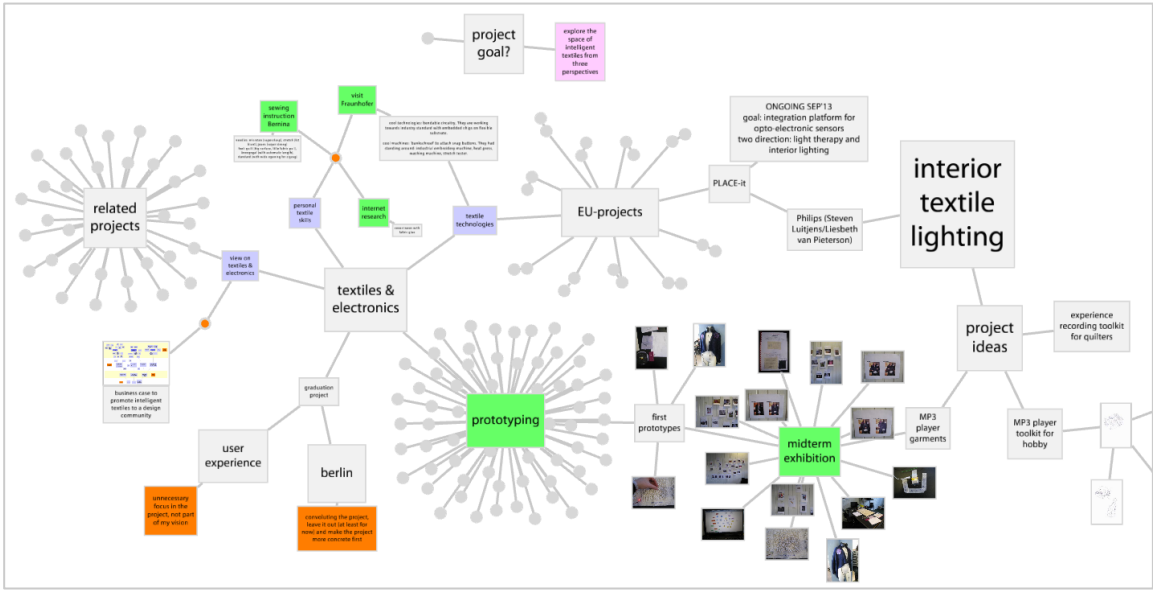


Figure 6.4-14: Part of the process view of P3.

Participant 4

P4 (male, orientation semester before individual MSc. grad. project) was setting up a project about supporting the conceptual phase of the creative process. An initial brainstorm led to two concepts, which were used to focus literature and technology research, and which were discussed with several experts and possible clients. This resulted in a focus for his coming graduation project (capturing and re-experiencing the process and context of creative sessions), and in a collaboration with a client.

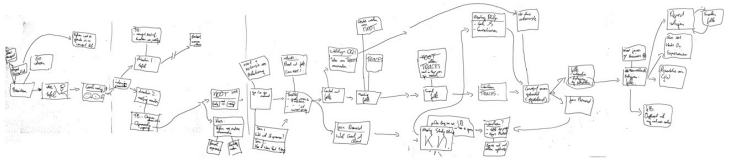


Figure 6.4-15: The process sketch of P4.

P4 created a view for each of the curricular learning activities that he did during the semester: One large view for his project, and four views for the modules that he took part in (Figure 6.4-16). He documented his project in a structured way, updating his process in Freed each two weeks. He explained that this helped him to have *'a good, structured overview'* of his process, which also showed while explaining his project using the process sketch.

For P4 Freed was a very useful tool *'to gain overview of the design process until now*': He indicated that each time he updated his process he also revisited the previous part of the process (e.g. ideas, results of a user test, coach feedback) and thought about the current part of the process. He also referred to the software as '*good for organizing a big pile of data'*, and that it therefore was more useful for his project and one of the more complex modules during which *'many things were done in parallel'*, than for the modules with a *'more straightforward and linear process'.* While documenting and organizing work in Freed, he gained insight in *'things that were done simultaneously'*, of which he was not aware during the process. Later this helped him to think about how to introduce and present these simultaneous parts in his report.

P4 did not use Freed as a tool for high-level reflection (e.g. exploring relations between what was learned during the various learning activities). P4 explained that at the end of the semester he quickly revisited his work in Freed, as well as his *'what-learned text-file*', a file containing bullets of things that he learned and reminders for reflection. He then started writing more elaborate reflections in a text-editor. *After* writing the reflections for his modules he did create a new view in Freed in order to explore which reflections were related to each other, but found out that this did not lead to new insight.

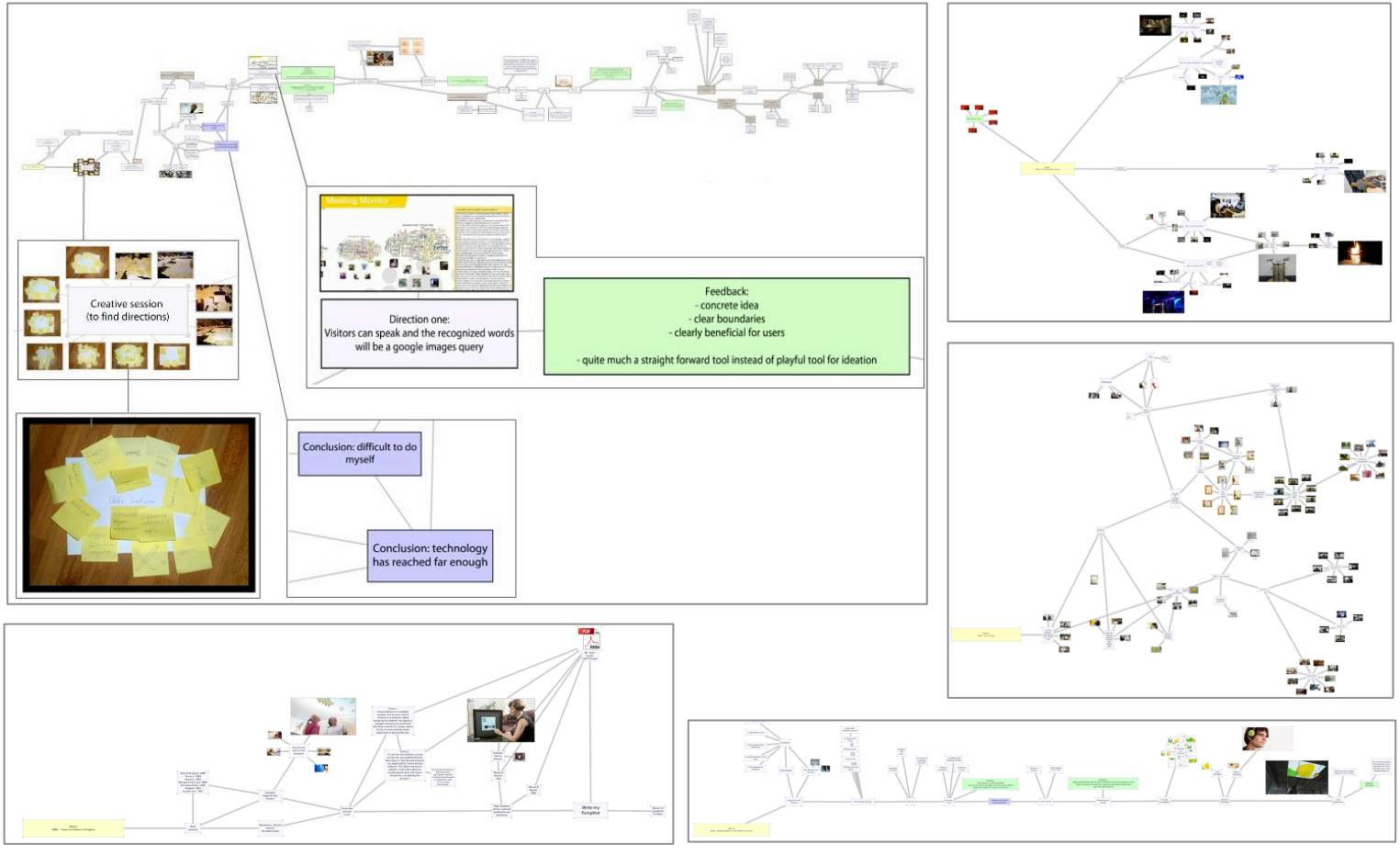


Figure 6.4-16: The views of P4.
Top-left: The project process view of participant 4, with below several examples taken out and magnified.
Other: The four views that P4 created for his modules.

Participant 5

P5 (male, MSc graduation project) was designing a system for monitoring and controlling energy use for in the home. During his process he continuously switched between designing from a '*node perspective'* (bottom-up, designing individual nodes of the system such as energy-monitors, sockets and light switches), and a '*system perspective'* (top-down, thinking about the integration of the nodes and about system properties such as automation/intelligence, modularity, openness/adaptability, persuasion/awareness and business aspects). In the end of his process these two perspectives became more integrated, as he moved towards his final system concept and prototypes.

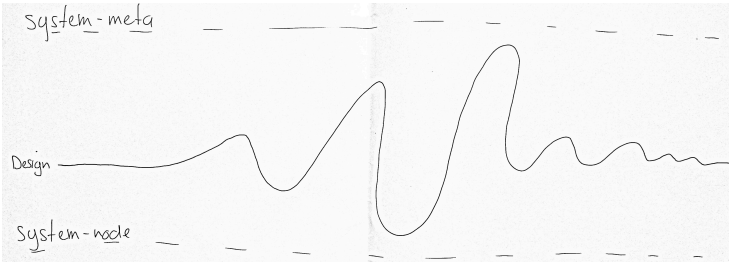


Figure 6.4-17: The process sketch of P5

P5 created three views with each containing several independent mind maps (e.g. figure 6.4-18). One of these views was created in the first stage of his process and contained basic mind maps of system aspects, interaction with system-nodes, and related products. The two other mind map views were created in the last phase of his process. One of these contained an overview of the various iterations of his final concept, and in the other he created several representations of his system in order to explore how to best present the system in his report.

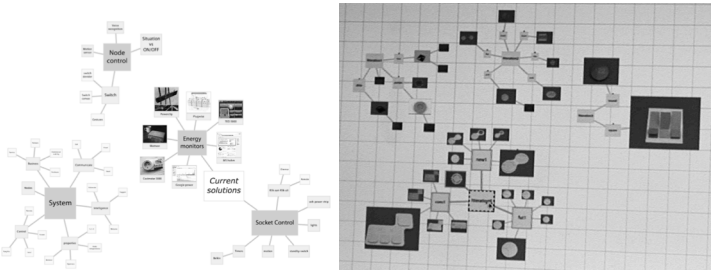


Figure 6.4-18: P5 created mind maps in the first phase of his process in order to think about possible components of his system (left), and in the last phase of his process in order to visualize the components of his system and to explore how to best present his system (right).

P5 also created a process view (figure 6.4-19). This view contained four parallel paths containing activities relating to users, business, technology and design. He explained that maintaining this view helped reminding him to digitize his visual material, to revisit his activities, to reflect on if he was heading towards his goal, and to check if his process was balanced. The view also helped him to revisit his work after the process: It for example reminded him of how certain user scenarios and interviews helped him to understand and validate his first concepts before doing another design iteration, and of specific activities that he had planned but did not pursue (Figure 6.4-20).

P5 described Freed as *'A free mind map and process visualization tool, which does not force me into hierarchical structures, and that lets me easily zoom and pan'*. He specifically mentioned that he liked the freedom that the software gave him and that he did not have to think about types of relations and types of content. He thought the multiple view functionality was one of the most important parts of the software. He wanted to use it more for presenting alternative perspectives on his project, but missed a visual overview of views, and the possibility to quickly switch between views and copy content between views. He thought he would use the software more if this workflow was improved, and if it would become easier to use the software for presenting and discussing work during coach meetings.

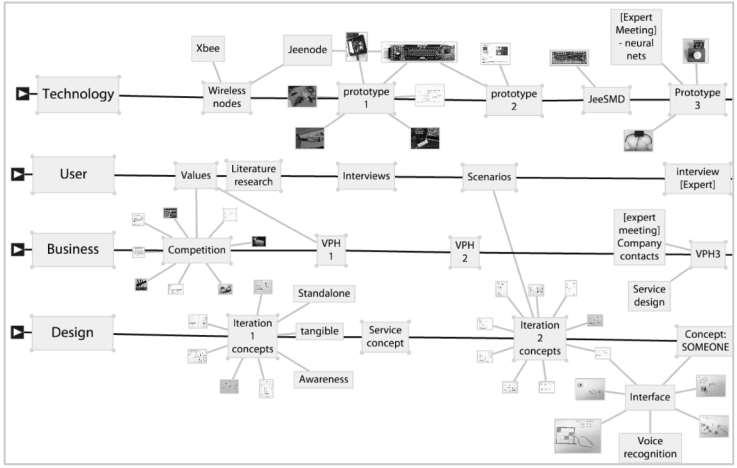


Figure 6.4-19: Part of the process view of P5.


Figure 6.4-20: P5 points at a dead-end in his process and highlights planned activities that he did not continue with.

6.4.4 Conclusions

The main goal of this evaluation was to gain insight in the use of Freed during the design process. A secondary goal was to gain insight in how this use could aid reflection, during the process as well as after the process.

Reflection during the design process

Most participants experienced Freed as providing added value to their design process: They stressed its value as a tool for *revisiting* and gaining *overview* of (plans for) design activities and work, as well as for *exploring* relations, perspectives and future work. The possibility to quickly organize a lot of images was experienced as important for revisiting and overview: The images were useful to better understand related textual content (i.e. keywords), but also reminded the participants of associated activities, ideas, questions, feedback and decisions, despite that these were not always explicitly (i.e. textually) documented in Freed. Participants explored relations, perspectives and future directions by creating separate views with mind maps, networks and clusters of work and ideas, but also by integrating small mind maps or to-do items (or in the case of P1 a more elaborate to-do diagram) in their process overviews.

Reflection during the process was mainly described as *'unconscious'* and *'implicit'*. It was regarded as interwoven with other activities such as creating overviews of work, communicating or discussing work, (mind-wandering while) travelling or reading, and more specific design activities such as sketching, making and experiencing prototypes. Despite that a lot of these reflections remained implicit, most participants did feel that creating overviews (i.e. documenting/organizing), revisiting and exploring in Freed contributed to reflection during the design process. Sometimes this reflection was intentional, for example when a process overview was specifically updated in order to '*get a grip on the situation'*, or when a spatial overview of work was created in order to better understand the relations within that work.

However, often reflection was unintentional and *triggered by other activities*, for example when the addition of '*new work'* to a process overview triggered participants to think about the relation between this work and previous work, as well as to explore future work. Especially due to this overlap between activities (documenting/organizing, revisiting, exploring) participants appreciated the possibility to freely and flexibly organize content, and thereby to integrate process overviews with overviews of specific topics, activities or project phases.

In most cases Freed was much less used for documentation and reflection during the last phase of the design process, which was mainly attributed to approaching deadlines and the much more focused (i.e. less explorative) work, or how P5 put it: *"In the end I am mainly building things and need less moments of reflection".* However, this 'building' process may lead to many insights, doubts and questions (e.g. about the initial goals and about the chosen concept) as for example P1 explained. Reflecting on this phase, as

well as its relation to the earlier project phases, is therefore highly valuable and should be supported better.

Reflection after the design process.

Reflection after the design process was described as a much more explicit and focused process. Freed was then mainly used as a tool for quick revisiting (e.g. as '*quick overview'*, '*checklist*', or '*inspiration*'), and more elaborate and high-level (i.e. abstracted) reflection happened mainly while writing (e.g. thinking about the project outcome in relation to the project goals, thinking about the process, thinking about competencies, identity and vision).

At this stage most participants did not add new content to their collection in Freed (e.g., adding work from the last process phase and by relating this to previous project phases, or adding reflections) because they were on a tight deadline, because the final stage of the process was still in their recent memory, and finally because other tools were more suitable for creating better looking and more abstract process visuals for inclusion in their deliverables.

This did not come as a big surprise: It is good to occasionally take some distance, and reflect in a focused way without being distracted by all your previous work and thoughts. Additionally, as P1 remarked, it can be '*refreshing to switch between applications or media*' once in a while. However, this does not eliminate the previously identified need for more documentation and reflection (and their integration) during the design process. There are still many opportunities for improving this process, and these are discussed below.

Opportunities for improvement

None of the participants liked the idea of including specific templates or reflective questions in the software, and as discussed, they did feel that the free and flexible organization of (mainly) visual content supported reflection. Still, many opportunities for supporting more elaborate reflection were identified. A few participants mentioned that a specific reflection-mode '*might*' help, such as a *'dedicated layer'* or '*focused writing modus*' for writing longer pieces of text that can be attached to (a selection of) a view. However, most participants mentioned that reflection, and the use of Freed in general, would benefit most from better support for *other* activities, such as documentation and communication, and from improving the multiple-view system.

Lowering the threshold: documentation and communication

One participant (P7) hardly used Freed. One of the reasons that he gave for this was that he was already using a blog for documenting his work in order to communicate it to the client of his project (which was located in another country). He was therefore less motivated to document his process in Freed (it felt as '*double work*'). He updated his blog three times during the project, taking him approximately a day per update. He explained that the disadvantage of the blog was that it forced him to use a linear structure that did not correctly

represent his process, but that this was also an advantage because it allowed him to focus on the content (i.e. on writing and selecting images).

The other participants did document their *visual* work in a reasonably structural way, ranging from approximately each two weeks to each four weeks, with exception of the last weeks of the semester. However, a large part of the participants mainly added basic keywords describing activities and ideas, and only captured a lot of questions, issues, thoughts, feedback and scribbles in tools that have a lower threshold for quick documentation, such as notebooks or in some cases text documents. This is a problem that mainly needs to be addressed by lowering the threshold for capturing, documenting and accessing content, for example by means of a mobile app for taking and importing pictures (of notes), better file-browser integration, cloud storage, and by lowering the memory usage and startup time of the software. It might however also be addressed by making the software more suitable as *communication* tool: Several participants explained that they would use the software more if it would be easier to use or export content for presentation or discussion purposes (e.g. for report, exhibition or meeting). Indirectly, this may also invite more *documentation* of feedback or thoughts that arise during discussions, for example during a coach meeting.

A balance between organization and visualization, between detail and abstraction

The question is how much layout, illustration and annotation functionality to add without compromising the focus on visual documentation and flexible organization: On the one hand, it would be great to see more abstract process visualizations that show process phases, iterations or perspectives (e.g. the sketch of P5 in figure 6.4-17). Such visualizations may be derived from, mapped over, or used as structure for the visual organizations of work in Freed (e.g. in a separate view, on a separate layer), and may invite more abstract, high-level reflection while working with the software. On the other hand, without the proper support of examples of work, these abstracted visuals can come across as disconnected or idealized. For example, it was often difficult to grasp what important issues and insights were, or sometimes even what the project was about at all, when the participants were discussing their project and process with the help of pen and paper. It seems therefore pivotal to find a proper balance between flexible organization and bottom-up thinking on the one hand, and abstract visualization, structure, and top-down thinking on the other hand.

The integration between views

The multiple-view system may be part of the solution towards this balance between flexible organization and abstract, structured visualization: One view can for example serve as a reorganized, abstracted, annotated version of the other. However, many challenges still remain for optimizing this system. These include features concerning overview and navigation, such as a visual overview of views, the possibility to directly link between views (i.e. jump to another view from within the current view), and the possibility to have multiple views open at the same time. But also other aspects need consideration, such as automatic recognition of newly added text and images that are already part of other views, the possibility to clone or instantiate content within one view, and a more straightforward interface for sharing content properties (e.g. color) across views while still allowing for visual differences between views. Ideally, such improved functionality will not only improve the exploration of new perspectives in new views, but also the integration of perspectives across views.

7 Expanding the view

7.1 Introduction

In this chapter the main focus is on the exploration of relations and perspectives. First, in the next section a design iteration is discussed, which mainly concerns improved interaction with multiple views. In section 7.3 I discuss five cases of students that used Freed to create personal views on work that was discussed during a module (i.e. class) on design theory. Section 7.4 concerns a case-study during which three designer-researchers created various views of a collection of student projects. Finally, in section 7.5, I discuss how I used Freed during the last phase of my PhD project.

