Expressive Product Design

Introducing the Product Design Canvas

Fred Voorhorst
In memory of Feja
Expressive Product Design
The Product Design Canvas

Fred Voorhorst, edited by Tom Brooks
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Chapter 1 - Introduction

"Out of clutter, find simplicity. From discord, find harmony. In the middle of difficulty lies opportunity."

Albert Einstein

How do you train the impact of perceptual constraints on design, if you are convinced that the key to learning is practical validation and verification?

A little over a decade ago I was invited by Prof. Krohn to give a one-week workshop at the Zürich Design Academy for students of Industrial Design Engineering. The scope of the workshop; ‘perception’. based on my background in Mechanical engineering, and having been trained on an empirical and iterative approach product design within the context of Gibson’s ecological approach to visual perception (Gibson, 1979), the workshop had to be practical, involving real tests exploring the impact of perception on product design and user-product interaction.

Consequently, I set my ambition at going through a complete design cycle in one week, from idea to prototype, to a empirical validation and finishing with a re-design, or at least with suggestions based on learning from the tests performed. Yes, one week is a bit short. But this limitation is one of scope, rather than time or organization.

The time constraint was faced by splitting the basic design process into clear trajectories. The first trajectory covers inspiration and moodboards, exploring perceptual requirements and constraints. The second trajectory focuses on designing a solution, prototyping and product design. The third trajectory covers experimenting, evaluating findings and preparing for the next iteration.

The real challenge was finding assignments that allow themselves to go through such a process within the given time-frame. One week is a bit short to explore, design, build, test and evaluate a new dashboard of a car, or a new water kettle, or a new bicycle. Achievable is, for example, a redesign of a light switch, an egg timer or a thermostat, anything with about one button and not much more than two states.

Since that first workshop I have repeated it several times and in different locations which has allowed me to learn more about the design process. I systematically collected feedback at the end of each workshop which I evaluated, considering also my own impressions. These data combined with related experiences from industrial projects have led to further evolution of the workshop, updating exercises and streamlining the overall structure.

Some things have remained constant. Constant was good overall ratings by the students. Also constant was the complaint about lack of time (despite various attempts to release the schedule). Constant was the request for a hand-out, as well as me remaining
Fig. 1: “The challenge is not just to prototype and test. Sure, prototypes are easy to build and even simple prototypes like this you put to the test and collect feedback. The real challenge is to prototype and test in such a way that you learn something, that brings the project ahead.”
stubborn in refusing to just hand out the slides, as these were created to be presented and were not intended to be read in isolation.

What also remained constant is my intention to write it all up in a more accessible format, as well as my lack of satisfaction with my attempts. There have been many attempts. What you have in your hand is yet another one of these. The next workshop is looming and again I am in a rush to finish yet another draft. I lost count somewhere between version 23 and 29, but this most probably is version number 42: Definitely number 42.

Previous versions of this book were discarded for various reasons including: lack of focus, overly academic focus, lack of practicality, lack of a paper model (I love paper models), or simply because it turned out to be a thin replication of what Donald Norman did much, much better about 25 years ago with his ‘Design of Everyday Things’ [Norman, 1988]. Occasionally, I even went as far to simply hand out copies of ‘Design of Everyday Things’, being the book that comes closest to the content of the workshop. Although this solves the problem of having no hand-out, it does not honour the activities and exercises I had learned to be effective in this workshop. Also, I envisioned a hand-out or book as something you can use; a do-book. It should offer a place for notes, it should have templates to work from, have a puzzle, and a paper model to build, just for the fun of it. Did I mention that I love paper models?

So, if you are reading this it means that the hand-out has finally become reality. Yes, it includes a template, a cartoon, space to take notes on, and even a paper model you can cut, fold and build.

Enjoy.
Chapter 2 - Interactive products

I fear the day that technology will surpass our human interaction

Albert Einstein
2.1 Introduction

This chapter presents a number of examples, selected because either they work beautifully, or because they illustrate an interesting mistake.

With the advance in technical possibilities many products seem to have become complex to use. Every now and then however, product arrives that ‘raises the bar’, like the iPhone, to set a new standard in usability AND increased possibilities. These products represent the exception rather than the rule. Despite technological progress, designing products that clearly express their use and function remains difficult and while it may seem that there has been little progress in usability, it could be that the game may have changed.

There was a time when tools were straightforward; literally. The use of these tools was inherent in the design and self explanatory. Think about a screwdriver, or a hammer. Even more articulated devices were more direct, such as the heating system of an old car (levers controlling valves) or the stoppers on a pipe organ.

Was designing interfaces for such tools easier, or was the task of the designer simply different? The ‘interface’ was in most cases fixed directly to the underlying mechanism, e.g. a lever was physically attached to the mechanism it was designed to control. Even when the connections were hidden from the user, there was a confidence that our activities were physically connected to the outcome. This was a mechanical world; to drive a screw you turned the screwdriver, to start your car, you had to physically crank the engine, to place a phone call you had to turn a wheel to create the impulses needed to route the connection, to listen to music you had to place the data reader (a needle) onto the data storage (LP

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Fig. 2: Example based on a Phillips cassette player. The second image shows how to start playing; pushing the control (head) forwards (against the tape). The third image shows stopping; pulling the control backwards. The last image shows rewinding (pushing the control to the left). With thanks to Tom Djadiningrat.

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or Long Play record) even at the risk of damaging the data. If you wanted to play the next song, you placed the needed on the next song (which sometimes involved turning the record as both sides were data carriers). This seems now quite cumbersome and crude but at the time it made listening to music a precious, personal ritual.