7.2 Design iteration

In this section I briefly discuss the main new functionality that was implemented in response to feedback obtained and observations made during the evaluations presented in the previous chapter.

Views browser

In order to improve overview of and navigation between views, the text-based views panel was replaced by an image-based views browser. This is a scrollable panel that shows images of the views, similar to an overview of slides in presentation software. The views browser is docked at the bottom of the screen, and its height can be increased in order to better see the images of the views. The views browser can be opened in normal modus, in which all views are shown (Figure 7.2-1), and in relation modus, in which only the views that include a specific node are shown (Figure 7.2-2). Browsing views in relation modus is similar to browsing related nodes and related paths, which was described in the previous design iteration in section 6.2. When moving the mouse cursor over a node on the canvas, a button pops showing the amount of other views in which that node is included. Pressing this button opens the views browser in relation modus.

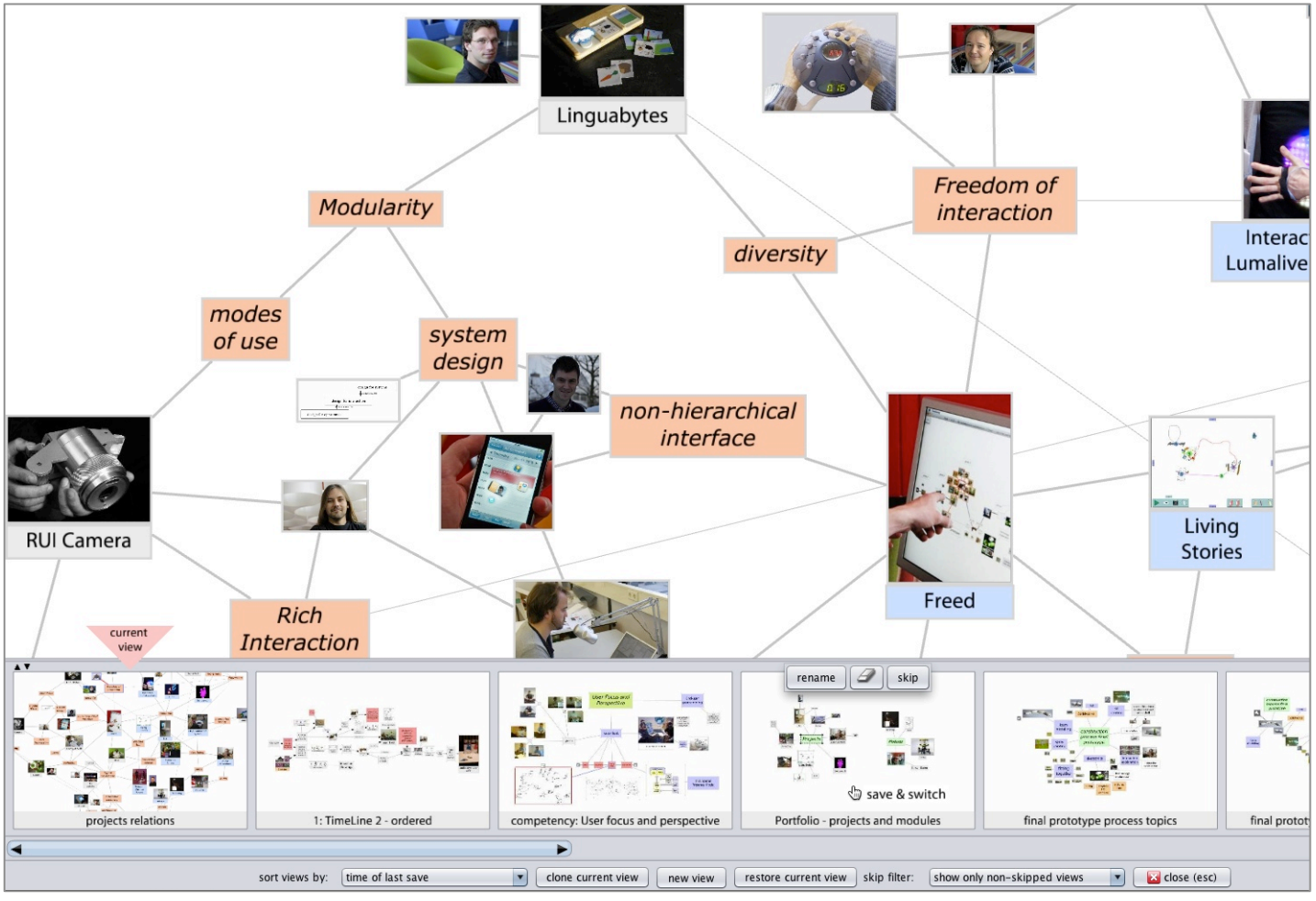


Figure 7.2-1: In its normal modus the views browser gives an overview of all views (except 'skipped' views) and facilitates navigation between views.

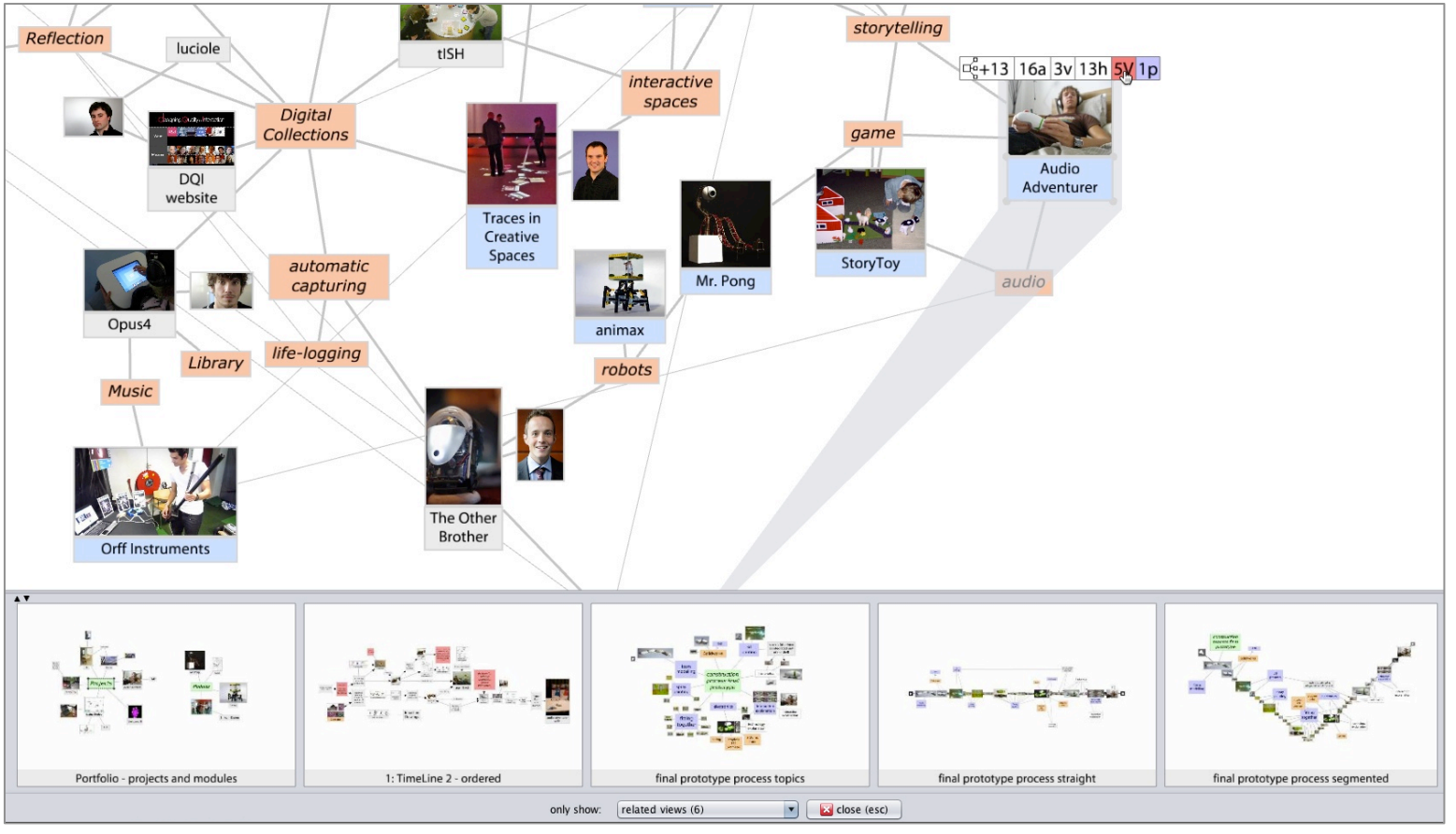


Figure 7.2-2: In relation modus, the views browser only shows the views that include a specific node. When moving the mouse cursor over a node on the canvas, a button pops up above the node (together with other buttons) showing the amount of other views in which that node is included. Pressing this button opens the views browser in relation modus.

Clipboard

In order to facilitate copying content between views, and therefore to improve the integration between views, a visual clipboard was added to Freed. This is a scrollable, resizable panel that is docked at the bottom of the screen, similar to the views browser and related nodes and paths browser.

The clipboard browser was especially needed because Freed does not have the possibility to have multiple views open at the same time, in order to quickly switch between views and copy content between views. When content is copied, it is added to the content in the clipboard, rather than replacing it. This is for example useful when 'collecting' content from various views in order to copy it all at once into one (new) view.

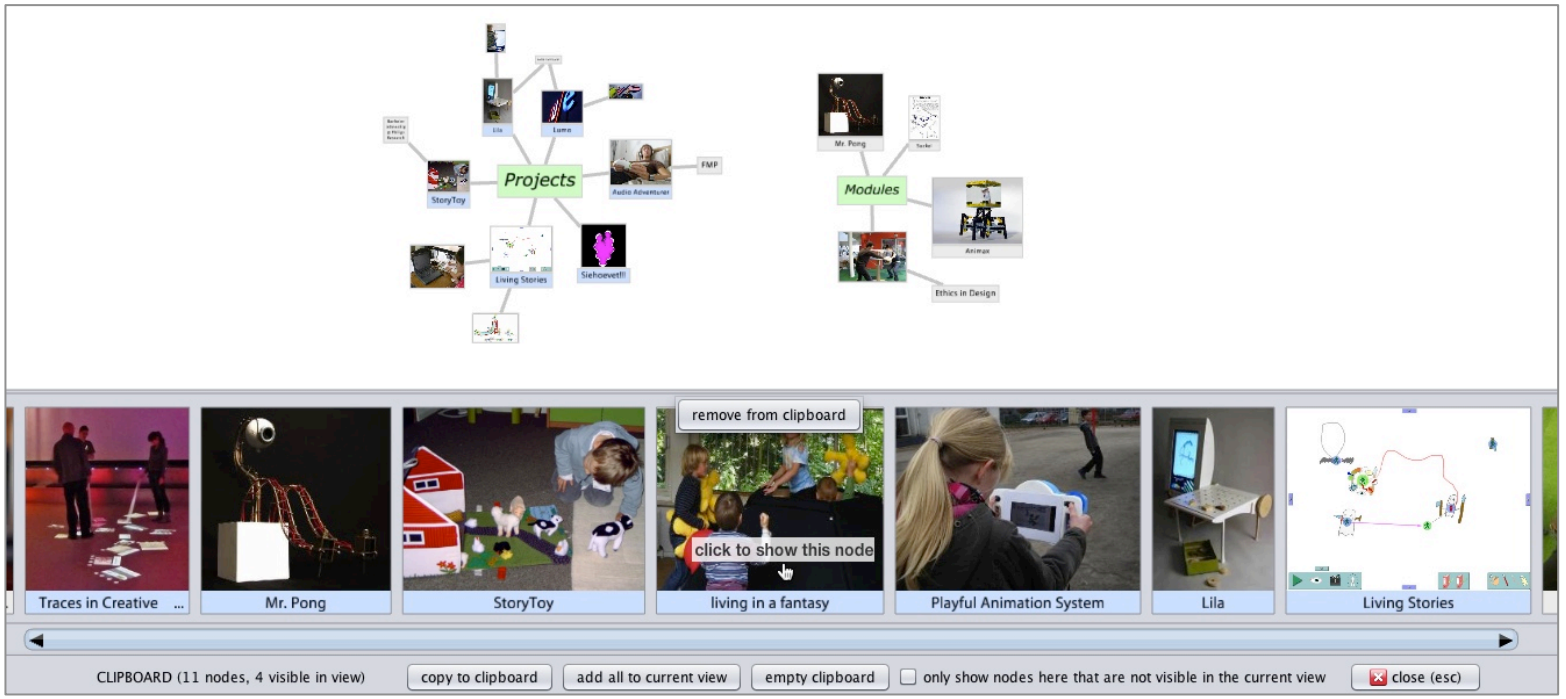


Figure 7.2-3: The clipboard browser facilitates copying content between views.

Views and clipboard access

Instead of adding the buttons for opening the views browser and the clipboard browser to the already too-crowded interface at the top of the screen, they were added at the bottom of the screen. This makes sense, because this is also the place were the browsers are docked (figure 7.2-4).

Additionally, a drop-down list (i.e., pull-up list) continuously shows the name of the current view and facilitates fast switching between views based on view names.

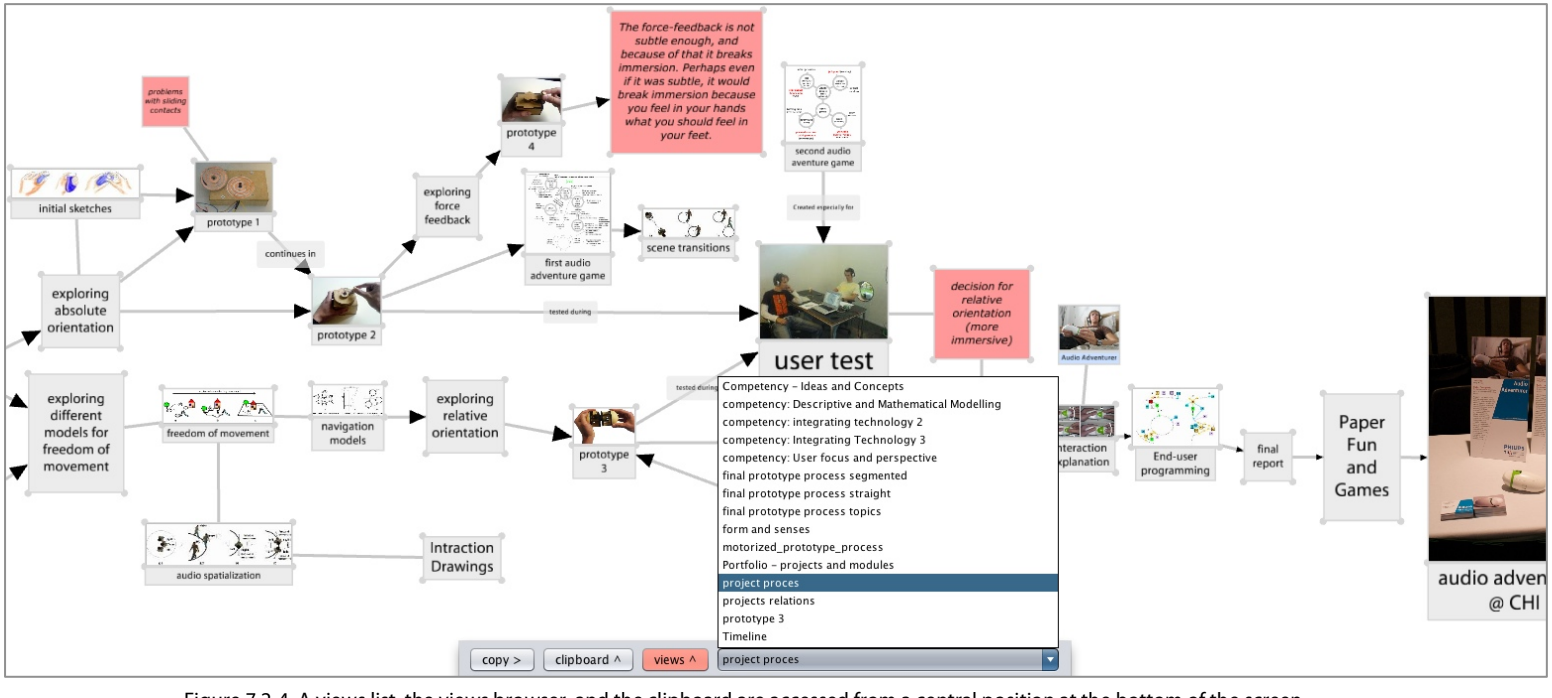


Figure 7.2-4. A views list, the views browser, and the clipboard are accessed from a central position at the bottom of the screen.

Import improvements, backups, and high-res export

In response to requests, functionality was added for exporting a view to a high-resolution image. Additionally, several improvements were made concerning file import: When multiple files are imported, Freed asks if they need to be automatically clustered or automatically laid out on a path (ordered based on filename). The software also stores a hash for each imported file so that an existing file (and thus existing node) is recognized and reused if it is reimported.

Finally, Freed is set to backup the entire collection every five minutes, and each time when content is deleted from the collection. Also a confirmation dialog was added that shows which views are affected when content is deleted from the collection (Figure 7.2-5).

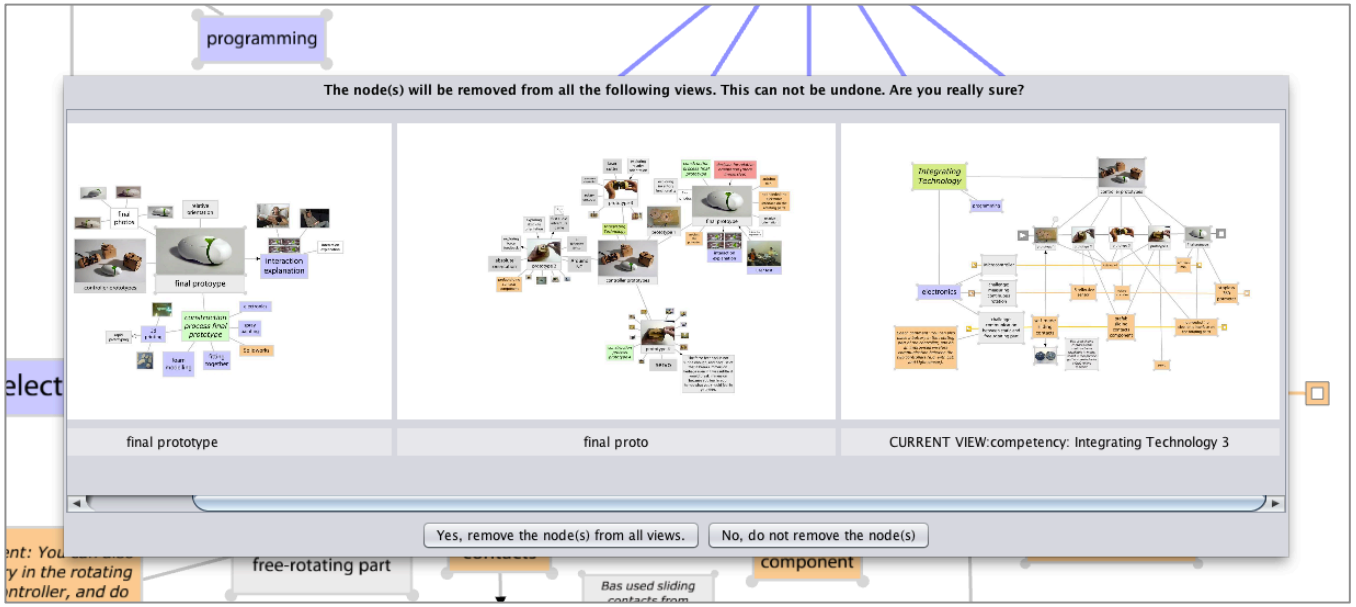


Figure 7.2-5. A confirmation dialog is shown when content is deleted from the collection.

7.3 Students' perspectives on design theory

7.3.1 Introduction

In May 2011 the Designing Quality in Interaction research group (DQI) organized a two-week educational module called 'DQI Theory' for sixteen Master students. During this module DQI researchers and invited speakers presented design-research work, methods and theories. The students read literature, took part in collaborative discussion-, clustering- and concept mapping sessions, and engaged in collaborative design activities. At the end of the module the students used Freed to gain overview of the material and activities, as well as to present their *personal views* on the matter. The main goal of this evaluation was to explore if and how Freed would allow them to do this, with particular attention to possible different ways of constructing their personal views.

7.3.2 Procedure

Near the end of the module I gave a 20-minute presentation about Freed and its main features to the students. Thereafter they individually used the software during two sessions of approximately three hours each. They used the first session to get used to the software and to create an overview of the topics and activities of the module. The students had access to a shared repository with presentations, pictures and videos from the module, but they also used their own pictures and notes. The initial overviews were presented to each other with the help of a projector. Most students also printed out their overviews on A3 sheets for further discussion and note-taking (Figure 7.3-1).

Figure 7.3-1: Students created printouts of their initial views, and used these for discussion and note-taking.

During the second three-hour session the students worked further on their initial views, and created one or more additional views to show how the topics discussed during the module related to their own identity (e.g., work, skills, interests and vision). These latter views were presented using a projector in a final presentation and discussion session with students and researchers. For each student there was approximately three minutes presentation time and two minutes discussion time available. During the presentations the students controlled the software from their own laptops (Figure 7.3-2). A few students walked up to the projection to directly point at content. In those situations I helped by panning and zooming the canvas when required.

Figure 7.3-2: During the presentations the students controlled the projection of their collection from their own laptops.

After the module I obtained the collection of each student, re-watched their final presentations (which were recorded on video), and had a 20-minute semi-structured interview with twelve of the students. During these interviews I discussed the students' views, how they created them, if and how Freed had helped them, what kind of tool they considered Freed to be, how they imagined using Freed in daily practice, and how they thought it could be improved.

Out of these twelve cases I have selected five that approximately cover the different ways in which the software had been used and experienced. These examples are discussed next. Thereafter I conclude with a more general discussion of how the software was used and experienced by all students.

7.3.3 Five cases

Student 1

In his first view (figure 7.3-3) S1 created an overview of all the days of the module and the topics discussed, as well as various forceless relations (i.e. cross-links) between these topics. He added images of the presenters and explained that their faces helped him to remember the discussed topics better. While mapping some of the more difficult topics (e.g. 'phenomenology', figure 7.3-4, bottom-left), he found out that he required additional information, searched for this online, and added it to the overview.

While mapping the topic of phenomenology, S1 realized that part of the presenters had talked about studying specific 'Phenomena' (e.g. 'unaware interaction', 'Perceptual crossing'), while others had talked about 'Methods' (e.g. 'Collaboration/co-design', 'Craftsmanship'). While relating the various topics to these overarching concepts, he realized that it was often difficult to exactly define whether a topic was a method or a phenomenon (e.g. 'Ethics and aesthetics in interaction'), and that while pursuing a specific method one may be automatically learning about it as a phenomenon (i.e., the process is part of the goal).

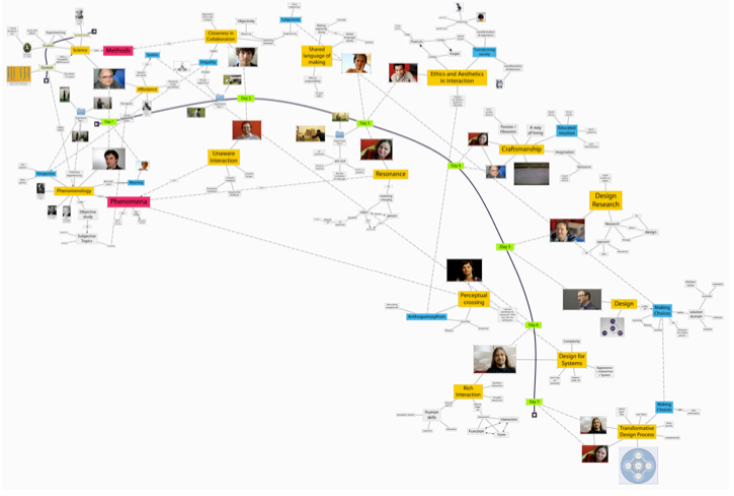


Figure 7.3-3: In his initial view S1 created an overview of the researchers and topics, organized by day, as well as cross-links between the topics. (yellow: main topic, blue: sub-topic, pink: overarching concepts 'Methods' and 'Phenomena').

For his second and final view (Figure 7.3-5), S1 planned to make a bold statement. He placed himself ('*Me*') in the center, and divided a selection of the content of his first view in two camps: Things that he liked (at the top, e.g. *'Transforming society'*) and things that he had '*mixed feelings about'* (at the bottom, e.g., *'The Lab-approach'*, design-research that is not connected to the market).

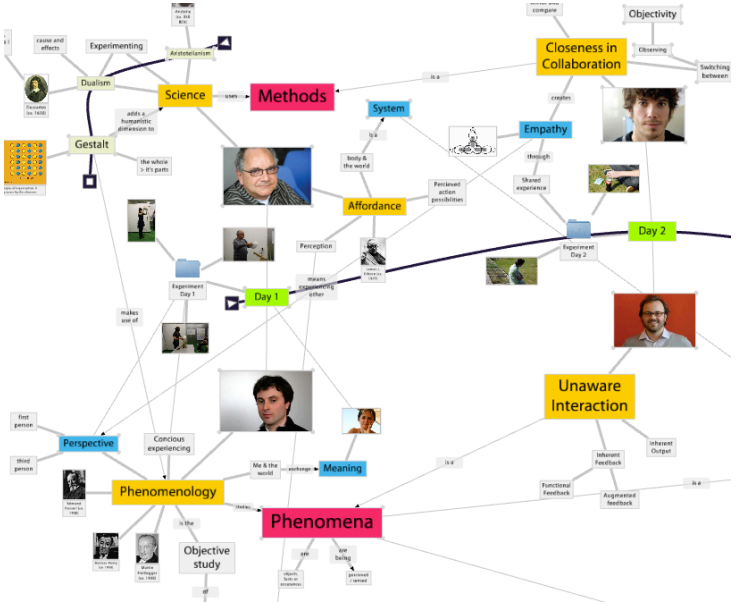


Figure 7.3-4: A small part of the initial view of S1 (see also previous figure).

Especially because this view again included part of the teachers' faces, this bold distinction raised a lot of rumor and hilarity in the crowd (e.g. Teacher A: *'I am not even in there.*' Teacher B: *'That's even worse!'*). This was followed by a lively discussion about how (design-)research could become less 'research-for-research-sake' and more connected to the 'real world' (e.g. by teaching students that later become part of industry), but also about some of the problems associated with being too involved with industry. In conclusion, the lack of nuance in the view probably meant that S1

needed to think some more about the (relations between) the topics, but his strong positioning did help to feed a lively discussion (which in turn helped to bring nuance).

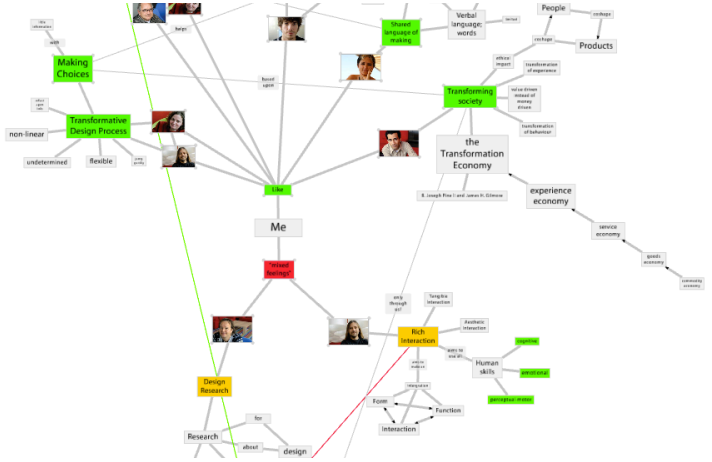


Figure 7.3-5: Part of S1's final view, which lacked nuance but raised discussion.

S1 described Freed as a research tool for mapping difficult topics and their relations (i.e., a concept mapping tool). He thought that sticky notes were more suitable for very fast reflection, and that Freed triggered more elaborate thinking ('*Typing and making relations makes me think.*'). He specifically mentioned freedom and flexibility as important properties of the software:

> *"The advantage is that this is very flexible; I really like the forces. In combination with locking they make it really easy to change and rebuild my structure… I can make many relations, but the main point is to filter out the important relations. That's what I like about this, the freedom makes me think."*

On the other hand, he mentioned that the force-based layout was sometimes distracting, due to the lack of grouping functionality for specific organizations of content (e.g. Figure 7.3-6). He preferred to lock such a selection of content in a group, but wanted the entire group to still be subject to the force-based layout. Additionally, he wanted to have the possibility to immediately create a force-less relation (e.g. using a dedicated tool) rather than turning of the force after creating it, because that would allow him to create a relation without disturbing his existing layout.

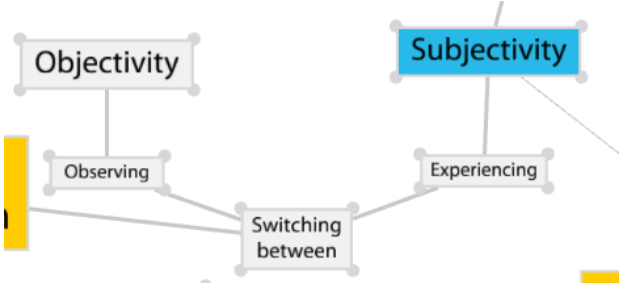


Figure 7.3-6: Sometimes S1 required grouping functionality to lock the positions of content in relation to each other (rather than locking it entirely/to the canvas).

Student 2

S2 started with clustering the topics that he considered to be most relevant using sticky notes. He then wrote everything on paper (A4), and connected the topics with relations (Figure 7.3-7). He explained that he was not fond of working with 'digital things', and that he always needed to 'put things on paper' first. He explained that this had to do with the 'fixed nature' of written content:

> *"If I write things down then I get them out my head. In the computer they are not concrete, and therefore they also remain fuzzy in my head."*

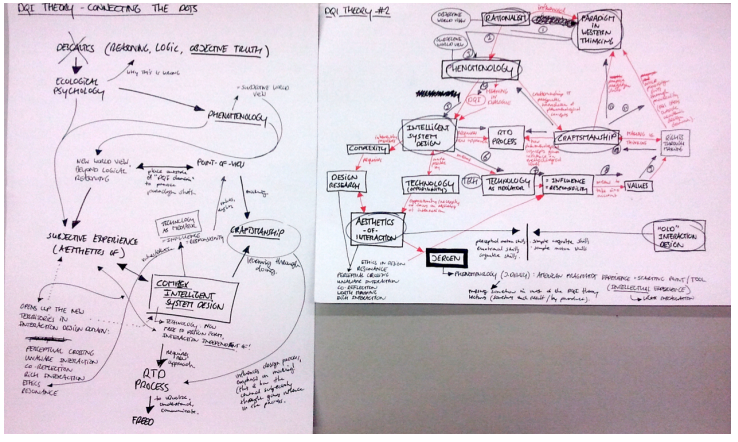


Figure 7.3-7: The initial concept maps of S2.

After working on paper S2 transferred the main points to Freed and created three different views. This helped him to reorganize his thoughts and think about new relations. He explained that most relations were already 'in the back of his mind', but that it was useful that Freed 'brought them to the front':

> *"Due to the flexibility a topic may be located next to another topic, which makes me think: 'Oh, that is also a possible relation'".*

It for example helped him think about how craftsmanship was related to phenomenology and how both were necessary for the design of complex, intelligent systems that are hard to predict and rationalize (Figure 7.3-8). Nevertheless, he did not use the force-based layout a lot, as it made nodes 'float' over relations (making it unclear which nodes were connected each other), and because he wanted to be in control. He suggested that there might be a more gradual transition between free-floating and locked nodes, for example by using 'hierarchy' in the force-based layout. He did mention that the software should remain more '*active*' than what he considered more *'passive'* hierarchical mind mapping applications.

When asked about his opinion on using an application such as Freed with more sketching capabilities and a tablet-and-pen interface, S2 responded negatively. He said that he preferred to work with paper, and that he would rather have functionality to quickly iterate between software and paper (e.g. print and scan). S2 concluded that he would never start from scratch in the software, as this would make him '*loose track due to being presented with many choices without having the foundation to base these choices on'.* However, he explained that after first having the main points clear

on paper, it was pleasant to *'be confronted'* with all these choices concerning positions of and relations between content. He explained that even when not using many of the relations in his final view and presentation, thinking about them did help him to reach a more holistic understanding of the matter.

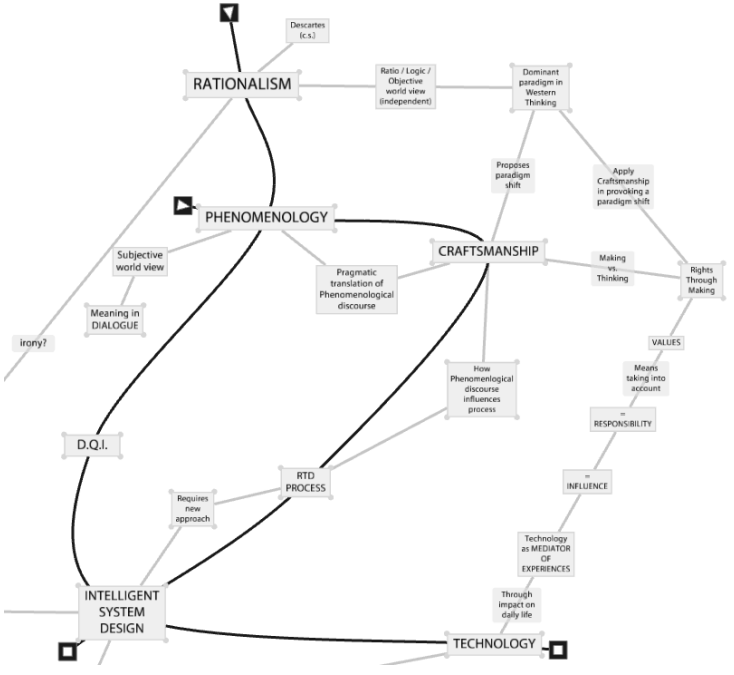


Figure 7.3-8: One of the initial views of S2 in which he explores the relations between the topics that he considered to be most relevant. The paths (black curved lines) are used to highlight the two main branches of his story.

Student 3

In his first view, S3 created a chronological organization of projects and theory addressed during the module (Figure 7.3-9). He copied a selection of the content that he considered to be most relevant to a second view (Figure 7.3-10). In this final view he added some examples of his own work and topics for discussion and reflection. He then structured everything loosely along two dimensions: He used the vertical dimension to contrast a more applied and structured way of working (top), with more abstract and intuitive methods and topics (bottom). The horizontal dimension and the blue lines were used to structure his story as well as to loosely explain his personal development. At the left he introduced himself in general, in the center he discussed his personal view on designing (i.e. the process) in relation to theory, and at the right he concluded with specific theoretical topics that matched his interests and work.

While navigating through the final view, S3 explained for example that he was an empathic person interested in the emotional and ethical aspects of design, but at the same time also a very structured person requiring a relatively linear design process with clear validation steps (referring to examples of own work). He explained how he learned to trust in his intuition more over time, but also how to externalize this intuition using various methods. He concluded by explaining how several theoretical topics (e.g. ethics/values) were addressed in his initial projects, but mainly when evaluating the products that he had designed, and not really as an inspiration for *'designing interaction*' as he was planning to do now in his final Master project.

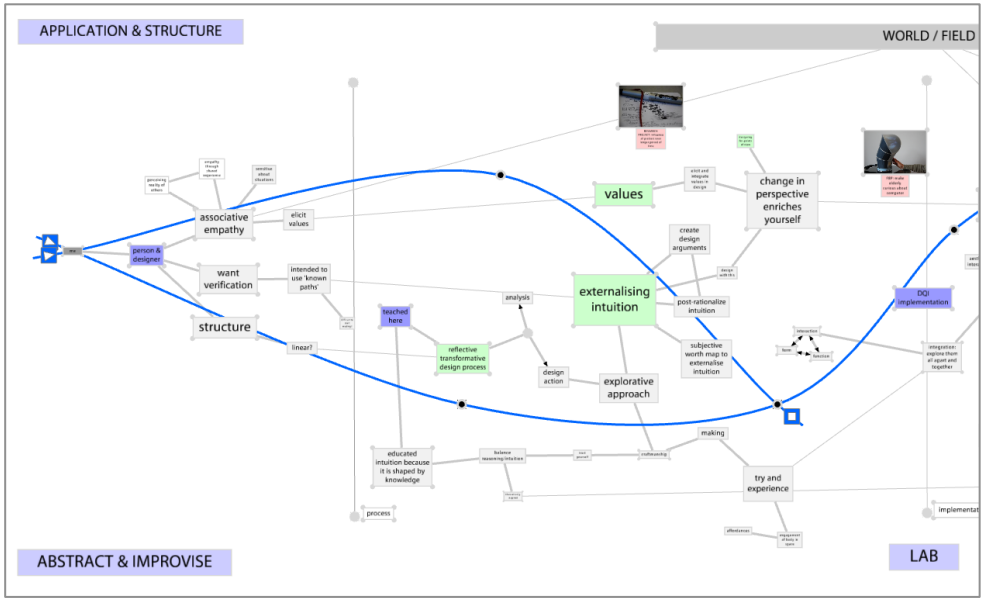
During the interview, S3 explained that Freed helped him to '*think in a more holistic way*' about his own interests and way of working, but he classified Freed more as an organization tool than as an elaborate reflection tool:

> *"I did use it for reflection. But I see it mainly as a very practical tool to create a quick overview of past work, to quickly show the relations between various topics…, and not so much to direct future work".*

He mentioned that he was interested in using the software as a quick process visualization tool for coach meetings and his report, but that this required more and easier functionality for creating good-looking visuals. He did specifically mention that this only required basic functionality (colors, line styles, alignment) and that it should not become a tool like Illustrator:

> *"It is good that the software has constraints, otherwise I am going to spend too much time on the appearance of the content".*

Figure 7.3-9: The first view of s3.



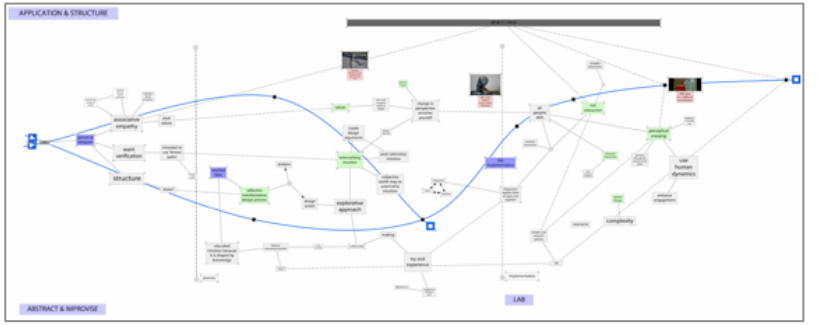


Figure 7.3-10: The second view of s3. Top: Enlargement of part of the view.

Student 4

In contrast to most of the other students, S4 started from a personal perspective. In his first view he created an overview of topics and some activities of the module that were most relevant to his personal interests, and included several reflections that he had written in his notebook during the module (Figure 7.3-11:top). He then cloned this view, cleaned it up (i.e., hiding some of the less relevant content), and connected the topics and activities to a more complete overview of the work and people of the DQI group (Figure 7.3-11:bottom).

He finally copied a small selection of the topics that he considered most important for his personal vision, and added these to a fresh empty view for his presentation (Figure 7.3-12). He used this view to explain that he liked to design for a *'preferred state*' and to understand '*complex matters'*, and not necessarily to design for '*the market'*. He supported this by referring to his final Master project, in which he was exploring how to *'stimulate intuition'*, inspired by theory about improvisation in jazz music. When someone from the audience asked him what he meant with stimulating intuition, he expanded the topic (i.e. he showed the hidden related topics that were created in the other views) and elaborated on it.