An example is shown by the sequence of images in Fig. 2; illustrating the process of playing, stopping, forwarding and again playing a cassette tape. Information is stored as a magnetic field on a cassette tape. You can ‘play’ the tape by starting the movement of the tape and either placing the tape against a reading head or placing the reading head against the tape as in Fig. 2. In this case, while pushing the head forward, you also trigger a switch that starts turning of the tape. Pulling the head back stops the playing of the tape. Moving the ‘head’ left would forward the tape while moving the ‘head’ right would rewind.

Advances in technology have made this direct mechanical interface a thing of the past, first with the introduction of miniature servomotors and mecha-tronics, and then with advance of computer technology. A subtle change in how products are designed and built allowed the decoupling between technology and interface components. In the example of the cassette player, instead of having to push the head against the tape, you could lightly touch a small electronic button which would start a small motor that would move the head against the tape. Instead of having to turn remove the cassette and turn it over, a small motor would simply turn the head and the tape would start winding in the opposite direction.

These mecha-tronic components offered increased flexibility. Suddenly, the shape of the

Fig. 3: Natural interaction appears to be defined based on the actual state of technology. Top: Mouse. Middle: Apple’s Newton; pen based PDA. Bottom: Virtual Reality (image based on the work from Hummels, 2000)
‘control panel’ became potentially independent from the mechanical components underneath. Instead of cranking a lever in front of the car, you now turn a key or push a button while sitting in the driver’s seat. Driving a screw became pushing the right button of an electric device.

The decoupling of technology and interface design or product design continued with the development of computer technology. Today in a data-driven super connected world, not only the gestures used to control music playback are abstracted from the mechanism of the music player, but the music file itself is abstract, invisible and potentially stored anywhere. Gestures like “shaking” to change songs, or “swiping” to browse electronic “covers” have replaced our simple direct mechanical actions.

Thus we have moved from a situation where the underlying technology is the main driver for product design into a situation where the interface, expression and interaction are key elements of design. How something works physically need no longer be considered part of the design process.

This advance in technology has led to great new products, new ways of working, and new ways of interacting with the objects around us as well as with each other. However, it has also changed the way in which we design products. It has removed hard constraints set by the technology underneath. Product design has shifted from ‘making clear the operation of a mechanism’ to ‘making clear a function’ which may even be disembodied and delivered across different physical devices. The challenge has thus shifted to designing product interaction, up to the complete end-user experience. Expressive design, and designing for ease of use.

The concepts of ease of use have evolved with technological capabilities. At the time when computers only had keyboards, the mouse gave new meaning to the concept of direct manipulation, until the introduction of the pen based computer, which again redefined direct manipulation. Virtual Reality techniques then introduced concepts such as natural interaction. Obviously, ease of use is not something absolute, but relative to the task at hand and the skills required to achieve them. ISO defines product usability as “The extent to which a product can be used by specified users to achieve goals with effectiveness, efficiency and satisfaction in a specified context of use.” (ISO 9241-11, page 2).

Expressive design (which in case of functionality translates into ease of use) has become central to product design. The purpose of this book is to offer tools and methods to improve the process of designing expressive artefacts, which are in turn more useable.
2.2 **Coffee & Cash**

This example examines the transaction of ordering and paying for a cup of coffee. Starting with the payment issue first, and then to ordering the coffee. There are two problems with cash points and digital payment solutions. The first is related to the PIN-code. Through habit, the sequence of numbers has turned into a movement, a gesture. Luckily, the keypads of the digital payment systems are equal, at least most of them are, regrettfully, not all. In most of the cases you find the 1 in the upper left corner, in few cases you find the 1 in the lower left corner. It will create embarrassing situations if - like me - your PIN is a gesture. This is one of the situations where standardization is critical to usability.

![Fig. 4: Examples of two common ‘key-pads’. Problem is that the spatial lay-out is different, which is especially a problem when your PIN has become a movement, a gesture.](image)

Standardization can increase usability but does not improve the user experience. Digital payment systems, even when there is a human cashier, feel rigid and inhuman. There is an interruption in the (albeit limited) social exchange. It is as if the person paying disappears for a minute and a half, while he interacts virtually with his distant bank and then reappears to take his product and the receipt. The cashier, in the real world, extends the receipt to the customer holding back the pressure of the next customer in line. More times than not the customer doesn’t want the receipt and, blindly returning from the virtual to the real world transaction takes it and either throws it away, pockets it distractedly or worse, walks away leaving it in the hand of the cashier who repeatedly suffers the abrupt interruption of natural human interaction.

Even in human-machine interactions much could be done to improve the experience. For more
than 10 years I have withdrawn cash from the same bank, and for more than 10 years the machine has asked me whether I want a receipt. In all these 10 years, the number of times I wanted a receipt is probably less than a hand-full. Those data exist somewhere in my bank and could be used to make my visit more pleasant and less stilted. No one likes answering an obvious question. Returning to the coffee transaction, I like to drink coffee and, living in an Italian culture, I have come to appreciate a nice espresso. Probably because of Dutch roots, I prefer an espresso-lungo; one with a bit more water. It took the barman at the company where I was working (and I was one of about 300 people working in the same building) between two and three days to remember I preferred my coffee ‘a bit longer’. Not 10 years, but less than 10 visits.

In the mean time, the cash collection points of the bank have improved slightly. It still does not know what I want, but it allows me to select ‘the same as last time’, which means same amount, same way of payment and no receipt. Starbucks would be proud.

### Making toast

An example of ‘elegant interaction’ is GE’s Hot Point Toaster (see Fig. 5). The problem, which this mechanism solved, was toasting a slice of bread on both sides. Modern devices have a simpler but less elegant solution: you simply slide down the slice of bread between two heating elements and a spring and bi-metal based mechanism releases it again when the slice has turned into toast. The ‘flopper’ mechanism was an

**Fig. 5:** The very successful Hotpoint toaster was the De Luxe, designed by Charles P. Randolf, manufactured from 1923 to 1933 (Source http://www.toaster.org)
earlier and I think a more elegant solution, at least from an interaction point of view. The ‘Flopper’ toaster had only one heating element, placed at the center of the toaster. In order to toast the slice of bread on both sides, you would need to turn it.