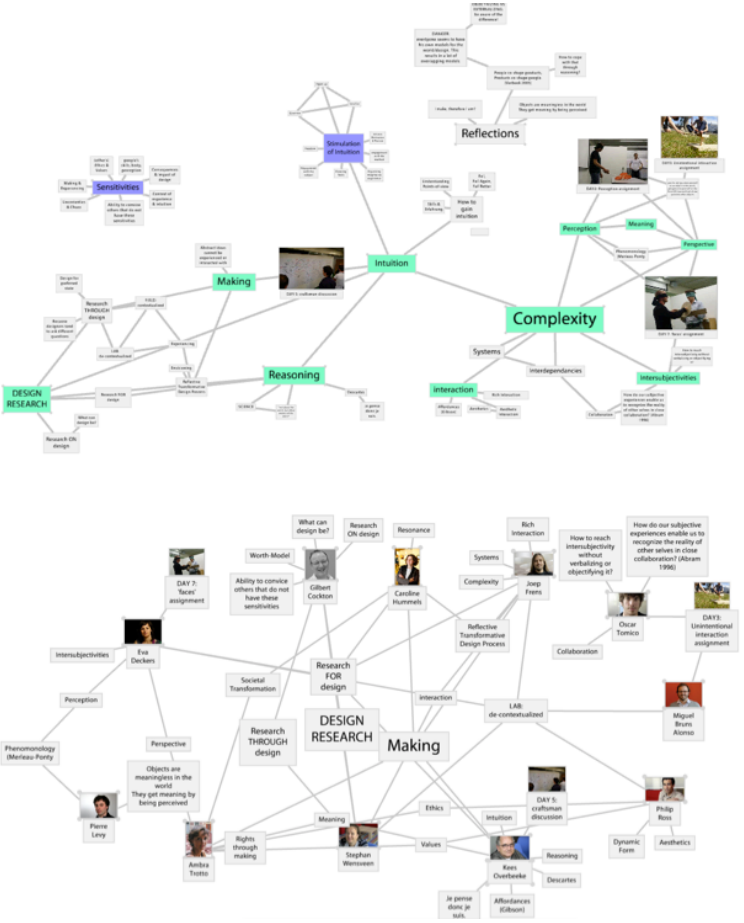


Figure 7.3-11: The first two views of S4.

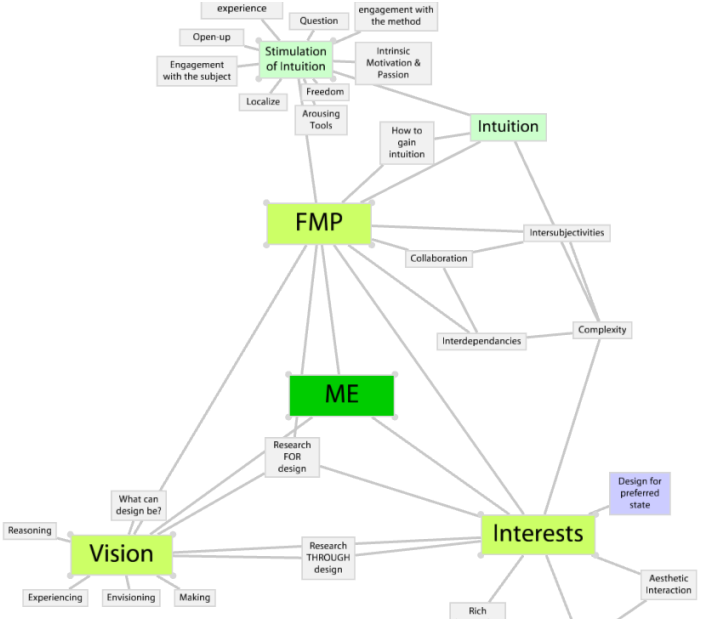


Figure 7.3-12: Part of the final view of S4.

S4 did not feel that Freed was a tool for explicit reflection: "*It's not so much for explicitly asking myself 'What have I learned?' "*. Instead, he called it a tool for gaining overview and exploring relations:

> *"Normally, when I am writing, thoughts pop up in my mind continuously and I end up with many separate pieces of text. Freed really helped me to beforehand think about the relations and how I thought about everything… It gives me the freedom to see structure."*

He explained that this was something that he clearly missed when trying to keep a blog during one of his previous projects.

He also referred to the importance of being able to hide content and to see multiple perspectives, which he missed when previously working with mind map software:

> *"Especially the differences between views give me the freedom to explore multiple perspectives… This is important for me because I like to work on complex projects, in which I have to puzzle the pieces together".*

He supported this by showing two additional views (not presented during the module) that he had created in Freed for his final Master project. One contained a mind map of several theories concerning intuition, and the other showed an overview of his sketches and explorations (Figure 7.3-13). He explained that when relating his specific design ideas (bottom-up thinking) to his more generic ideas about stimulating intuition (top-down thinking), he gained insight about the value of part of his specific ideas. He did mention that he missed the functionality to '*clone'* content: He sometimes wanted to have multiple instances of the same node in a single view, in order to directly compare alternative organizations side-by-side without needing to switch between views.

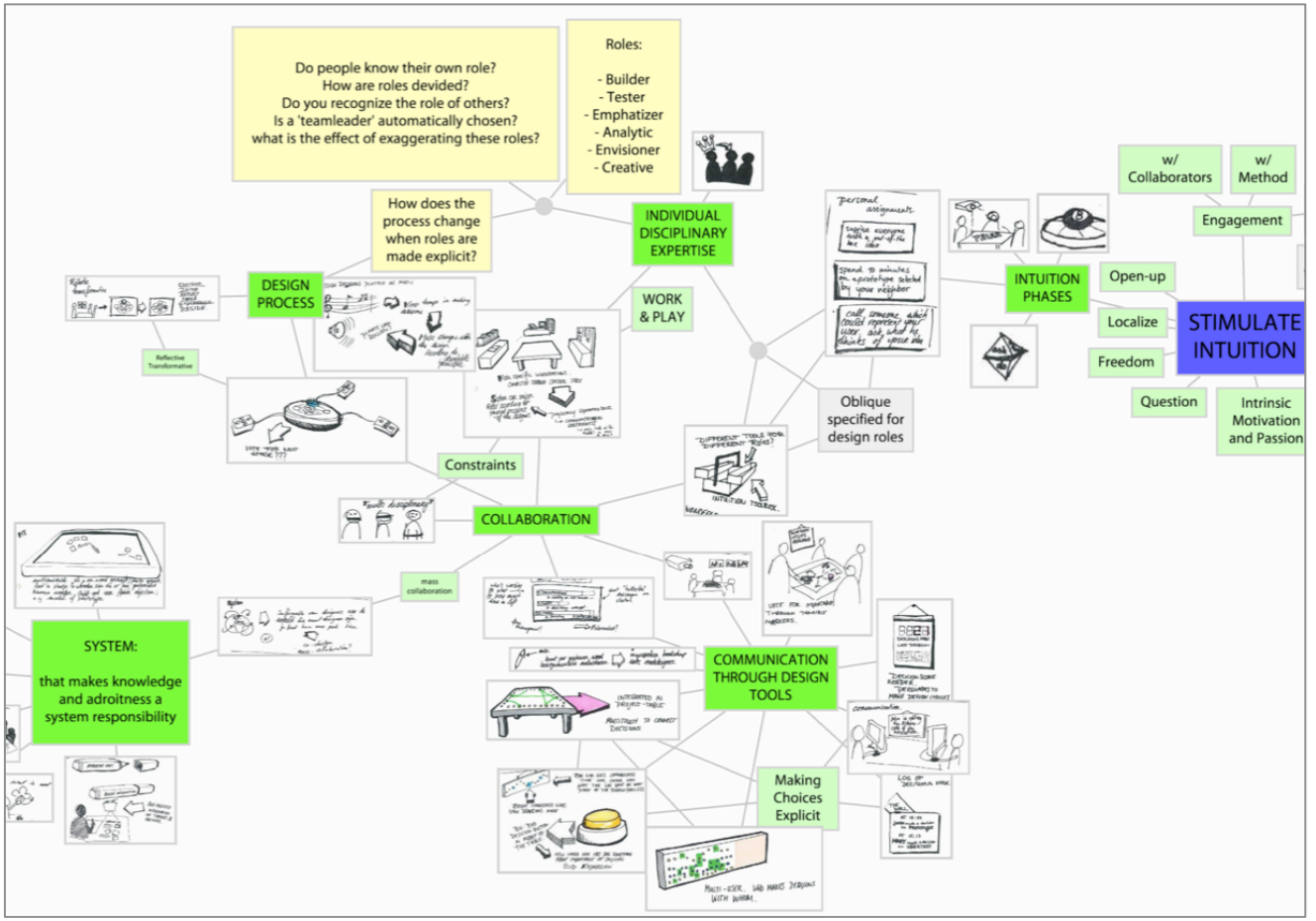


Figure 7.3-13: Part of one of the views that S4 created for his MSc. graduation project about 'stimulating intuition'. These views were not presented during the module, but were discussed during the interview.

Student 5

In her first view S5 created a horizontal chronological overview of the module (Figure 7.3-14:top). She placed discussed topics, (screenshots of) presentations and articles at the bottom of the overview. At the top she placed the photos of the design and interactions explorations that she had been involved in during the module. She mentioned that she would have liked to also add the explorations of other (groups of) students to the overview in order to compare it to her own work, but did not find the time for this.

The second view of S5 (Figure 7.3-14-bottom) was based on a session in which she together with other students used sticky notes to create an overview of the module. She explained that it was an advantage that Freed '*gave her the freedom to create relations between individual topics'*, but that the sticky notes were easier for creating an initial organization. Additionally, she thought that creating clear '*groups*' was difficult using Freed *and* using sticky notes. She therefore questioned whether it might be possible to create lines (i.e., clear boundaries) around selections of content in the software, perhaps on a separate layer. She also suggested that a (semi-) transparent layer on top of the content might be useful for emphasizing part of the view, mainly because she was not yet comfortable with the alternative: Hiding content or relations. This gave her the feeling that she *'lost them'*.

Figure 7.3-14: The first two views that S5 created.

S5 used the visual clipboard of Freed to copy selected content from her initial views into her final view (Figure 7.3-15). This view contained a network of examples of her own work (mainly images from previous projects), topics explaining her interests and opinions (blue) and related topics addressed by DQI (red). She loosely organized the work horizontally, showing at the left her *'vision on design*' and at the right her *'vision on designing*'. The former contained for example references to project topics and interaction styles, and the latter to design approaches and a specific tool that she created for visualizing the design process.

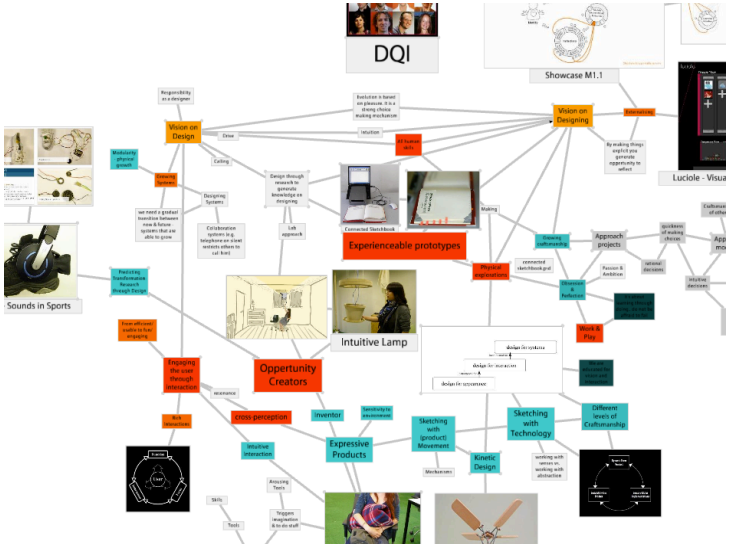


Figure 7.3-15: The final view of S5.

S5 explained that she considered herself to be more an '*opportunity creator*' than a problem solver, and how experiential prototypes had gradually shifted from being project outcomes to being tools for exploration. This required a new way of working which she called '*sketching with technology'.* She explained this did not only concern software and electronics, but that it also required a lot of physical design and interaction skills (Figure 7.3-16). She supported this with examples of her own work concerning '*expressive products'* and '*kinetic design'*.

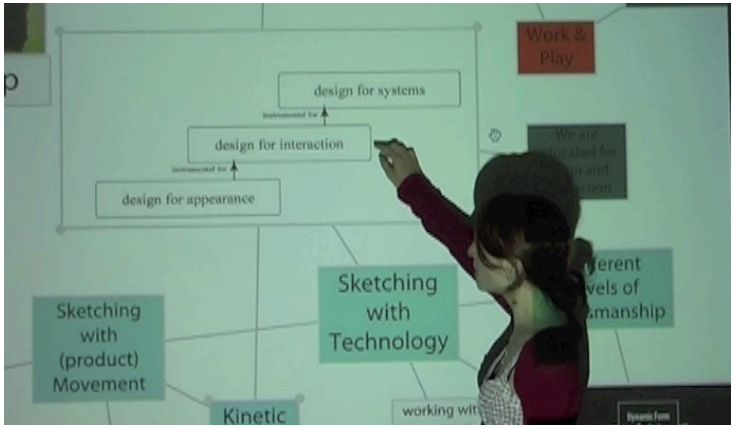


Figure 7.3-16: S5 explains what she means with 'sketching with technology' by relating it to a diagram from one of the articles that was discussed during the module.

S5 thought that it was '*difficult to say*' if Freed had helped her to gain *new* insights, but that it definitely helped her to name them, make them explicit, and to contextualize them. She described Freed as a '*mapping tool',* thereby mainly referring to the possibility to map her own work and interests onto the work of DQI. During the entire module she had various moments where she thought about her own work and way of working, but she explained that such thoughts are quickly forgotten if they are not contextualized like in Freed. Moreover, she explained that contextualizing these thoughts also triggers further reflection:

> *"If you document them and group them you attach new meaning to them. You expand them… I had an approximate image in my mind of what my story was about, but now it is more elaborate: It is not only that I like making mechanical products, I now better understand that this is related to the expressiveness of these products. My insights are grounded better".*

7.3.4 Conclusions

An integration of different organization styles

During this evaluation Freed was used as a tool for creating an overview of DQI work and related theories, as well as for giving a personal vision on these. Different techniques were used for creating the overviews: Most students first created a chronological overview of topics and activities of the module. Some of these used locked nodes or a path to make sure this organization remained chronological, and then added (force-less) relations between topics. Others first created a new non-chronological view before exploring relations. In these initial views the students used a lot of visual material, such as photos of the researchers, screenshots from presentations, videos from the explorations and frames from these videos (made with or without Freed) to contextualize the abstract topics, and added article- and presentation files for quick revisiting. The students valued Freed as a tool for creating a quick overview of visual work and topics, as well for showing the main relations between these topics. They also appreciated that they could switch between different ways of organizing (i.e. the different views), so that they could look at the work from a different perspective and focus on new relations.

A thin line between inspiration and information overflow

Working with Freed became more difficult when the amount of content and especially the amount of relations started to grow: This could lead to a chaotic layout (nodes obscuring relations, no clear groups/clusters) and information overflow (too much content, too many possibilities for creating relations). Some students indicated that the main challenge (and skill) is to focus on the most important relations. In many cases a new view was started when the current view became '*too complex'.* Additionally, multiple students expressed that exploring relations was less taxing if, in contrast to starting with a totally empty view, part of the structure or main topics of the view were already defined. This foundation could for example be derived from a chronological structure, from the sticky note

clustering session, from diagramming on paper, or from a selection of content copied/filtered from a previous view. In summary, a balance needed to be found between having enough content for exploring relations, and keeping enough order and simplicity for keeping overview *and* focus.

A balance between freedom and structure

Freed was appreciated for exploring relations and alternative organizations. It was therefore seen as a good intermediary between mapping main points using sticky notes or pen and paper on the one hand, and writing a reflective story on the other end. One student for example compared Freed to using sticky notes:

> *"We first thought that we were also going to reorganize the Post-its, but in the end there were so many that we did not do this".*

Both the force-based layout and the multiple view system were appreciated for their flexibility, but both also lead to occasional frustrations. The difference between hiding and deleting content was not always clear. In a few cases this led to students accidentally deleting content from their entire collection (all their views) instead of hiding it, despite the warning dialog. In other cases this same warning dialog was experienced as annoying when the students wanted to quickly delete an accidentally created relation or text node. Also, some students indicated that they did not like to hide content as this gave them the feeling that they lost it. The force-based layout occasionally led to chaotic networks, which triggered students to lock a lot of content. (Figure 7.3-17).

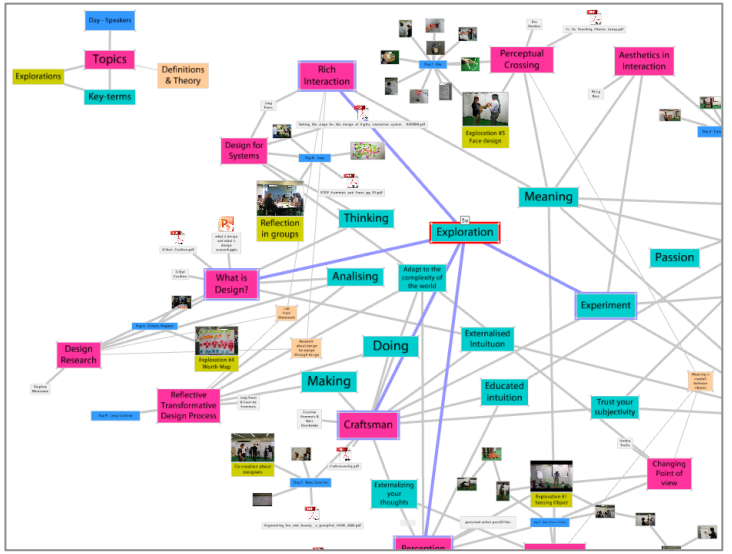


Figure 7.3-17: Part of one of the initial views of one of the students. He locked the main topics and activities on the outside of the views, and let the 'key-terms' float in-between (occasionally locking them to avoid overlap). He initially wanted to have a more flexible layout:

> *"I wanted to gain insight by seeing which clusters and which gaps emerged in the network, but of course this became impossible when I started locking all the content to create more order."*

These layout and multiple-view issues are partly related to the fact that the application was new for the students. Various students reported that they discovered features while working with it (the

clipboard, showing content by relation, minimizing content, the collection panel, force-less relations) and explained that it was *'surprising how fast you learn to work with it'*. Nevertheless, these initial frustrations are critical for software that needs to be used in demanding situations (a busy design process) for an activity that does not seem to come natural to most people (explicit reflection, stepping out of the immediate work). Therefore improvements need to be considered, such as having multiple views open simultaneously, having a 'home view' that includes all content, and finding a better balance between freedom and structure. The latter may for example be done by combining a force-based layout with hierarchies or groups, or by providing more and better visual organization and annotation features. However, care has to be taken, as several students explicitly expressed, that the application then does not loose its flexibility.

Presentation, identity and expression

Freed was not so much experienced as a tool for gaining specific insight, but mainly as a tool for putting previous thoughts into context, for coming to a more holistic understanding of material, and as a preparation for later (more focused) textual reflection. During the presentations the many topics, examples and relations in the views helped the students to improvise part of their story and invited questions from the audience, but occasionally also led to presentations with too little focus (e.g. without a main message or storyline). Freed did help the students to relate DQI work and associated theories to their own identity in various ways. Some students mapped their own development through the module material, some identified multiple dimensions or opposites in the module material and used these to map their own work and interests, and others created a more free network-style mapping.

The freedom of organization therefore allowed the students to express their identity in various ways. However, a crucial factor for expression seemed to be the inclusion of visual examples of personal or inspiring work (e.g., of previous projects). Not all the students found the time to do this in their final views, and the presentations of the students that did include personal visual examples felt not only more personal but also more focused and meaningful. In my experience, this is not exclusive to the 'spatial' reflection in Freed, but central to reflection in general. Personal expression can also be supported better by offering more and better 'visual features' (e.g. styling, annotation, illustration). However, several students mentioned that such features were mainly necessary for bringing more order (i.e. visual differentiation, making things 'look clean'), and that it is ultimately the content that makes things personal.