The toaster has a door to hold the bread against the heating element. This door is closed by a spring. A simple lever allows you to open the door. The shape of the door and the location of the hinge make it so that the bread slides down when you open the door. The side of the bread that is toasted ends up on the door. Closing the door automatically puts the side of the bread not yet toasted against the heating element. In effect, opening and releasing the door turns the bread. Opening the door for a longer time releases the bread from the toaster, i.e. it slides over the door onto the plate (or table in case you forget to put a plate). Open quickly to turn the slice of bread open slowly to remove the toast.

The design of this toaster may have been due to practical considerations (no standardized pre-sliced bread at the time) or maybe inspired by budget constraints as the heating element was the most expensive component. At the end of the 1920s, the price for such a toaster was 8$. By comparison, the price for bread was 10cents a loaf.

This interaction is elegant and the mechanism is direct, mechanical and visible and yet there is something surprising in the application of physical mechanical laws. There is room for the user to develop and fine tune the gesture and that gesture can become part of a morning ritual. Technology integrated seamlessly into life.

Standard mechanically pre-sliced bread went on sale only end of 1920s. Around the same time (1929) Patent 1,698,146 for an automatic pop-up toaster for home use was approved.
2.4 Church candles

We observed this example of the importance understanding the end-customer for product design around 2007 in a church in Gandria, an ancient village on the lake of Lugano. In this example the interaction is only ritual. Gandria is a very beautiful fishing village built on a narrow strip of land, between the mountain and the lake. Built before the invention of automobiles, the streets of Gandria are narrow. With narrow I do not intend narrow as, for example, the old streets of Sienna, Italy. These were also built before the invention of automobiles. In Siena if two of the smallest of Fiats happen to meet they have serious problems passing each other. The streets of Gandria are even narrower. Cars are not allowed, probably on the grounds that they would get utterly stuck, if they were allowed. At some places, even two people on foot have difficulties passing.

Although the village is ancient, the church is modernized. Churches usually have small worship areas, where you can light a candle in memory of someone (Fig. 6.) The transaction, which is ancient and well ingrained in the culture, is to take a candle, light it, place it on the rack and, if you please, make a donation. The monetary and spiritual transactions are related but separate. The lighting of the candle can be achieved with either a match (supplied) or with an already burning candle.

For unknown reasons, an electrical candle (Fig. 7) has replaced the manual version. Maybe to reduce the consumption of candles, the production of damaging smoke, or the amount of maintenance required by the church. At some abstract level the process has remained the same: you pay and you will light a candle. The user places a coin in the container as before, but then technology takes over: one of the electric candles starts blinking. After four or five blinks, it stays on, and remains on for a certain period of time (until the coin has run out).

During our visit an elderly man came in with the clear intention to light a candle. Since there were no matches, the wise and inventive signore walked towards a table somewhere in the corner and picked-up a real candle, already lit. With this candle, he tried to light one of the electric candles. When the first one would not take, he tried a second one. We tried to explain that
the candles were electrical, and that the payment would lit one of them. Clearly the man was accustomed to electricity however, despite our effort and patience, he failed to understand why the candles would not light.

This electronic candle seems to have been designed to mimic in a broad sense the original routine of lighting a candle in the church, without the overhead and maintenance of real candles, other than emptying the money box and an occasional replacement of a light bulb. The cause of the failure of the man-machine interaction in the case of the old man (a key demographic target of the church) is the focus on the final result (candle is lit) and not on the ritual, i.e. the process of achieving this. It is the lighting of the candle, not the lit candle which is the ritual. Without that ritual the process is meaningless and (thus) confusing.
Opening a Top

In the early 1990s Philips produced a set of household appliances designed by Alessi. The set included a coffee-maker, a citrus press, a toaster and an electric kettle. The design was in line with the – at the time – back to the 50’s movement. Usability, or elegance of use, was clearly a focus. For example, the process of switching the heating of the water on is fluently integrated with placing the kettle on its stand.

The kettle also has a very interesting usability flaw: opening the water kettle’s top (See Fig. 8). From the design, there appears to be a clear and simple way to open the top. See for yourself, there is no trick question here. Whenever I ask this to students of a class they hesitate. You probably guessed, as is illustrated in Fig. 9: put your thumb on the lever and push. As you also may have guessed – this is after-all an example – this is not how you open the top. To open the top you have to pull the lever backwards.

The kettle was designed to be opened by pushing the lever, and the lever’s shape is designed to be an intuitive cue. Technically, the opposite mechanism was applied. The top is opened by sliding the lever backwards. The arrow embossed on the top of the lever was a clear giveaway.

So what went wrong? I can only speculate, but maybe industrial engineering was cost-driven. Perhaps the product design and product engineering were two separate and independent steps of the process. The engineering team maybe discovered that a mechanism needed was too complex, or maybe the marketing team decided it was too expensive. Maybe the ‘end-user’ argument was simply overruled in the interest of a deadline, or perhaps it was a
shops or if needed end-customers can order these to replace the parts most likely to be broken. For example, the light switch or the inside filter. The lever was not on this list. However, the shop employees soon discovered it should have been on the spare-parts list. What happened was that people in the shop, inspecting the kettle before purchase, tried to open the top, try to push it down and broke off the lever. Other clients returned the kettle with a broken lever.