7.4 Collaborative reflection on design projects

7.4.1 Introduction

In February 2012 two colleagues, both designer-researchers, approached me to use Freed for creating an overview of student design projects. In this section I discuss how they used the software, with particular attention to the use of Freed for exploration.

7.4.2 Participants, intentions and procedure

Both designer-researchers (from now on referred to in short as 'researchers', R1 and R2) were doing their PhD projects in close connection to the educational theme *Wearable Senses*, which primarily concerns the interplay between electronics and textiles. Both had been heavily involved in setting up and coaching student projects in this theme, and in bridging these projects with various industrial, academic and other societal partners.

R1 just started the fourth year of his PhD project and his research concerned how interaction design concerning textiles and electronics could be used as a tool to develop meaningful products for the *sporting goods industry*. R2 was in his second year of PhD research, questioning how to design intelligent products and systems for *social well-being.*

The researchers reported that their general reason for using Freed was to create a *collaborative overview* of student projects in the Wearable Senses theme, and to *gain insight* in different project *topics* as well as in the *development* of these topics over time. Another goal was to create a *balanced selection* of projects for inclusion in a showcase booklet, which they needed for communication to various partners. A third researcher (R3, an assistant professor) was also involved in creating this selection.

I demonstrated the main functions of Freed (force-based layout, multiple views) in roughly 20 minutes to R1 and R2. They then decided to build the collection on the laptop of R2, because the software worked most smoothly on that (more internal memory). R2 therefore became the '*controller*': the main person who interacted directly with the software.

Within a timeframe of approximately one month, the three researchers had three meetings in which Freed was used. During these meeting the researchers also physically organized printed images of the projects. In-between the meetings R2 used Freed individually to map results from previous meetings and to prepare coming meetings. After a month I had a two-and-a-half hour loosely structured interview with R1 and R2 together, and a separate 30-minute interview with R3.

7.4.3 Overview of use

The researchers already had digital images of a large part of the projects, and a selection of these images was already organized per semester in eight folders in R2's file browser. They used this same chronological organization in their initial view in Freed: They imported the images per semester as clusters, and connected the clusters with a path (Figure 7.4-1). The other images that were not chronologically organized were dropped in the initial view on meaningless positions underneath the timeline-path. The researchers mentioned that for these projects they did not know the exact time. Finally, three topics were added that had an immediate connection to several iterations of student projects.

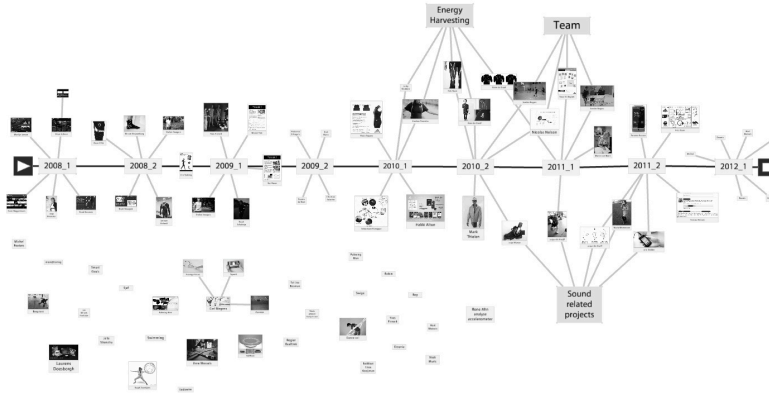


Figure 7.4-1: The initial view in which a path is used as timeline. Three topics are added that are related to projects from several semesters.

The researchers used their initial view as a foundation for creating new organizations in new views. R2's technique was to clone the initial view, and then add new topics and relations in the cloned view. This was useful because R2 knew the positions of the projects in the initial view by head. After creating the new relations, the timeline-path was hidden. The researchers mentioned that is was pleasant to then see the content move to new positions and to see clusters emerge. In the first week the researchers used this technique to create a new view with varying topics such as *Performance, Wellbeing, Social*, *Accelerometer* and *Lifestyle*. They commented that although some of these topics were related (e.g. Performance and Wellbeing), most of them were not, and that they mainly used this view as '*temporary working view'*, to explore new topics and relations (Figure 7.4-2).

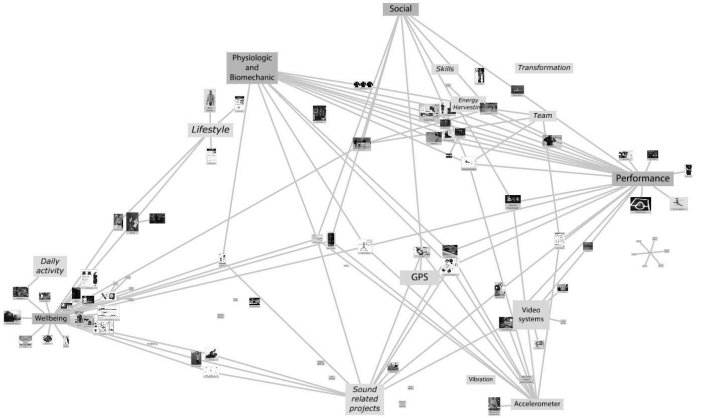


Figure 7.4-2: The 'temporary working view' in which various partly unrelated topics and their relations to projects were explored.

While organizing, the researchers were occasionally reminded of projects that were not yet in their collection. They then created temporary text-only nodes for these projects, or immediately looked up the images in their file-browsers or grabbed them from a related design report or portfolio website.

In the second week R1 and R2 had a three-hour meeting with R3 in which they created three views, each with a different category of topics. In the first view they clustered the projects based on various sensory modalities, the second view was based on different technologies that were used in the projects (Figure 7.4-3), and in the third view the projects were clustered by client (e.g. a company). One week later R1 and R2 had a meeting in which they created another view in which they clustered the projects based on whether they were Master or Bachelor projects.

In the third week R1, R2 and R3 had another three-hour meeting in which they made a *selection* of the most interesting projects, as well as an organization based on (partly) new topics for the showcase booklet. This time they were organizing physically using printed images, in order to work collaboratively as well as to move towards consensus about the selection and organization. They organized the images on the wall (Figure 7.4-4). A projection of Freed was present on another wall, and Freed was occasionally used to check the relations of specific projects that they were adding to their final selection on the wall. This was done in order to discuss why these projects were interesting to add to the selection. Some projects were for example interesting because they were very versatile (related to many topics), and others because they were very strongly related to one specific topic of interest.

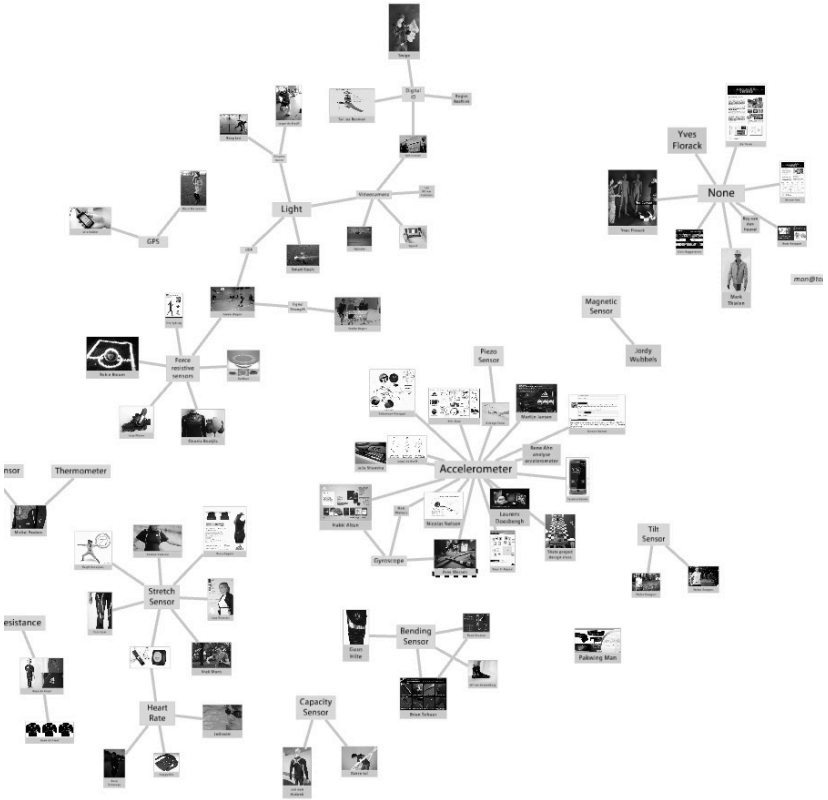


Figure 7.4-3: The 'technologies' view

Figure 7.4-4: A physical organization of printed images on the wall was used to move towards a final selection of projects and topics for the showcase booklet. A projection of Freed on another wall was occasionally used to check the previously created relations of specific projects, in order to discuss why these projects should or should not be selected.

After each meeting R2 individually 'integrated' various views, in order to be able to discuss the *relations between different organizations* with the other researchers in following meetings. He copied topics from one view to the other, and then moved the mouse cursor over these topics in order to see the hidden relations (Figures 7.4-5, 7.4-6, and 7.4-7). He for example created a view with all their selected projects, connected these to a node named '*selected',* and copied this node to other views in order to explore the versatility of the selection. He also explored how specific topics that they were interested in, such as *Performance* and *Wellbeing*, integrated with the various views.

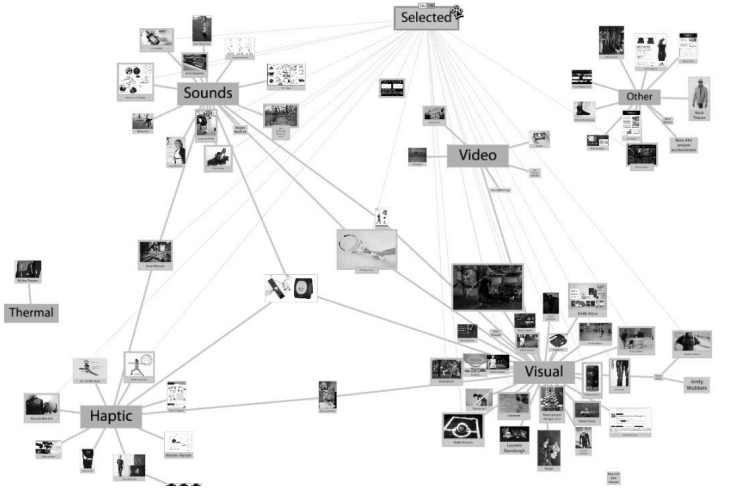


Figure 7.4-5: The selection explored in the context of the sensory modalities view

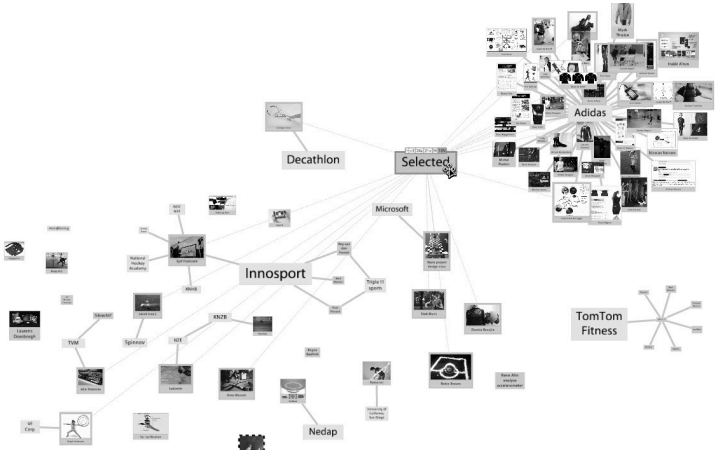


Figure 7.4-6: The selection explored in the context of the 'companies' view.

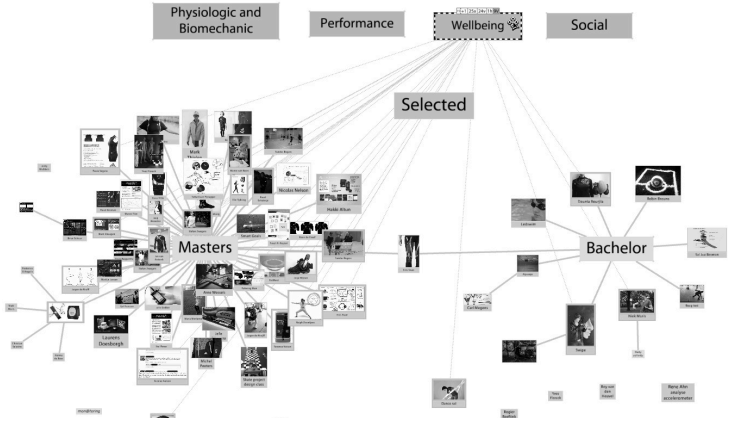


Figure 7.4-7: The topic 'Wellbeing' explored in the Bachelor-Master view.

The final organization on the wall contained more specific topics such as '*Energy harvesting', 'Team coaching'* and *'Lowering Threshold',* of which some emerged while clustering, but of which most were already known before. At the point of interviewing the researchers, there were still additional meetings planned for fine-tuning the topics that were defined on the wall. Their plan was to use these topics as main structure for the booklet, and to use the relations and topics that were explored in Freed as meta-data (i.e. tags) in the booklet. R2 translated the clustering from the wall to Freed, but did not yet find the time to integrate the topics with the previous views (Figure 7.4-8).

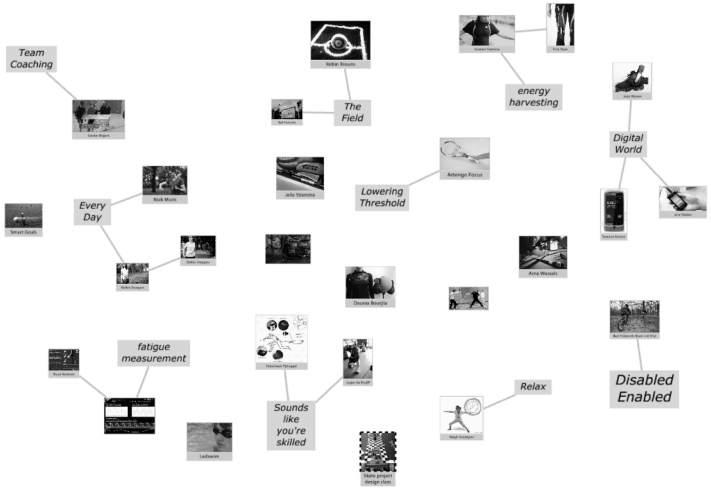


Figure 7.4-8: The topics that were chosen during the physical clustering session were translated from the wall to Freed by R2.

7.4.4 Overview and communication

Freed helped the researchers to gain overview of the projects. This was especially the case for R2, who in contrast to R1, was not yet teaching during the first three of the eight semesters of projects. He explained that at the beginning R1 immediately wanted to start with clustering the projects by topic, but that he (R2) first needed the time to explore the projects and to gain overview. Eventually, because he was most actively involved with Freed, the roles were turned around, requiring R2 to remind R1 what a specific project was about in terms of related topics.

While organizing the projects in Freed (projected on the wall) and discussing them, R1 and R2 explained the projects to R3, who only knew a small part of the projects. R2 mentioned that in this way Freed worked well for communication, as they could quickly zoom in on a project to explain it to R3, and additionally use the relations (related topics, related projects) to support the explanation. R3 acknowledged that the discussion using Freed helped to learn about the projects, but also mentioned that he occasionally needed to ask the others to slow down, because he was not controlling the software.

7.4.5 Exploration, discussion, reflection

R2 labeled the reflection that occurred during the meetings when relating projects to topics as '*basic reflection'*, particularly because many of the topics were either already known (e.g. '*performance*') or fairly obvious (e.g. a technology or company name). He labeled the process of integrating the different views as '*high-level reflection'*: This allowed them to explore how the different categorizations of projects were related to each other, as well as to explore specific projects in the context of different views.

R2 explained that exploring the selection of projects for the booklet in the context of multiple views helped to check whether the selection adequately represented the '*versatility'* (e.g. in terms of skills, topics, partners) of projects done in the Wearable Senses theme. This made them discover '*holes*' in their selection, and led to discussion about whether they should select different projects, why they left out specific projects, and if they perhaps required more projects.

Apart from creating a selection and structure for the showcase booklet, R1 and R2 were also exploring the direction for the final part of their PhD research. R1 stated that the focus of their research had changed over the years, and R2 added that through the overview of projects and semesters in Freed and through the discussions during the meetings they gained insight in this focus-shift. They for example explored the topics Performance and Wellbeing in their initial timeline-path view (Figure 7.4-9). They were expecting to see a gradual shift in project focus from *Performance* to *Wellbeing* over time, but found out that this was less the case then they had expected. This led to further discussion and exploration, during which another categorization was discovered: Some projects involved '*finished*' products, while others involved '*open tools'* or

'platforms' which allowed for a more gradual introduction of the product on the market.

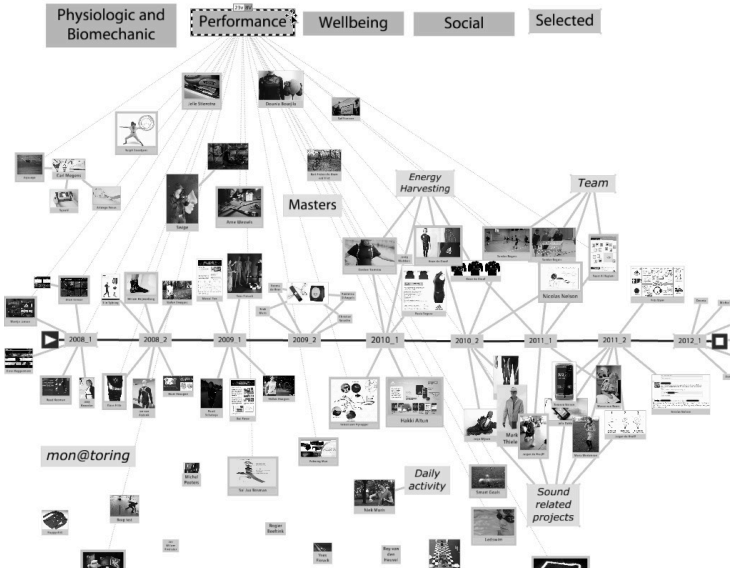


Figure 7.4-9: The topic 'performance' explored in the initial timeline-path view.

7.4.6 Possibilities for improvement

R2 missed the option to make the projects that are added in the current view automatically visible in the other views, especially in their initial view because they used that as a foundation for creating new views. He mentioned that being able to hide and show content per view was one of the strong parts of the software, but that he sometimes wanted to override this behavior and have the options '*show this node in all views'*, or '*always have this node visible in all views'*.

R1 and R2 experienced the animated view-transitions as important for understanding the rough differences between views such as whether there is a lot or little overlap, or whether the new view is an iteration of the previous view. They, however, would have liked to have direct manual control over the transition (e.g. sliding back and forth between views, rather than controlling the speed through the preferences panel). This would allow them to focus on more subtle differences between views, such as how the relations of a specific project or topic change.

R1 posed that it may be useful to have a modus in which projects can be organized on a dimension of topics, such as the dimension '*performance-wellbeing*'. R2 countered this by saying that this was already possible by locking all the content or by disabling the force-based layout. Both researchers were skeptical about adding functionality for creating weighted relations (i.e., to adapt the force or length of individual relations). R2 expressed that this would '*force him to express an intuitional weight into specific numbers'.* He was worried that working with weighted relations would make the software too specialized and that it would take *'the free out of Freed'*. He stressed that the strength of the software was that you could use it for '*your own things in your own way'*, for example for '*mapping your questionnaire results if you want to'*.

Finally, the researchers indicated that they would like to access the shared collection simultaneously from their laptops in order to use it individually in-between meetings, and to have an interactive projection that could be used collaboratively during meetings.