Swift action was take to resolve the situation. As a first step, the item was placed on the spare parts-list. The second step was to ‘update’ the design, by changing the shape of the lever to better match the mechanism and the perceived interaction. The updated version showed two ‘bunny ears’ that needed to be squeezed to open the top (see Fig. 10).

case of “The Emperor’s Clothes” in which no one had the courage to question a design signed by Alessi. The consequence of this - possibly last minute - update was profound. Typically, before bringing a device to the market, it is common practice to define a spare-parts list, so that shops or if needed end-customers can order these to replace the parts most likely to be broken.
2.6 Roadmap

A map has two primary objectives; to tell you where you are, and to help you move from where you are to wherever you want to go. Fig. 11 and Fig. 12 show examples of a Swiss and a French road-map. These are nice extremes of solutions supporting both objectives.

The Swisstopo road-map (see Fig. 11) perfectly documents the area allowing you to find out where you are with a great deal of detail. The country is perfectly split into a grid, with each grid documented with a detailed map, showing the topography with contour lines, and even the location of individual houses.

The Michelin road-map (see Fig. 12) appears to be designed to assist in movement between points. It shows some overlap between different maps. There is even a special map for a road often travelled (Route the Soleil), which combines parts of two other maps. The Michelin road-map is developed both within the context of the range of maps as well as the context of the use and most prevalent use cases.
2.7 **Personal Toolbox**

In advertising, associations with other objects are often made to highlight certain properties of the advertised object. For example, Apple used to have an advertisement where a Pentium chip was mounted on a snail to highlight that a fast chip does not necessarily make an item fast. The bus line uses a Greyhound dog to indicate its swiftness. A similar example is an investment bank showing a Victorinox knife to illustrate the variety of services offered. A phone company used an extended version of a similar knife to illustrate an even more extensive service offering. These are metaphors of features and properties of a product or service.

But quality is not the number of functions nor is it the number of features or tools or services. Quality is the degree to which a specific customer need is addressed. From that point of view, the Fig. 13 example illustrates a disadvantage of the phone company rather than advantage, it is saying: “We have whatever you want but we are not able to combine the service you need into a usable offering”

Focusing on the quality that is needed can be illustrated by the same knife manufacturer, although it may have been the result of a learning curve rather than proactive planning. Around 2000 Victorinox came out with a knife that included a USB stick. It was a real sensation and it immediately became one of the must-have gadgets for the IT business man. The knife itself, scissors and other tools were part of the context of the USB stick, they were “nice to haves” not “must-haves”. These soon became a major liability as the pocket knives were confiscated at airports. Probably in an effort to recover, they now offer a ‘pocket knife’ that has only an UBS stick. The lesson is that integrating a feature into a product is not the whole picture, the feature must integrate into the life of the user and the context of its use.

![Fig. 13: Examples of Swiss pocket knives](image)
2.8 Safe-cracker-proof tea

This example I encountered when visiting friends who offered me a cup of tea. As always, I was delighted. Even more because of the teapot they used (shown in Fig. 14). No doubt with the purpose of preventing the top from falling off when poring tea, the top had two additional features. First, as a common solution to this problem, on one part of the inside the top had a small lip. In addition, as a second feature, the rim was a bit oval to make sure that, unless it was in the absolute correct orientation, it would not fall out. Although this prevents the top from accidentally falling out, it also makes it virtually impossible to take the top off intentionally. Especially, as the outsider was perfectly circular. Like a professional safe-cracker, you have to slowly turn the top and try if it comes off. The teapot does not present its action possibilities in such a way that the user is assisted in the simple task of removing the top.

This example is almost as bad as the round Apple mouse, delivered with the first iMac series. Not quite as bad, but almost.
Chapter 3 - A Product Design Canvas

“It is a mistake to think you can solve any major problems just with potatoes.”

— Douglas Adams
Products and production processes have grown to such a level of complexity that product design has become a multi-disciplinary effort. As a product designer you need to be able express the design challenge and elaborate potential solutions to different people across different disciplines with different skills and importantly, different views on the product. This is not unique to product design; a similar problem exists in business process modelling. Also with Business Modelling, there is a wide range of stakeholders from whom input needs to be collected. Osterwalder (et al, 2010) have developed a very effective tool to support this process; the Business Model Canvas (BMC); a strategic management template for developing new business models or documenting existing ones. The canvas is a visual overview showing the various components that are important to understand a company's business model, its value proposition, how value is created, delivered to the customers, and how the business is financed (see Fig. 15).

This canvas is simply a great tool. In recent years I have used it on numerous occasions ranging from mass customization projects to developing communication strategies or software development projects. What makes the template so effective is that it provides a

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**Fig. 15:** Business Model Generation describes and introduces the Business Model Canvas, a powerful tool to understand and resolve business (process) challenges
structured overview of all of the important aspects (building blocks) of a business, and puts them in a form that ‘facilitates description and discussion’. The canvas helps you to maintain a holistic overview, even while focusing on details that span only a few building blocks. Add to that a basic structure of a SWOT analysis and you end up with a generically applicable, yet powerful tool to address all sorts of (business) process modelling challenges. It is designed to help you analyse your situation and discover business structures and opportunities.

The BMC is specific for Business Modelling (however generic that may be), but there are numerous design problems that could benefit from a similar yet specific canvas. I was (and still am) expecting canvases to erupt for all kinds of problems and creation challenges. Based on my own experiences and certainly biased by my enthusiasm, I was expecting a true tsunami of canvases; a template for IT solutions, a template for Shop design, one for project management, one for organizing hospital situations etc. Specific templates to support any creative or exploitative activities, especially where a project spans multiple areas or departments (which is, what?, 90% of the time?) Where you need to keep a global overview, even when you are focusing on a small element of the entire process. There are a few, such as the Product Canvas\(^1\), or Hambrick & Fredrickson’s Strategy Diamond\(^2\), or the Value Proposition Canvas\(^3\), intended as a plug-in for the BMC. Not really a tsunami, at least not yet.