7.4.7 Conclusion: The nature of Freed

This case study showed the value of Freed as a tool for exploration, thereby supporting discussion and reflection. R1 explained that Freed helped him differently than expected: He was mainly aiming to use the software to document projects, gain overview of them, and present them, but along the way he noticed that it was a '*discussion and reflection tool*'. He elaborated:

> *R1: "The result is not the most important aspect of Freed. It are mainly the overview and the relations that develop in your head while organizing and discussing that matter."*

This case study also highlighted the differences between free and flexible digital organization and physical clustering. R2 defined Freed as a tool that allows you to temporarily explore a new perspective and take a stand during a meeting, or individually when preparing the meeting or reflecting on the meeting.

> *R2: "Freed can help to temporarily loose the group consensus".*

R1 added that physical clustering helps to quickly gain consensus among the group and make decisions due to the collaborative work on a relatively static organization, but that Freed helped to provide input for more dynamic discussions and for insight to develop gradually. Finally, R3 explained that with physical clustering sessions, there is often the intention to reorganize, but that this hardly happens in practice because it takes courage and effort to *'mess up*' the collaborative organization that is on the table. He therefore considered Freed to be useful as complementary to physical clustering.

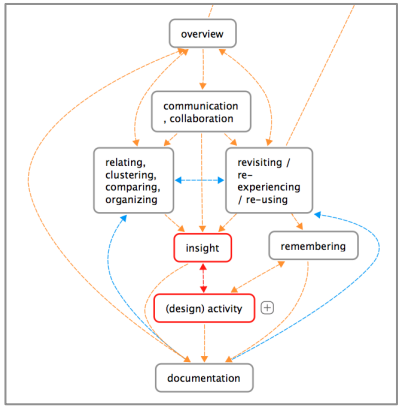
7.5 Personal use of Freed

7.5.1 Introduction

In this final section I briefly discuss how I used Freed, and other tools, for reflecting on my own research. I mainly used Freed at the end of the process, while writing this thesis, to gain overview of all the work that I had done. I first created diverse views of the design concepts and their relations, the functionalities and versions of the software, the various case studies, and literature and related work. I then used selections of content from these views to create a process overview, and used this overview to highlight the main topics (i.e. insights, questions) of my research. Finally, I created several views in which I explored the relations between the main topics.

7.5.2 Reflection on use

I was initially too much focused on creating a 'complete' collection in Freed, and used it too much as a thinking tool instead of a visual reflection tool: I for example created mind maps or diagrams with many topics and subtopics (e.g. '*what is reflection*?', '*what is overview*?'), mind maps with many notes from literature, and views in which I clustered and related many quotes from interviews. In these views, the abundance of text, the lack of images, the lack of hierarchy, and the movement of the force-based layout, made me loose overview. I experienced that Freed works best as a tool for creating overviews *of work* intuitively without trying to create a 'correct' or perfect diagram with accurate relations and descriptions. After realizing this, I started using Mind-Node, a mind map application, for creating more textual, hierarchical diagrams (Figure 7.5-1), and used Freed for creating more visual and explorative views (Figure 7.5-2).



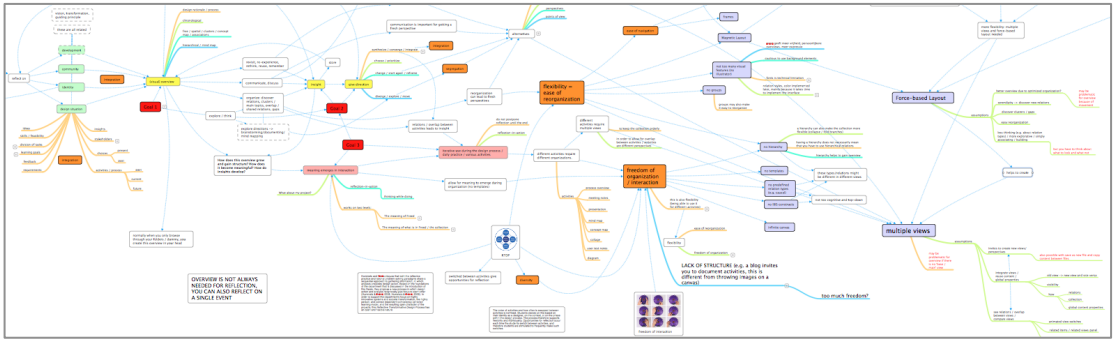


Figure 7.5-1: I used Mind-Node to create specific, hierarchical and textual diagrams.

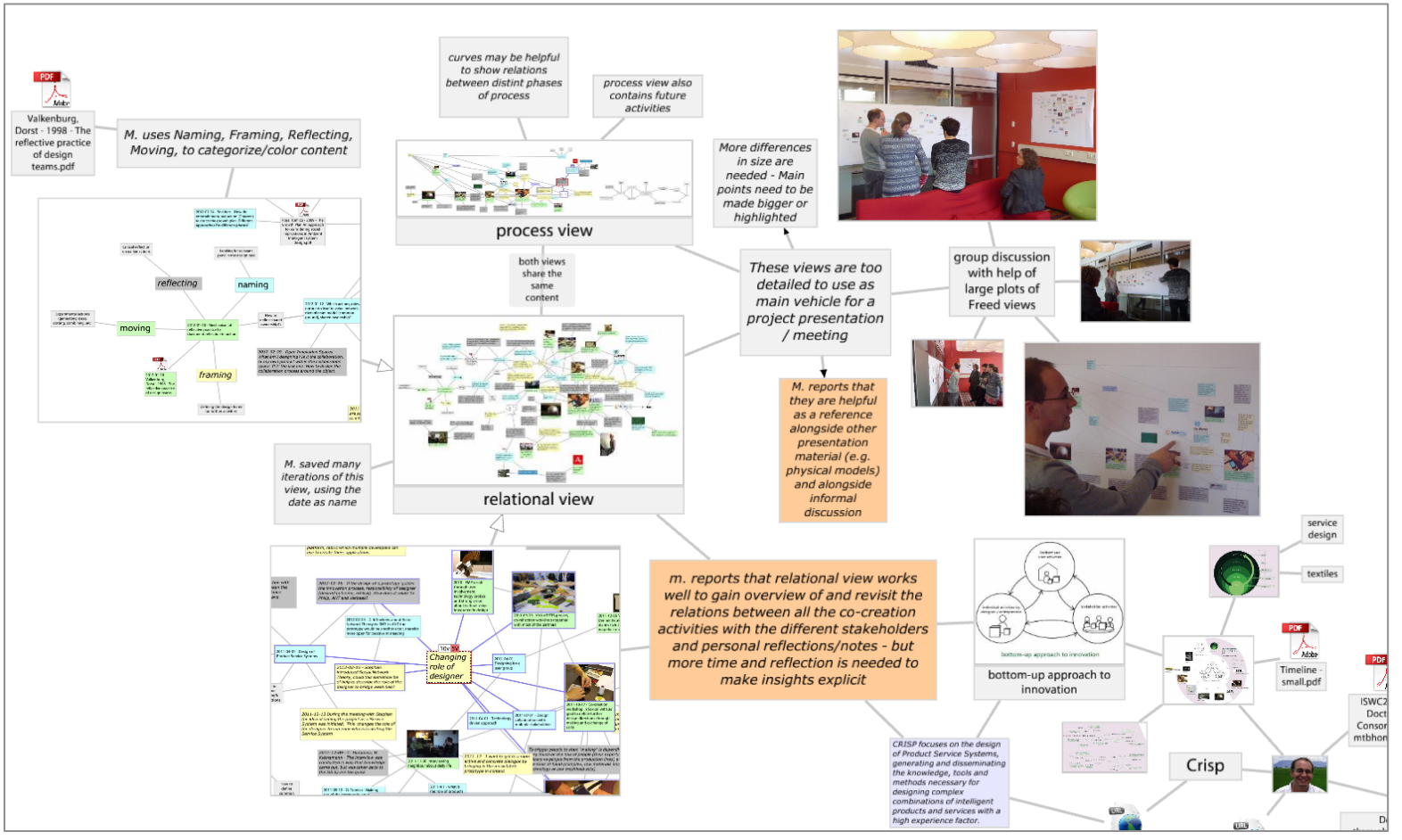


Figure 7.5-2: Freed was used to create visual overviews of work (mainly from the case studies) and related thoughts, feedback and files. It also includes (ongoing) work that is not included in this thesis, such as the case study that is shown in this figure.

Switching and previewing views

While my collection, and the amount of views, was growing, I increasingly often encountered situations in which I was adding or mapping content that was (perhaps) already part of other views. At this point, functionality to quickly switch back and forth between views, and to have multiple views open simultaneously (e.g., in tabs) was clearly missed. Additionally, a side-view was desired that (automatically) gives a preview of the context of selected or focused content in other views (i.e., without switching to other views). For example, when typing a new topic, it may give a quick preview of how this topic is related to other content in other views.

Integration with files and websites

On many occasions, I copied quotes or images from within documents or websites, and then added a link to (i.e., attachment of) the document or website. When later revisiting these quotes or images, I often needed to lookup their original context, and needed to open and search within the linked document or website, which broke the flow of using Freed. Functionality to directly preview the context of content within a document or website was desired. For video, this *was* possible: I often created screen-recordings while exploring a participant's collection, and added these videos to my own collection. While playing back these videos inside Freed, I used Freed's functionality to create snapshots of interesting parts and added notes to these snapshots.

Index view

The visual views-browser was helpful to gain overview of the many views in my collection. However, it lacked the possibility to cluster or show relations between views, or to show a hierarchy within the views. I for example often saved iterations of views, or created explorative views that did not work out well or that I did not follow-up on. These 'old' and unfinished views cluttered the views browser. Because I did not want to delete them, I 'skipped' (i.e. temporary hide) most of them. This is not ideal either, because I eventually forgot about them.

In order to solve these problems, I created an 'index view' (a standard view in Freed, no new functionality) in which I represented several of the main views, by copying a representative image from inside each of these views into the index view. I could then spatially organize and relate these images, and use them to click-through (i.e. switch) to the associated views by means of the related views panel. This temporary solution can be much improved, by making the index view standard functionality and giving it a fixed and easily accessible place in the interface (instead of sitting in-between the other views), and by making it possible to directly drag and drop view images from the views-browser into the index view.

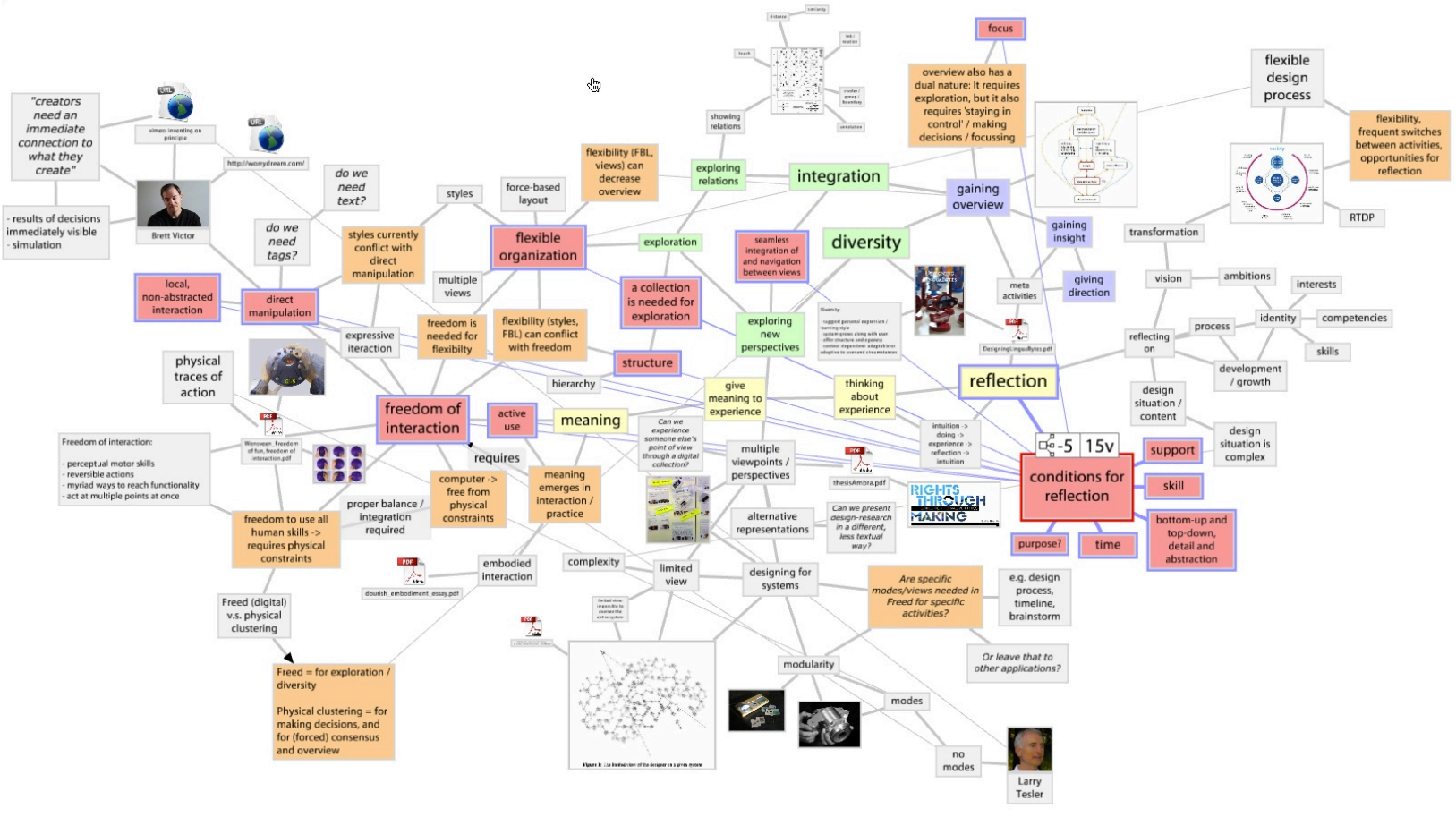


Figure 7.5-3. An example of one of the final views in Freed in which I explored relations between the main topics of my research. This led to a rough selection of 'conditions for reflection'.

Final reflections

Exploring relations between the main topics in the final views (e.g. Figure 7.5-3) helped to create a rough foundation for writing the final chapter of this thesis. Again, I noticed that it is better not to aim for an accurate selection or organization while organizing in Freed. I preferred to intuitively create an overview in Freed, and to explore the emerging relations and topics further in writing. Writing allowed for a more focused way of reflecting.

On the one hand writing gave more freedom, because relations could be loosely described using language, instead of using explicit lines in Freed. On the other hand it was more constraining, due to the linear structure. To make the writing process a bit more flexible, I used Scrivener for writing the first version of the final chapter. That is a writing tool that makes it easy to rearrange snippets of text (Figure 7.5-4).

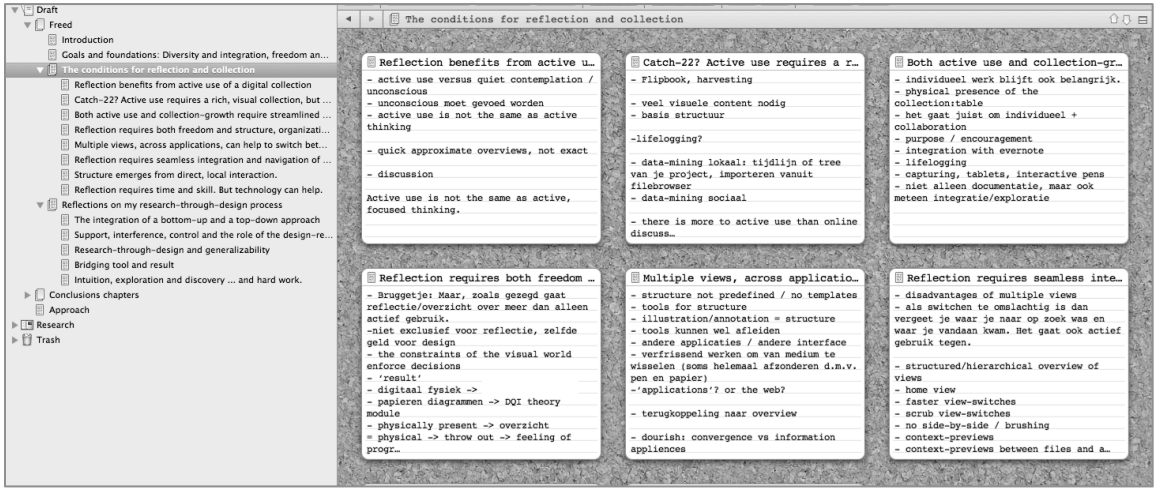


Figure 7.5-4. Scrivener helps to make the writing process more flexible.

8 Reflections

8.1 Introduction

In this chapter I reflect on this research-through-design project as a whole. First I summarize the goals of this project and the foundations of Freed. Next, I discuss what I have learned from designing, using, evaluating and discussing Freed, in terms of *conditions for reflection and collection*. Following, I shortly discuss possibilities for future work. I conclude with reflections on Research-through-Design.

8.2 Goals and foundations

This project started from two angles: On the one hand it started out of the personally observed and experienced need for a diverse but integrated digital collection that could serve as a means for reflection. On the other hand it started out of curiosity in *how* such a collection can come to be, develop and be used in daily practice. These angles are linked by the simple fact that in order to reflect by means of a digital collection, one needs to have a digital collection in the first place. Moreover, they are linked because reflection is not only an explicit activity that requires designers to step out of their daily design activities, but also an implicit, continuous process that is inherent to these activities (Schön, 1983).

I defined reflection as a process that helps designers to *gain overview of*, *gain insight in*, and *give direction to* their work. Freed was developed to explore the opportunities and challenges of creating and using a digital collection for reflection, in diverse contexts and for varying purposes. With Freed I aimed to support *diversity* and *integration*, or in other words: to facilitate the creation and exploration of multiple perspectives, as well as gaining overview of and exploring relations between these perspectives.

In order to do this, I emphasized *free* and *flexible* organization. At the start of this thesis, I defined *freedom* as the possibility to let structure and meaning emerge during interaction, instead of being imposed by the structure application. It can also be referred to as the openness of the application, or its ability to be appropriated and used in diverse situations. I defined *flexibility* as the possibility to easily reorganize and reuse work and to switch between perspectives on this work.

8.3 Conditions for reflection and collection

Freed was used in diverse situations: It was used for creating a research group presentation, for creating overviews of work during individual design processes, for creating personal views on design-research theory, and for designer-researchers' collaborative reflection on a collection of student projects. The fact that the application *could* be used in these diverse situations may be a basic indication of the potential of supporting free organization of designers' digital collections. However, in order to discuss the true

potential of free *and flexible* organization *for reflection*, a discussion of the similarities and differences between and within the diverse use-cases is required. In the following subsections, I discuss what is learned and envisioned in terms of *conditions for reflection and collection*.

8.3.1 Reflection builds on active use of a digital collection

During the various use-cases Freed was foremost experienced as a tool for '*gaining overview*'. One way of gaining overview is by *making an overview:* Participants explained that Freed contributed to this by making it fast and easy to create rough, initial spatial organizations of images, text and relations. This was often attributed to specific features of the software, such as the possibility to include a lot of visual content, to import multiple files at once, to quickly add text, the fast way of creating (multiple) relations, the zoomable unconstrained canvas and the force-based layout.

However, gaining overview is much more than seeing content together in a single view: *It is a process that develops through use and over time*. Just as designers get a better overview of the situation through a process of continuous information gathering (e.g. by creating and evaluating prototypes), Freed helps to gain a better overview by using it in context: For example, the presentation that was created for our research group contained multiple overviews of related people, projects and topics, but the main process of *gaining* overview came from *actively building and discussing the overviews* and from *revisiting and discussing the content inside* the overviews.

The designer-researchers that used Freed for organizing student projects mentioned that the '*result is not the most important aspect of Freed'* but that it were mainly *'the overview and the relations that develop in your head'* while organizing and discussing the projects that mattered.

Several students that used Freed to reflect on the design theory module expressed that the main benefit of Freed was to actively organize and revisit the topics and activities of the module in different views, such as chronological, categorical and personal views, and to present the views to each other. Finally, some of the students that used Freed to create overviews during their design projects expressed how reflection was often unintentional and *triggered by other activities*. For example documenting new work into a process overview triggered them to revisit previous work, think about the relation between the new work and the previous work, and to explore future work.