“Imitation is considered the highest form of flattery” (attributed to Charles Caleb Colton, 1820). However often imitation is considered a rip-off or simply theft. My appreciation for the Business Model Canvas has motivated me to develop one for Product Design, and it is clear that the aim was to develop a canvas that is at least as effective and structured, and ‘flatter’ Osterwalder et. al.


\(^2\) [http://www.provenmodels.com/598](http://www.provenmodels.com/598)

\(^3\) [http://www.businessmodelcanvas.it/bmc/value-proposition-canvas.html](http://www.businessmodelcanvas.it/bmc/value-proposition-canvas.html)

What’s up, Doc?

Tex Avery
3.2 **Product Design Canvas**

Product design is a multi-disciplinary field. This includes not only end-user related issues, like how the device is used, what are the user needs, how does the product need to work within the context of the user’s life, but also what are the other devices the user will work with in combination. In addition, production related issues such as how are the components going to be produced, how are they going to be assembled, maintained, as well as business related issues, are of critical importance in product design, impacting various parts of the design.

The Product Design Canvas (PDC) was developed to support this multi-disciplinary process, and covers the main aspects to consider in product design, as illustrated through the examples in Chapter 1. With the most important aspects combined into a one-page logical overview, it supports product designers, clients, consultants and executives in their interactions, discussing scope, position and solution opportunities. The canvas eliminates misunderstandings during discussions by depicting in a structured way all elements that are relevant to the discussion.

In the next part of this chapter we will illustrate the elements of the Product Design Canvas.

The user/end-user is the person who operates the product with the objective of achieving some goal or objective. Basic to good (i.e. user-friendly, expressive, etc.) product design (or interface) is an understanding of who the end-users are and how they are going to use the product or interface (see e.g. Raskin, 2000).
A product is an article or substance that is manufactured or refined for sale (Oxford English Dictionary). A product combines art, science, and technology to create useful objects. A product also has to meet the requirements of the portfolio of which it is to become a member, as well as other business and production constraints.

When designing a product the designer should consider the complete end-user experience within the entire product life cycle, perhaps starting with the marketing announcements, but certainly including the packaging, after-sales services and support and event its eventual re-use, recycling or elimination.

Users have an objective, a goal, a task. This can be an externally given objective (write a report, control the machine), but it can also be a personal intention (e.g. play a game, watch a movie, solve a puzzle etc.). These objectives and intentions determine not only what functions and interaction possibilities to offer, but also their respective importance and priority.

End-users bring with them their previously developed skills and past experiences. These skills and experiences, in part, separate the end-user from the rest of the population and make them unique. Understanding the skills and experiences of a particular user helps in two ways. First, to ensure that the final product is effective, its interface has to respect the skills and experiences the users bring to the table. Second, during the design phase, understanding the skills and experiences of users is inspirational for product and interface design.
Materials constrain the solution space for the product to be designed and impact all aspects of the product, from appearance to weight, stability and rigidness. Further, companies increasingly aim to re-use components, resources and technologies to maximize efficiency and return on investments, or in the interest of sustainability choose to re-use materials and components products returned at the end of their life cycle. To avoid a product ‘upgrade’ during production, these issues have to be considered during the design phase. This includes total life cycle calculations as well as pricing, perceived quality and customer loyalty considerations.

Both the prototype and the final product may be limited by the tools and resources available. Naturally, with the launch of a new product the company may decide to invest in new resources and technology. One of the challenges is therefore to develop prototypes already in line with available production technologies and manufacturing capabilities. These constraints are challenges that should stimulate rather than limit design creativity.

In most cases, with the exception of start-up business, there will be a portfolio into which the product should fit. Understanding the portfolio, its collection of functions, pricing and target market helps to position the product to be designed, both in terms of cost and price structure as well as issues like appearance, organization of the interface and target market segment.
Perception and action are closely related. **Action** refers to what input and control possibilities the product offers the user. What is the product supposed to do? What need is it supposed to fulfil or what task is it supposed to perform. **Perception** refers to how the product presents its action possibilities. What controls does the product offer, how are these controls organized spatially or functionally (e.g. in layers of a computer interface). How does the presentation of these controls contribute to a clear and effective communication of the product’s purpose and function?

Pricing, target market price or maximum cost price for the manufacturing, is often part of the design brief. As a product designer you are faced with the challenge of staying close to the price mark. As it often is easier to simplify and reduce afterwards, you may want to ignore pricing during the early stages of the design process to avoid blocking the creative process. Once a design vision has been established, price constraints (and other constraints), can be applied.

A product always has context. At a holistic level, the product will be selected from amongst a set of related products (either own or competitive) offering similar or the same functionality. While specific functionality and features may be critical, presentation and clarity of purpose and use also are key to the success of a product. At a practical level, the product may be used in a specific environment (operating theatre, tool shop, kitchen), or while other tools or products are being used either collaboratively (a mixing bowl and a mixer) or competing for the user’s attention (calling while driving).
Fig. 16: The Product Development Canvas. Download from www.brick42.com
The spatial organization of the Product design Canvas (PDC) offers a sequence in which to address main design aspects we have discussed here. As described above, the power of the Business Modelling Canvas (BMC) is not only that it lists the main aspects of Business Process Modelling, but also the manner in which these elements are organized. Centered around the value proposition, starting from the customer (reading from the right) and covering all aspects up to suppliers and partner companies, and supported by cost and revenue streams. With the PDC, we take a similar approach, placing the product interaction (perception and action) in the center, linking the customer properties (right) and product properties (left), all supported by context of use and product context (see Fig. 16). Similar to the BMC, the PDC has different patterns, depending on purpose and application. A few are described in the next section.

Resource-driven; The idea is that existing resource or production capacity is used for something it was not originally built-up for. For example the German airplane industry just after the second world war converting to the production of cars, or the Michelin network of tire shops being used by Citroën car manufacturers to create service posts.