This brings me back to the following quote, as previously discussed in chapter 3:

> *"Key to providing a structure for reflection is being aware of the purpose of that reflection and guiding thinking to that end: having no clear purpose then might limit technology only to (providing time for and) provoking reflection - not to structuring and encouraging it. In this way opportunities for reflection may be lost."* (Fleck and Fitzpatrick, 2010)

Freed can support various 'purposes' of reflection, such as thinking about process, development, identity, vision and community, but the

actual purpose lies in using the collection. This *use* helps to make time for reflection and to become skilled in it. It does not *'guide the thinking*' of designers, but rather facilitates it by enabling them to actively use their digital collections.

8.3.2 Active use benefits from having a rich, visual, integrated collection

Having an existing collection of topics, visual content (e.g. images, videos), as well as a collection structure (e.g. relations, spatial organization), supports active use. For example, the design-researchers that created overviews of student projects already had a large collection of images, and they used the chronological organization in their initial view as foundation for creating new views. The students of the design theory module had a collection of visual content and topics from the module to construct their initial views with, and used these views as foundation for creating new views. Using Freed became more difficult when creating new empty views, and when using a lot of text without images. In general, images were experienced as important for keeping overview and as inspiration for organization, discussion and reflection.

However, this rich, visual collection is not always directly available: It needs to *grow* through active use, and this requires integration and, besides individual work, also collaboration. Creating the presentation of our research group helped to build a collection, but could have benefited from having an existing group collection, or individual collections of group members. Vice versa, the group members that individually worked with Freed could have used a group collection to provide content or structure for organizing their own work. Similarly, many of the 'personal views' of the design theory module students could have benefit from a better integration between personal (e.g. project) work and content of the module, in order to better express their identities.

8.3.3 Reflection requires both freedom and structure

As discussed, Freed was mainly defined as useful for gaining overview, by creating overviews and by actively using the collection. But what is overview? In some cases overview helped to *gain* insight, but overview mainly included previous insight. Overview was described as overseeing a complex situation, understanding it in a holistic way, and not overlooking or forgetting important aspects. It referred to knowing which aspects are at stake and how they are related, but also which aspects are still missing (e.g. a planned activity) and which relations still need to be explored (e.g. a reminder for later reflection). But overview seemed to concern more than knowing what's at stake and how aspects are related: It also has to do with understanding the relative importance of aspects and being able to focus and progress.

This dual nature of overview, and in my definition, of reflection, can be exemplified by the case study of the designer-researchers who organized student projects. They used Freed to actively explore alternative spatial organizations, categories and relations. In addition, they physically clustered printed images of the projects.

Clearly, the latter allowed them to work simultaneously and collaboratively, which Freed did not support, but there was also another difference: The physical and social constraints of a physical, collaborative collection enforce decisions and group consensus, and help to move towards a *result*, or a *fixed structure*, while using Freed was '*not about the result*' but about the process.

Additionally, several students that used Freed during their individual projects explained that they would be motivated to use Freed more if it would lead to real *results*, such as clear diagrams for inclusion in a report or for discussion during a meeting. One of the students mentioned the importance of physical results, such as printed work, not only for physical presence and communication in the workspace, but also because it gives a *feeling of progress.* Finally, one of the students of the design theory module named the fixed nature of physical diagrams and drawings as an advantage over digital ones, because it gives a feeling of closure.

In conclusion, structure can be provided by the *tool*, and as discussed in the previous subsection, by the *collection*. Freed is all about exploration and provides little structure, although it does invite to create explicit relations. Its multiple views can help to balance freedom and structure to a certain extent: One view can for example serve as a structured, abstracted, filtered or annotated version of the other. For example, during the design theory module several students created new, partly overlapping views when their current views became too complex. The views themselves can also provide structure: While creating the presentation for our research group the views represented the main presentation topics that were defined in advance. This top-down style of working was merged with a more bottom-up-style of working within each view, and eventually allowed use to weave the main topics together by means of examples and relations. Still, Freed does not enforce decisions, due to the multiple views, the ease of reorganization, and the lack of hierarchy. It can be used as complementary to techniques that do enforce decisions, such as digital mind mapping, illustration, physical clustering, and writing. How these various techniques and the associated collections can be integrated will be discussed in the future work section.

8.3.4 Structure emerges from direct, expressive, local interaction.

One of the foundations of this research, as discussed in chapter 2, was the notion that meaning emerges in interaction. Still, I was initially too much focused on the global structure of the collection, such as the relations that develop when reusing content across views. I now think that the global structure is foremost support, and that the true meaning is in how the collection is *used* locally. The main reason for this has already been discussed in the previous sections. Freed is not about the resulting structure, but about exploring, revisiting and discussing the content. A different reason is that focusing too much on the global structure distracts from these activities. I will elaborate below.

The first prototype (The Magnetic Collage tool) did not have explicit relations. Relations and the force-based layout were added to Freed to support easy spatial reorganization, and not for defining an ‘exact’ or ‘correct’ structure. Relations were also added to make it easy to explore and reuse content across views, or in specific: To ‘expand’ nodes and to explore hidden content by relation. I therefore defined relations as global entities that exist across views. This seemed the sensible thing to do from a standpoint of global flexibility and clarity, and this is also what is done in most applications that feature *multiple coordinated views* (Roberts, 2007): The views are different visualizations of the same dataset and changes are automatically coordinated across views (so that the effects of a change are immediately visible).

However, global structure and automatic coordination can lead to problems. While creating the presentation for our research group I quickly found out that some relations needed to be visible in one view and not in the other. This could be solved by creating functionality for hiding relations. This functionality is, however, not problem-free: Users need to understand and get used to the conceptual difference between deleting (global) and hiding (local). Automatic coordination can lead to confusion and frustration (e.g. accidentally ‘messing up’ other views), especially because views in Freed are not simultaneously visible. It for example required me to create a confirmation dialog that shows images of all the views that are affected when a user deletes content and relations. However, sometimes users were confused that items were not automatically visible in all views. In short, how to deal with global structure and coordination is a complicated problem because it is very person and context-dependent.

Besides the visibility of content and relations, other differences between views were needed, such as the style of specific relations (e.g. direction, arrow), the style of specific content (e.g. text background color) and sometimes even slight changes to specific text. I added functionality for creating global ‘styles’ that allow for automatic coordination of changes across views, and functionality for setting local styles and properties that could override the global styles. This may seem to be ‘flexible’ as it allows for easy global adaptation of appearance as well as for local variation (e.g. similar to what CSS does for websites). The problem is that these options usually require indirect interfaces (e.g. menus, property panes), lead to conceptual difficulties, and impose *thinking* about global structure.

These problems distract from what really matters: Direct *interaction* with and *use* of the collection content. I believe that structure should emerge from direct, expressive local interaction. This will become especially important in complex systems of multiple products, applications and users, in which the global structure is impossible to oversee, only partly accessible, and continuously changing.

8.3.5 Using a digital collection for reflection requires time and skill.

Even though some users expressed that it was surprising how fast they learned to work with the main functionality of Freed, it does take time and skill to reflect by means of free and flexible organization. I for example personally experienced that I tried to overuse Freed, and it took me a while to learn not to use it for creating specific diagrams, or as a tool for mapping topics without actual examples of work to reflect on. It is also a challenge to find the right level of detail. For example, clustering a lot of interview results in Freed did not help me: It took a lot of time and it brought more chaos than overview. And finally, as with design itself, a balance needs to be found between diversity and integration, and between freedom and structure.

8.4 Future work

8.4.1 Collaboration and design practice

A crucial direction for future work is to explore how individual and collaborative collection and reflection interact in a shared system. A system is needed that allows for the integration of individual work, online collaboration, and co-located collaboration. The advantages of such a system seem clear: It provides opportunities for integrating, experiencing and discussing each other's work and perspectives. However, it will be a challenge to find a balance between individual freedom and a manageable collaborative collection.

A collaborative system will also be needed to explore collection and reflection in design practice. As described in chapter 3, the need to reuse prior design knowledge for reflection purposes and the need for more integration and exploration of digital collections are also observed in design practice (Keller et al., 2006; Herring et al., 2009; Bales & Do, 2009; Sharmin et al., 2010). However, designers in design practice are in general more specialized than the students and designer-researchers that participated in this research, and their projects are likely less explorative. Additionally, there is more teamwork. This will all have implications on the collection and reflection process, and therefore requires further research.

8.4.2 A system of diverse products and applications

Freed is a research prototype and not a fully optimized and fully featured product. It for example does not run on mobile devices, it is not lightweight enough (in terms of memory-use) to run in the background next to other heavy applications, and it has a relatively long start-up time. It is therefore by no means an always-on-always-available documentation tool, such as a physical notebook, or such as modern note-taking and collection software that feature mobile apps for taking and importing pictures, text recognition and cloud storage.

Perhaps the most ubiquitous of these applications, Evernote, is currently releasing a new product together with Moleskin, a manufacturer of high-end (designers') notebooks. This 'smart notebook' allows for easier capturing (photographing) of physical notes and sketches and makes it possible to link physical and digital information. Another relatively new product, the Wacom Inkling, is a special pen that digitizes your notes and drawings while you work on standard paper or in standard notebooks. Other smart pens such as the Livescribe pen allow for linking physical notes with audio-recordings.

Finally, perhaps the most important development of all: Tablets are making on-screen drawing and note-taking more affordable and widespread. These developments will play an important role in streamlining documentation, the integration of digital and physical work, and visual expression. Freed can still be improved a lot regarding the latter. For example, instead of how paths are currently implemented, it may be better to let users draw simple lines and shapes (as in handwritten diagrams) and drag and arrange content on and in these lines and shapes. However, Freed should not loose its flexibility. It should not become a diagramming, illustration, writing or blogging application.

A system is needed in which diverse physical products, such as the concepts discussed in chapter 4, and diverse software products work together with a shared digital collection. It is therefore necessary to think about how these different products can share and integrate information, or in other words: to stretch the concept of 'view' across products. This already partly exists: It is the structure of the World Wide Web, with all its hyperlinked webpages. But it is also much more than what currently exists: A large part of the internet lacks diversity and rich interaction. With the exception of relatively isolated plugins (e.g. Flash, Java, Unity) everything looks, feels and behaves the same. But times are changing: Although they are not yet able to provide the same experience as 'native apps', web-technologies such as HTML5 and JavaScript start to enable rich, diverse experiences that still allow for integration.

Freed can benefit a lot from a more web-browsing like experience: It is currently not possible to have multiple views open at the same time, and this makes it difficult to quickly compare views, compare content across views, switch back and forth between views, and copy content between views. Having the possibility to open multiple tabs, each with its own visual history of visited views and back and forth buttons would be highly convenient, as well as functionality for creating direct links between (locations in) views, and for searching within views.

Having the possibility to compare views side-by-side (i.e. split-screen modus) and to use 'brushing' (automatic highlighting of focused or selected content across views) may be useful on large high-resolution screens or projections, but may prove to be inconvenient on smaller screens (e.g. a laptop or tablet). On these smaller screens, it will be more useful to be able to quickly preview the context of content in other views. These context-previews can act as *portals* to other views (Figure 8.4-1), and may be associated with a search function, such as the 'Instant Previews' of Google Search.

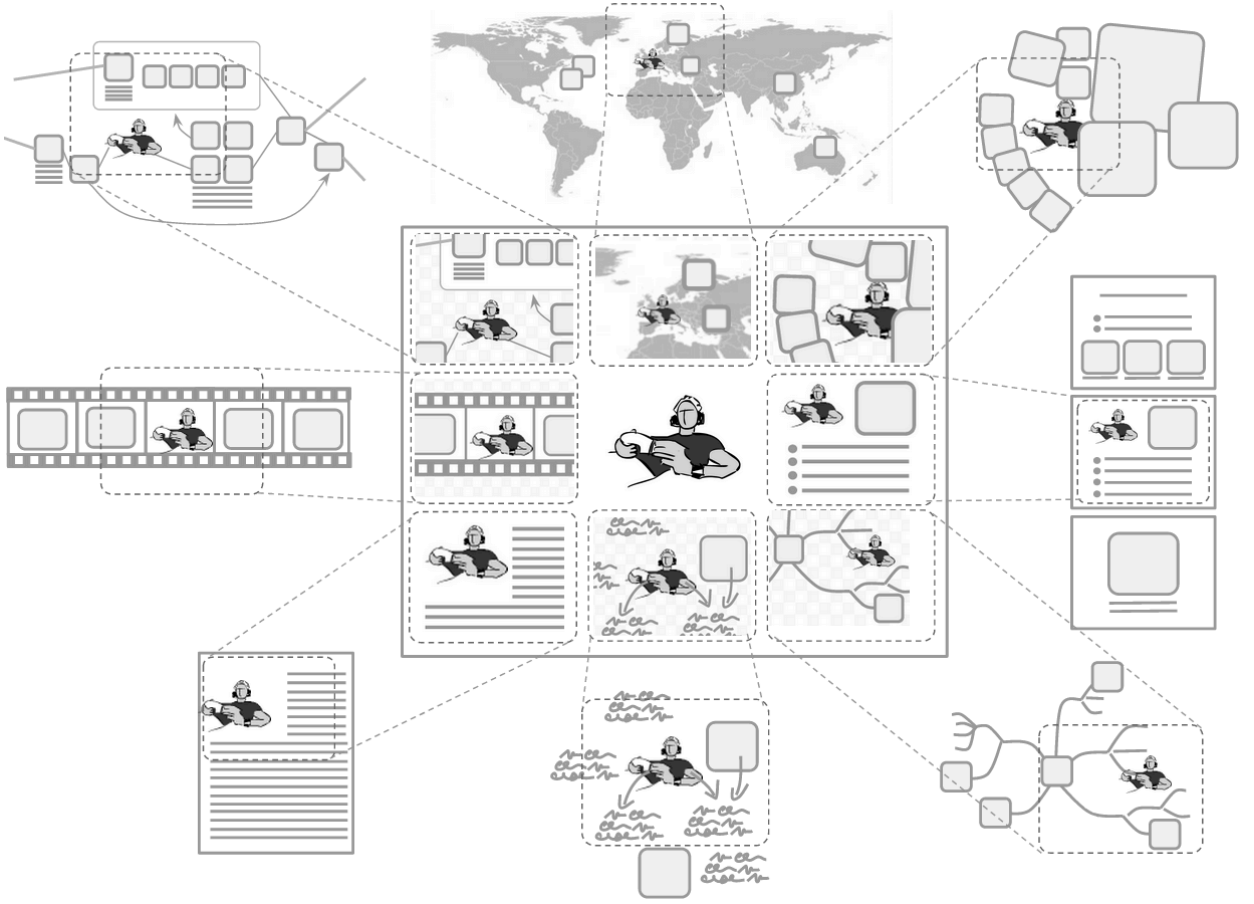


Figure 8.4-1: The concept of 'view' needs to be stretched across products and applications. It will helpful if the context of content in other views can be quickly previewed, and if these 'context-previews' can be used to navigate to the other views.

8.4.3 Towards a better understanding of reflection

This research was a first exploration towards understanding how designers can use their digital collections for reflection. I defined design as a process of active *exploration* that helps to *gain insight* in the design situation, and discussed how a software application can help to create *overviews* of this process and situation and how it can be used for *exploration*, and that this active use of the software can help to *gain overview of* and *insight in* the design process and situation.

Overview and exploration play a role in *reflection*, but much can still be learned about this relation, how they help to form *new* insight and overview, and how these are used to *direct* design action. These questions require a better understanding of the relation between reflection and action, of how to digitally represent design action, and how to capture reflection.

The images and topics in Freed help to revisit actions and directions, not only results, and therefore the software supports reflection *on action.* However, as previously discussed, more freedom of expression (e.g. drawing on tablets), as well as more use of video, may help to better represent design actions and directions. Freed also helps to reflect *in action*, through active use. However, there are still many opportunities for improving structural use of a digital collection during the design process (e.g. while sketching, building or experiencing prototypes, discussing), and this will likely require more than a (single) software application.

Finally, to better understand the relation between reflection and action, the use of tools such as Freed needs to be studied more structurally and closely as part of the design process, and as part of dedicated reflection sessions. I will briefly return to this point in the next section, which concerns the Research-through-Design process.

8.5 Research-through-Design

8.5.1 Integrating a bottom-up and top-down approach

Designing for the integration of diverse activities, such as individual reflection, collaborative reflection and related activities such as documentation, (process) visualization and (informal) presentation, is a huge challenge. Inevitably, some focus is needed. The difficulty is to focus without loosing a holistic view of the situation, and without neglecting the dependencies between the activities. Moreover, it is difficult, or perhaps impossible, to understand the full scope of activities and their dependencies in advance, especially in the context of complex, dynamic systems (Frens & Overbeeke, 2009). The question is, then, how designer-researchers can best approach these complex situations.

In chapter 4, I discussed how I started with naming various activities, designing concepts based on these activities, and why I focused on software. On the one hand, this was a choice for integration: The software tied the various concepts together. On the other hand, it was a choice for diversity: The software could be used by many designers individually, to work on their personal collections whenever they needed to, without being constrained by a collaborative interface and process.

The plan was to explore collaborative collection, and the integration of diverse individual collections, later in the project. In practice this was difficult, due to challenges involved in supporting individual reflection and related activities (as discussed in the previous section), and the complexity involved in making the software. A more parallel exploration of collaborative and individual reflection, allowing both to support each other, would have been preferred.

From these experiences I conclude that, in line with Hengeveld (2011), designers should use an integrated bottom-up and top-down approach to systems design. Ideally in a team-project, using a bottom-up approach, dedicated (interface) prototypes are designed and evaluated for each activity. Additionally, using a top-down approach, the integration of the prototypes and information (e.g. collection content) is explored. This will help to balance diversity and integration, and to gradually bring focus to the design(-research) project.

8.5.2 The role of the designer-researcher

In this research I have made use of case studies, in order to explore reflection in context. Alternative approaches, such as controlled experiments on specific features or comparisons of one tool over the other seem to narrow: Controlling for individual differences seems to be nearly impossible, and specifying tasks does not match the nature of creativity (Shneiderman & Plaisant, 2006).

During the case studies I actively discussed Freed with the participants. This is crucial, because it allowed me to explain and adapt the system when needed, but moreover, because it helped

me to reflect on my own goals and assumptions. Freed thereby acted as a 'physical' hypothesis (Frens, 2006). During most case studies I did not push participants to use Freed in a specific way and they were free to use other tools. This helped me to learn about the relation between reflection and other activities, the relation between Freed and other tools, and the differences between participants. On the other hand, a more active role, for example by supporting part of the collection and integration process, and by facilitating reflection sessions, could have helped to learn more about (collaborative) reflection.

From these experiences I conclude that designer-researchers should take an active and flexible role in evaluating (information) systems during case studies. They should let participants use a system in daily practice, according to the participants' own goals and preferences, but they should also provide active support when needed. This support goes beyond explaining and adapting the system: It includes facilitating the activities that are of main interest, by taking part in other activities that they depend on, and by organizing or accompanying sessions during the process. This inevitably means that the process that is researched (e.g. reflection and its relation to collection) is influenced by the designer-researcher, but this a trade-off that has to be made depending on the specific case.

8.5.3 The need for better tools

I started this thesis with a quote from Bret Victor:

> *"My guiding principle is that creators need an immediate connection to what they create".*

He uses this principle to design tools that allow creators to instantaneously explore the effects of their ideas, such as animation tools that allow animation to be acted out and recorded rather than created indirectly through timeline animation, live coding tools in which changes to code result in immediate visual feedback, and simulation tools in which time can be paused, rewound and projected on space, allowing one to instantaneously see the (future) effects of actions.

Unfortunately, the gap between idea and feedback is still enormous in most software development environments. I have personally spent a lot of time programming interface elements and loading 'assets' (in stead of drawing them), setting up and compiling projects, and struggling with buggy visual interface builders. These tools should become more experiential. It should also become easier to create the 'back-end' of an application (e.g. storing and sharing information), so that designers can focus on interaction: Designers of interactive systems need a flexible (test-) platform for sharing and integrating digital work, which can be used to experiment with prototypes (such as Freed).