Portfolio-driven; The idea is that a new product is designed with a specific positioning in mind, to extend an existing product portfolio. For example, Apple’s introduction of the iPad was intended to fill the gap between the iPhone and portable computers, the addition of new model to the Mini car offering, etc. This is a quite standard and continuous approach of extending but also simplifying and clarifying the product offering.
Use-centered; this situation occurs when the customer, in combination with the context of use are inspirational for product development. Classic examples are the iPod and the iPhone, building on existing technology although breaking with the company’s traditional product range, and branching into new areas.

Product-driven; the situation occurs when a product is being (re-)positioned or technically optimized. For example, products that are not an immediate market success are evaluated for the customer segment they address. Alternatively, products that are well established may undergo a process of technical redesign/optimization without changing the product/user interaction.
Chapter 4 - Getting inspired

“I dream my painting and I paint my dream.”

- Vincent van Gogh
4.1 **Inspiration**

The beginning of a product design and idea generation process starts with the collection of examples and objects that are inspiring and somehow relate to the product to be designed. Typically the examples and objects are collected on a board, called a moodboard. The purpose of a moodboard is to stimulate your creativity, to shape your initial ideas and to help develop them. It helps to focus on the aspects and issues that are relevant to your design project. When designing a new collection, the moodboard may include samples of fabric, colour samples, details and so on. When designing a product it may include examples of shapes, materials and related objects.

There are no ‘rules’ when it comes to how to structure or organize a moodboard, or when it comes to what it should contain. A moodboard is sometimes simply a stack of cards, freely put on the table like a stack of holiday photos. However, since relation and structure are important, I prefer the images to be fixed on a surface.

Before the Internet and Google, moodboards were created from pictures cut from journals and magazines. Especially Google's 'similar' function (although recently a bit hidden) makes the search for images easy and effective. However, moving from cutting images (using scissors) to cutting and pasting images (using a computer) often results in a collection of whole images, which are then neatly organized in a rectangular grid. When working manually with scissors, it is completely normal to use only a part of an image; you are cutting anyhow, so you naturally cut out the part of the image that really interests you.

Although a moodboard is typically built from pictures, it can also include real objects or even be without pictures. Especially in the case of designing physical products, it serves to find examples of objects, shapes and surfaces that capture the expression you are looking for.
**Fig. 17:** Example moodboards on various topics
4.2 Fashion moodboard

The example described in this chapter is based on experiences working with the product development center of a major international fashion brand. The talent pool is a team of 4 to 6 students who work closely with one of the creative directors for a period of 6 months, with the objective of building a small visionary collection. To become member of the talent pool you have to apply and undergo a careful selection process.

The objective of the talent pool is to attract, position and retain gifted designers. Over the course of almost 2 years we managed to increase retention of talent pool members from 40% to 85%.

The initial challenge is to on-board and ramp up the talent pool and develop the members understanding of the brands. Obviously, they need to have a good feel for the brand they are going to work for (‘their’ brand), but they also need to understand how their brand relates to the full portfolio of products. To ensure effective collaboration with the different design teams and success of the talent pool project, it is fundamental that members of the talent pool understand the boundaries between the brands, and that they able to discuss the brands freely with the brand director. This requires developing a vocabulary specific to each brand.

On-boarding, i.e. understanding the different brands, is a perceptual challenge requiring the designer to develop the perception of the differences and similarities between the brands. In fact, perception is mostly about differences [see e.g. Gibson, 1979]. In this case the learning focuses on two specific differences: whether or not something belongs to the talent pool’s brand, and whether it belongs to one of the different yet closely related brands.

The on-boarding process was accelerated by having each member of the talent pool develop a moodboard. The talent pool was given two specific tasks with the purpose of training their perception of differences. First, they were asked to create 3 moodboards; one for ‘their’ brand, and two additional for the brands most closely linked to ‘their’ brand. Second, they were asked to apply a specific order to the images and items collected for the moodboard, and ‘not just ‘place’ the images anywhere. Instead, they were asked to a) make sure all of the images or parts of images on the moodboard belong to the brand depicted, and b) arrange the images from ‘fitting well’ to ‘fitting perfect’ starting from the lower left to the upper right.

This assignment had a particular effect on the team dynamics. Where, with a normal moodboard, the discussion is about, first, whether an image belongs on the
board (does it fit to the brand) and second, where should it best be placed on the board to support the overall layout and composition. This assignment motivated the students to debate every image to find out, compared to other images, whether it belonged ‘more’ or ‘less’ to the moodboard’s brand. The results were 3 moodboards on which the upper left area fit the brand well, and the lower left fit less well. See Fig. 18. The talent pool was given two full weeks to work on their moodboards, receiving occasional feedback from designers from the various brands. At the end of the two weeks, they delivered 3 moodboards they all felt best described the assigned brands.

The first time we applied this approach we were exploring new territory; would it work? Were the students able to capture the different brands? Were they able to differentiate between what fit well and what fit best? In the same period, the company’s innovation-lab was preparing a presentation day to show results

**Fig. 18:** Moodboards produced by the talent pool for different brands. One brand more casual, one more fashion and the third one more business oriented.
and materials collected over the course of the previous months. We took this opportunity to show the moodboards to a wider audience and organized a corner of the presentation room to perform a small experiment.

People entering the area were presented with a print-out showing the 3 moodboards, and posing two questions:

1. The first question was to indicate for each of the moodboards the most likely brand from amongst all of the brands. The expected result was that the moodboards were assigned to the corresponding brands.

2. The second question was, for each of the moodboards and for the brand they indicated the moodboard represented, to circle in red the area least belonging to the brand, and to circle in green the area

Fig. 19: Aggregated overview of the results from indicating the ‘best fitting elements’ on each moodboard.
best belonging to the brand selected. Assuming the brand representations in the different areas of the moodboard applied generally, the expected result here was that the majority of green circles will be found in the upper right corner while the majority of red circles are found in the lower left corner.