8.5.4 Intuition, exploration, discovery ... and hard work.

Now, at the end of this thesis, I get back to the quote of Jonathan Blow at the start of this thesis. He described the design process of his award-winning independent computer game Braid as an amazing design experience and a process of discovery by playing with his initial ideas and prototype:

> *"It's like sitting on top of a gold mine and that you don't really have to dig, but just scoop some dirt aside and there is like a little chunk of gold, and then scoop some more dirt… The most laborious part of the process is picking up these heavy chunks of gold and moving them…"*

So was this the case for designing Freed too? Not entirely. I *am* a big believer in early ideas and intuition. But these early ideas are rough and full of doubts. They need to be made experiential. Highly interactive prototypes are indeed essential in this process. They are tools for exploration. In previous projects, they allowed me to explore what it means to play an audio-only adventure game, or to explore what happens if your projected silhouette dynamically adapts to your movement. Also in this project Freed allowed me to 'play' with free and flexible organization and explore what it means to use a digital collection for reflection.

These explorations showed that free and flexible organization is only part of the digital collection and reflection process. Supporting activities that do not come natural to most people, during busy design practice, is something else than designing entertainment products such as an audio-only adventure game or an interactive dance installation. So to get back to the quote: Besides scooping, this project required a lot of digging and moving. Additionally, I needed a better shovel. I think I will design one, but not today. I need some time to reflect, and a new perspective.

Appendix 1: Force-based layout

In chapter 5.3.2 the force-based layout mechanism of Freed was introduced. Here more details concerning its implementation are given. Its main setting is *distance between nodes*. This setting is constrained between 0 and 400 pixels, and defaults at 120 pixels. To put this in perspective: The default width and height of a new text node are 150 pixels, and a new image node is scaled proportionally so that its area is 150 * 150 pixels.

The second main setting is *distance between clusters*, which helps to let clusters emerge: Nodes with many relations will be placed relatively far away from other nodes with many relations, and similarly, a node with only one or a few relations will be placed relatively close to its related node(s). The distance between clusters value is constrained between 0 and 200 pixels, and defaults at 40 pixels.

Both main values are used for computing a specific *desired distance* for each pair of nodes. The nodes will try to repulse each other if the distance between them is smaller than their desired distance, and will try to attract each other if they are related and the distance between them is larger than their desired distance. Only directly related (i.e. adjacent) nodes attract each other: no attempt was made to use the graph-theoretic-distance for computing desired distances between indirectly related nodes (see Kamada & Kawai, 1989).

To compute the *desired distance* between a pair of nodes, the following functions are used (in pseudo-code):

```
K = minimum(amountRelationsNode1, amountRelationsNode2) – 1;
K = maximum(0, K);
desiredDistance = distanceBetweenNodes + K * distanceBetweenClusters;
```

For example, when using the default settings, the *desired distance* between a node with five relations and a node with eight relations is:

```
120 + (minimum(5,8)-1) * 40  =  120 + 4 * 40  =  280
```

The exact values are hidden from the user, because it are mainly the relative values that matter (Figure 1).

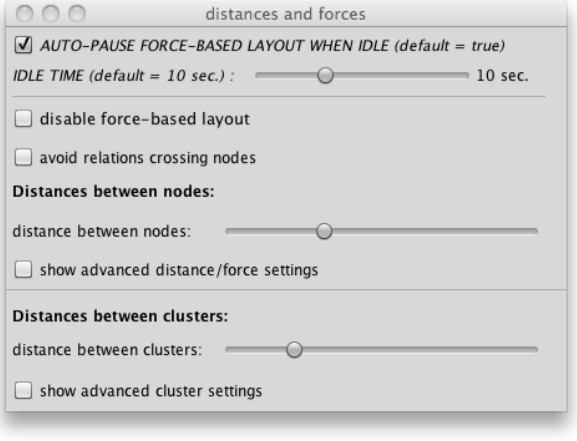


Figure 1: The distances and forces panel

Because nodes in Freed can have very different width/height ratios, a simplified model for computing the approximate distance using imaginary circles around each node was disregarded. Instead, the actual distance is computed for each pair of nodes. Depending on the relative positions of the nodes, this will be the distance between two sides (Figure 2a,c,e) or between two corner points (Figure 2b,d,f). Translating nodes along the direction of their distance vector (Figure 2a,b) has the disadvantage that the network of nodes does not easily untangle/optimize itself due to directly opposite forces (left vs. right, or up vs. down). Therefore the nodes are translated along the line between their center points (Figure 2c,d,e,f). Mapping the difference between distance and desired distance to this line gives the problem that the direction of the distance vector may change (Figure 2c) or will change (Figure 2d) during translation. No further effort to solve this problem was made, because translating the nodes over their center-to-center line with an amount equal to the difference between distance and desired distance (Figure 2e,f) gave results that were visually pleasing.

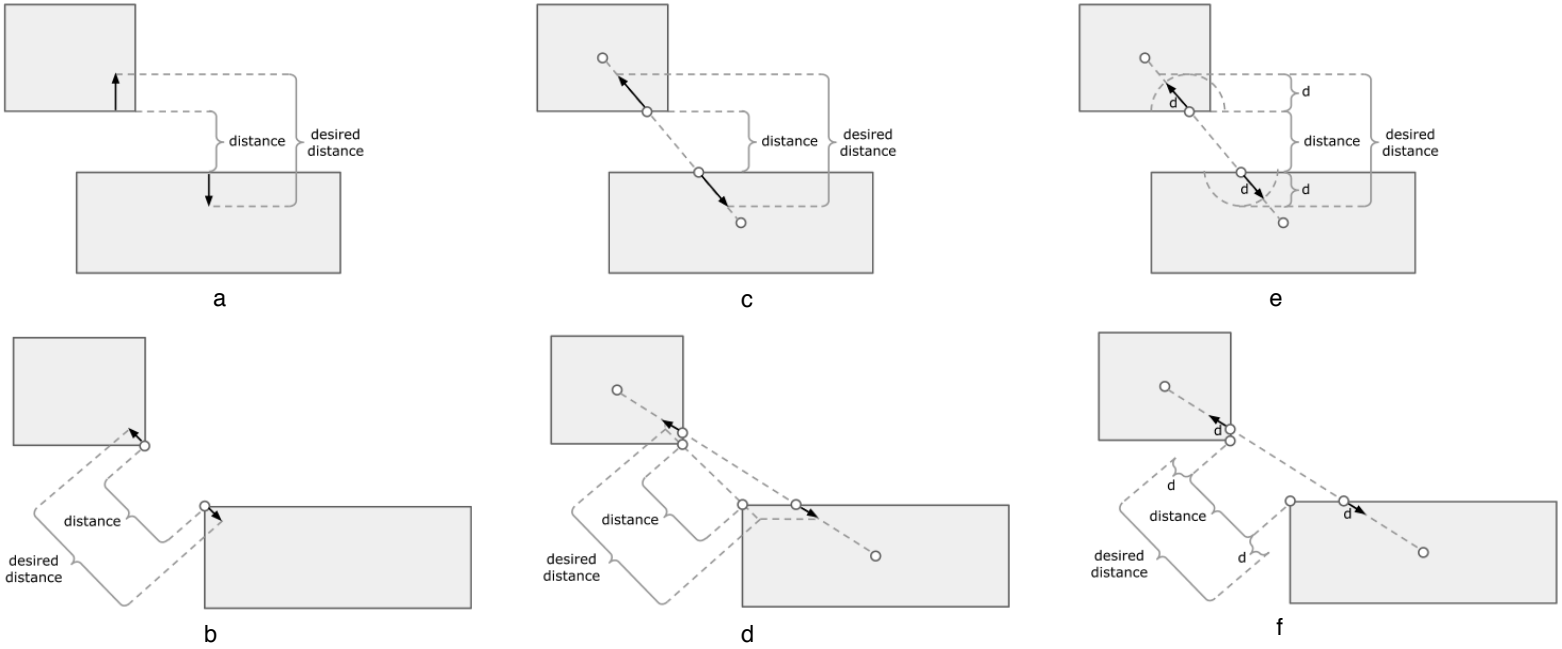


Figure 2: Distance and translation

Minor, advanced settings include separate distance settings for related and unrelated nodes, and for the distinction between contraction, expansion and repulsion (i.e. 'avoid') 'forces' (Figure 3). These settings were mainly used for personal experimentation, and are hidden/collapsed by default. Expansion force is only used for related nodes and repulsion force only for unrelated nodes. The 'forces' are basic relative weights, and do not behave as physical forces (e.g. they do not depend on distance as in Hook's law or Coulomb's law, and mass and acceleration are not used).

For any given node, the desired translations due to contraction, expansion and repulsion are summed separately, and then the final translation for the node is computed using the following function:

```
translation =
(sum(contractionTranslations) * contractionForce +
sum(expansionTranslations) * expansionForce +
sum(repulsionTranslations) * repulsionForce)
/
(amountContractionTranslations * contractionForce +
amountExpansionTranslations * expansionForce +
amountRepulsionTranslations * repulsionForce)
```

A first effort was made to make relations and nodes repulse each other (checkbox '*avoid relations crossing nodes'* in Figure 3) in order to avoid the sometimes-confusing overlap between relations and nodes. This functionality is, however, immature because it occasionally hinders the untangling/optimization of the layout.

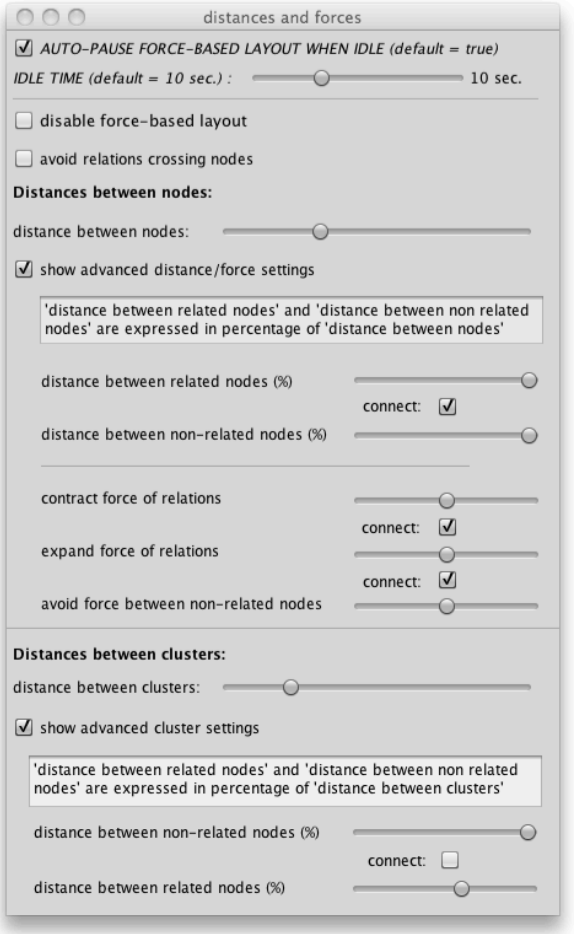


Figure 3: The distances and forces panel with advanced settings shown.

In some situations, when many nodes are forced in a relatively small space, the layout does not optimize. Occasionally nodes then keep rotating around each other. This effect was mostly experienced as distracting, but sometimes as desired and playful. It may be countered by varying the force-settings (e.g. set the repulsion force relatively low compared to the contraction and expansion forces) or by changing the implementation of cluster distance (e.g. use average instead of minimum).

Additionally, ‘forces’ can be implemented differently, based on distance (e.g. Eades, 1984), and desired distances can be based on the amount of nodes per area (e.g. similar to Fruchterman & Reingold, 1991). In the latter case, ‘area’ may need to be considered locally (e.g. for a subset of nodes) rather than globally (as there is no boundary or frame in Freed), and node-sizes may need to be taken into account.

Appendix 2: Questionnaire

Questionnaire used in chapter 6.3.

Part A: Collection and reflection

1. Do you think that it is important to keep and organize a digital collection during the entire design process and of all your work? Or do you think that this is a lot of unnecessary work?

2. Please describe how you create and use digital and physical collections in the context of specific design activities and specific design process phases.

3. Please describe how you create and use digital and physical collections in the context of the following general activities: documenting, organizing, communicating, reflecting, planning

4: What tools and/or methods do you use to reflect on your work? Or more general: How do you reflect?

5: If existing, what are the main problems you encounter relating to creating and using digital and physical collections of your work?

6: If existing, what are the main problems that you have with reflecting on your work?

Part B: Workshop

1: Please describe shortly and chronologically how you built your collection during the workshop.

2: Did you plan ahead how you were going to create and organize your collection or where you inspired while creating/organizing/exploring?

3: Did you create multiple views? If not, why not?

4: Please describe for each different view that you created what it's about, why you created it and how you created it.

5: If you made more than 1 view: Is there overlap between your views?

6: If you made more than 1 view: Where the latter view(s) only a different layout and selection of the first view, or did you also add new content and relations in the latter view(s)?

7: If you added new content and relations in the latter view(s): Did you later made part of this content or relations visible in the first view?

8: Did you gain any new insights in your work (reflection), or ideas/plans for your work during the workshop? If so, please describe them. If not, why do you think not?

9: Please mention the main usability issues that you encountered during the workshop (e.g. things that you did not understand, or that did not work properly or smoothly).

10: Please mention the main features/functionality that you missed during the workshop.

11: Please mention the main issues (apart from the previous two questions) that you encountered during the workshop.

12: Did you have enough and useful content?

13: Did you search for content on the internet during the workshop?

14: Did you miss an example collection, or example views?

15: Did you miss templates for structuring/organizing your collection?

16: Did you like the ‘freedom’ that Freed provides?

17: How did you make use of the force-based layout and (un)locking nodes? Did you appreciate it? What are the advantages/disadvantages?

18: Did you use paths? If so, why?

19: What would you do different if you would do the workshop again?

Part C: Intended use

1: Do you see Freed as a useful too for you? Why (not)? What do you consider the most important features?

2: Do you intend to use it? If not, why not?

3: If you intend to use it: Are there any specific activities or project phases that you are mainly interested in using Freed for?

4: If you intend to use it: Are there any general activities (documenting, organizing, reflecting, planning, communicating) that you are mainly interested in using Freed for?

5: If you intend to use it for the entire design process: Do you think that you will use it structurally during your design process?

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Summary

From Collection to Reflection: On designing Freed, a tool for free and flexible organization of designers' digital work.

Designers collect a lot of information during the design process, such as background research, ideas, notes, sketches, photos, videos and feedback from various stakeholders. A large part of this information gets lost in folders on individual computers, inside documents and presentations, or on pages in designers' notebooks. This is wasteful, because this information can be used for *reflection*.

Reflection enables designers to give meaning to their experience and to develop. When reflecting designers think about what, how and why they design, or more specifically: It allows them to *gain overview of, gain insight in and give direction* to their design process, ideas, designs, skills, knowledge, interests, ambitions, identity and community. Reflection concerns *integration*, i.e., to explore relations, and *diversity*, i.e., to explore new perspectives.

Reflection has a dual nature. On the one hand, it is an explicit action that requires designers to step out of the flow of designing. On the other hand, it is an implicit process that happens automatically while designing. This dual nature also holds true for how reflection can be supported. On the one hand, one can specifically dedicate time for reflection. On the other hand, reflection can be captured 'in the action', during or right after other activities that are part of the design process.

This project adopts a Research-through-Design approach: By designing and evaluating a software application called *Freed,* insight is gained in *how designers' reflection can be supported by means of their digital collections*. Freed is discussed and evaluated with design students and designer-researchers at the department of Industrial Design at the Eindhoven University of Technology. This context, which has strongly inspired and influenced this work, is introduced in the first chapter.

In the second chapter, the foundations, goals and approach of this research are outlined. Based on the goal of supporting both integration and diversity, the case is made for *free* and *flexible* organization. *Freedom* is defined as the possibility to let structure and meaning emerge during interaction, instead of being imposed by the structure of the application. It can also be referred to as the openness of the application, or its ability to be appropriated and used in diverse situations. *Flexibility* is defined as the possibility to easily reorganize and reuse design work and to switch between perspectives on this work.

Related work concerning reflection, design and collection, is discussed in the third chapter. This chapter ends with the conclusion that design is about action and exploration, and that reflection cannot be seen independent from action. Opportunities for reflection can be provided by a flexible person- and context- dependent design process that allows for many switches between activities, and regular reframing of the design situation. A system for

supporting reflection should fit this flexible nature, and give designers the freedom to use the system for their own purposes. This desired combination of freedom and flexibility is not found in existing tools and systems. For example, existing tools and systems include elements that may inhibit free and flexible organization of the collection, such as similarity criteria, IBIS notations, and hierarchical relations.

The main process of design and evaluation is discussed chronologically in chapters four to seven. The fourth chapter introduces initial design concepts, and argues for a focus on software. A first software prototype called *'The Magnetic Collage Software'* is discussed, along with a personal reflection on the use of it. From this reflection is concluded that the initial prototype works well for gaining overview quickly, but that it needed to be improved in order to support more active exploration of relations and perspectives.

In chapter five the initial version of Freed is discussed. The main elements of Freed are a zoomable unconstrained canvas, a force-based layout, and the possibility to create multiple organizations of the same content. The purpose of the force-based layout, in which related content attracts each other and non-related content repulses each other, is to encourage the exploration of relations and different spatial organizations. These organizations, or '*views*', can for example be used for a specific design activity or project phase (e.g. presenting, mapping related work), for creating an overview of the entire design process, for a portfolio of multiple projects, or for explaining the perspective of a given designer or stakeholder. The chapter concludes with a discussion of first feedback from design students and a case study in which the software was used for building a presentation and collection of the research group in which this research is carried out. The case study showed how the activities of building a presentation and collection can support each other and how this active, integrated use can lead to reflection.

Chapter six focuses on the use of Freed during the design process. It discusses a design iteration, an introductory workshop and questionnaire, and a semester-long evaluation during student design projects. This evaluation showed that Freed was valued as a tool for gaining overview of and revisiting design work and process. Additionally, it showed that in order to support more exploration and reflection during and after the design process, the threshold for documentation and communication needed to be lowered, a better balance between organization and visualization needed to be obtained, and the integration and overview of views needed to be improved.

Chapter seven focuses on using Freed as a tool for exploring relations and perspectives. It discusses a final design iteration, an evaluation during which students used Freed to explore their personal views on design theory, a case study of designer-researchers using the software for organizing student projects, and a reflection on personal use of Freed. These cases showed how Freed provides the freedom to be used differently by various design students and how multiple views can help to integrate work and to

explore relations and perspectives. They also showed that both freedom and structure are needed for reflection, and how Freed can be used complementary to other activities such as physical diagramming or clustering. For example, physical clustering (e.g. of Post-it notes or printed images) helps to quickly gain consensus among a group and to make decisions, while Freed provides input for more dynamic discussions, allows for personal exploration (i.e. to temporarily loose the group consensus), and allows for insight to develop gradually.

Chapter 8 concerns a reflection on this research as a whole, and discusses '*conditions for collection and reflection'*, future work, and Research-through-Design. The main conclusions are that reflection builds on active use of a digital collection, that active use benefits from having a rich, visual, integrated collection, that reflection requires both freedom and structure, that structure emerges from direct, expressive local interaction, and that using a digital collection for reflection requires time and skill. In future work, there's a need to move beyond the confinements of a single software application, and to explore how to design for systems that integrate diverse products and applications. Additionally, there's a need to explore the integration of collection and reflection in a collaborative setting (and) in design practice.

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Curriculum Vitae

Philip Mendels was born on 18-04-1983 in Nijmegen. After obtaining his VWO diploma in 2001 at ‘The Nijmeegse Scholengemeenschap Groenewoud’ in Nijmegen, he studied Industrial Design at the Eindhoven University of Technology. In 2007 he graduated on a portable device for playing audio adventure games. In 2008 he started a PhD project at the same department of the same university, in the Designing Quality in Interaction group. The results of this project are presented in this dissertation. For his PhD project work he received the Best Contribution to Creative Communication award at the Creativity & Cognition 2011 conference in Atlanta, US. Since the end of 2012 he works as an interaction designer and front-end developer.