In total 50 people participated in the test. Each participant received an A4 with a print of the moodboards. Below each moodboard there was an option to check one of the 3 brands. The participants also received a red and green pen, to indicate the area best fitting for each brand (a green circle) and the area least fitting (a red circle). There were no constraints for circle dimensions. At the end of the day all returned forms were scanned and both red and green circles were aggregated on a single page for evaluation (shown in Fig. 19).

It was not a rigorously controlled experiment; more exploitative (‘fishing’ as my father would call it) with the purpose of checking whether there is reason to believe opinion is unanimous. A proper follow-up experiment would show the moodboards in random order, under controlled conditions and with minimal distractions, allowing the subjects to form their opinion in isolation. As it was, at times groups of 2 or 3 subjects were evaluating the moodboards at the same time, clearly also discussing the moodboards as they went along. In spite of this, the results satisfied our curiosity and gave some confidence about the validity of the approach and its value for developing the talent pool.

Concerning the first question, labelling the moodboards, the answers were unanimous. All participants assigned the moodboards to the appropriate brand. This is not completely trivial. I often show this example during workshops and, after having introduced the brands involved, I ask the participants to assign the moodboards, and especially between the fashion and the casual moodboard there usually is some discussion.

Concerning the second question, indicating best and worst fitting elements, there appeared to little consensus (see Fig. 19). A cluttering of green and red circles was expected in line with the assignment to structure the moodboard from best fitting elements in the upper right to the least fitting elements in the lower left area. Instead we found that both red and green circles are found all over the moodboards. During the day one could observe different behaviours when assigning best/worst fit areas. Some participants would indicate an area, while others singled out one specific element of the moodboard, but all a different one.
Reflecting on the talent pool activity and the results of the validation we made the following observations:

1. Creating moodboards for the brand in the context of two related brands in combination with the task of structuring the moodboards according to best/worst fitting, demonstrated a fast-track towards obtaining a thorough understanding of the brand. The same effect was observed in two subsequent talent pools where we have taken the same approach.

2. The moodboards may reflect only broadly the content they were designed to present, and this high level may be difficult to translate later into single elements.

Based on the experience and results of the verification, we adopted the approach into the standard on-boarding of talent pool. Experience with two subsequent teams showed similar results; accelerated learning about the brands and their differences, moodboards that expressed overall the individual brand although at a detailed level they can be disputed. It also has been the standard approach in the workshops, although in most cases the time for moodboards was limited and therefore the effect less clear compared to the observations with the talent pool.

The ‘customer’, who has no name, no face and no history, and who likes everything and nothing, basically whatever you want; nobody will be able to argue the contrary.

Fred. He is a bit academic but overall creatively practical, able to fit any problem into a solution matrix. He wakes up early, preferably with coffee and something sweet.

Fig. 20: The difference between a customer (left) and a person (right). A customer is faceless and nameless, and will agree to anything. A persona - Fred - has a personality developers can relate to, and of whom they intuitively understand likes and dislikes, and therefore assist the developers in creating a product that the customer (represented by Fred) wants.
4.3 Personas

In 1998 Alan Cooper published the book “The inmates are running the asylum”, evangelizing the method of using personas to give a face to the end-user. Cooper developed the method based on his own experiences as consultant, searching for a way to explain design ideas to software engineers\(^1\).

The basic principle underlying personas is straightforward; in the absence of a specific person you are developing for, you will typically design for yourself. If you set out to build something that your mother would like, most likely what you produce is indeed something your mother likes. Fashion companies have long understood this and typically hire a designer who himself or herself is in fact part of the target audience so that when the designer

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\(^1\) http://www.cooper.com/journal/2008/05/the_origin_of_personas.html
develops something he or she likes, chances are that the target audience likes it as well. This is not possible if you develop something for ‘the customer’.

For you as a designer, working by yourself, developing personas help you to get a better picture of the target customer, which in turn helps in taking design decisions throughout the design process. This is different from ‘knowing the customer’ and ‘having a clear image of the target customer in mind’. Having an image in mind – however clear - is not as confronting as having a picture in front of you on the table.

Personas have especially benefit in teamwork. As your team members are presented with a clear picture of specific target customer they can relate to as if it was a person they know. As such, personas help you to explain why certain properties or solutions are more appropriate than others. Moreover, the discussion shifts from “in my opinion the customer needs...” to “I think Mark needs...”. This shift may seem subtle, but is a crucial one, especially in a team of junior designers. Without using personas ‘the customer’ is not a person you can relate too, and the discussion will be directly or indirectly about ‘your opinion’, inherently making the tone antagonistic and defensive. When using personas, the discussion will be about ‘Mark’. Since Mark is a person you can relate to, you can debate what he would or would not like, inherently making the discussion positive and constructive. This difference disappears with the maturity of the team members, but maybe also the need for personas as tool to guide the discussion.
4.4 Chocolate exercise

What I call the chocolate exercise, is a more structured way of using moodboards. It has little to do with chocolate, other than as a side effect the participants enjoy leftover chocolates, which since I only need a few pieces often ends-up being quite a lot.

The inspiration for this exercise comes from Gibson’s Ecological approach to visual perception which predicted that perception is sense-independent, and from the experiments conducted by Smets and Overbeeke [1989] investigating sense interdependency of information through product design. They performed a series of experiments where they tasked students to design shapes based on specific sensory information, such as smell, taste and sound, and demonstrated that designers are able to communicate the same information via different sensory channels.

With the chocolate exercise, a second layer is placed in-between the ‘sensory’ information, the ‘master object’ and the design process. The layer in between consists of groups of similar objects, each of which are scaled based on how well they fit the master object.

The exercise has two parts. The first part consists of the scaling of the objects. For each of the objects every student is asked to give a rating of how well the object fits to the master object. Based on this, the objects are ordered from best fitting to least fitting. The second part of the exercise consists of one student designing an object based on how the objects are ordered. Naturally, the student assigned to create the design does not take part...
in the scaling of the objects and also has not seen the master object.

The master-object typically is a stuffed animal, for the occasion especially borrowed from my daughter\textsuperscript{1}. It could be anything, but typically I use a stuffed animal because it is endearing (the participants take some time to play with the stuffed animal) and very tactile and tangible.

The groups of objects - scales - include items such as elastic bands, playing cards and chocolates. A scale of elastic bands consists for example out of 10 to 12 items all different in colour or size (and therefore elasticity). The same is true with the playing cards. Typically I use cards from children, and select up to 10. The chocolates are the small ones you get with your coffee. I purchase a small bag, take out the few that I need (one of each flavour), and distribute the remaining under the participants to consume\textsuperscript{2}.

There are a few scales that I repeatedly use in every exercise, since they capture some of the properties of the master object very well. I am convinced, and experience has shown me, that the approach works with any group of objects. To demonstrate this, and also to test my own belief, every exercise has a few objects contributed by the participants. My favourite item to ask from the students is one of their shoes. This is effective as it gets them out of their comfort zone, and into a more open state of mind. Other objects used over the past years include chairs, computer covers, postcards, newspaper pages, pencils etc.

Before starting the exercise, I show the master object and the different

\textsuperscript{1} Borrowing the stuffed animal and convincing my daughter Bear will not come any harm usually is the most difficult part in the whole preparation.

\textsuperscript{2} You have to take care that only left-over chocolates are consumed, and not those from the exercise.
objects to be scaled. The master object makes it’s round (under the strict instructions to be very careful as any damage to the object reduces the possibility of borrowing another stuffed animal from my daughter). Various items from the groups of objects are passed on, so the students get a feeling for the key characteristics of each.

Also before starting, we go through the process of scaling. We discuss how to indicate the degree to which an elastic band matches to a stuffed bear, or a shoe? How well does the Eiffel Tower match with an elephant? Or a lion? Whatever your personal conclusion, you are able to indicate this by assigning a number between 1 (least fit) and 10 (best fit). Most students grasp the concept, but every now and then there are those who do not. They simply find it too strange and resist the experiment. These students will rate most objects with a one. Eiffel - Elephant do not match (obtains a score equal to 1) and neither do Eiffel - Lion. Experience indicates that the impact of sceptics is absorbed by the rest of the participants.

Finally, before starting the exercise we agree on a code to ensure that each object is uniquely identifiable. For example, E stands for Elastic band while C stands for Chocolate. Then when the students rate chocolate number 8 and assign 6 as rating, they write the score on a piece of paper; e.g. C8 - 6.

The process is straightforward. Typically, the students sit in some sort of circle. Then, one by one, I take a random item from the pile and give this to the first student. He or she rates the match, and passes it on to the student sitting next to him or her, who does the same, etc. This continues until all students have rated the match between every item

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1 Not formally assessed. Groups size differs between 12 and 18. Typically, there are one or two sceptic ones.
and the master object. The order at which the workshop participants rate the objects may be different from person to person. Since the speed at which students assign a rating differs, at various locations buffers emerge. The order in which an item is placed in the buffer may not be the same as the order in which the items are retrieved from the buffer.

After all objects have been rated we all unite in calculating the totals for each item. Item by item, and one by one, every student says out loud the rating given for a specific item. As the numbers sound through the room, I add them into a total and write this down. Then, after each item has a total, the items are placed in order from least fitting (lowest total) to best fitting (highest total). Objects that end up having the same totals are placed next to each other.

One time, during the preparation I asked a student to select about 10 chocolates from the pack I brought, unaware that the pack hold less than 10 different ones. After the whole rating process I noticed the student had taken two of every flavour and even while all chocolates went through the rating process randomly, you could see the matching items ending up receiving same or similar total ratings. This being an indication of internal consistency, ever since this ‘accident’ I have made it a rule to duplicate some items, to test for internal consistency. With success.

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**Fig. 21:** Examples of the scales produced during the chocolate exercise
After completing the scaling exercise, all ratings are added giving each item a final score. Based on the final scores, each group of objects is placed on the table ordered from best fitting to least fitting. Experience has shown that all workshop members - even the sceptics - agree the final result of the scales represents the master object.

Now that the scales have been created, the floor is given to the ‘designer’; the one workshop member who has volunteered did not join in the scoring. Having hidden the master object, the designer is presented with the scales, explained the structure (from best fit to least fit) and given the task of designing an object matching the information presented by the scales. The designer has about an hour, after which he or she has to explain what information was read from the scales, before presenting the design. The object to design is something related to the original, e.g. a stuffed animal or a toy.

The ‘reading’ of the scales by the designer is always striking, and the remaining workshop members recognize the master-object in the description. The reading is often more detailed compared to the crude and intuitive way of creating the scales.

Most of the time, the design resembles main properties the master object, but not always. Once there was a ‘designer’ who gave a stunningly perfect interpretation of the scales, followed by showing a design of a ‘stuffed animal’ (as requested) that seemed to have been designed ignoring the scales completely. It was as if the process of interpreting and the process of designing were two complete different activities.

What I aim to illustrate with this exercise is the extent and
flexibility designers have at their disposal to communicate ideas, where communication can be 1) to yourself, by building a moodboard and forcing yourself to decide not only what fits, but also what fits best and what fits worse, or 2) from you to your client or audience, or 3) the communication from your client to you. Offering your client examples to select from, to indicate what fits better and what fits worse may help you in better understanding. What seems at first difficult cultural or linguistic challenge is later revealed to be a simple use of human intuition, relying on shared sensory experiences.

Fig. 22: Examples of the designs created during the chocolate exercise.
Chapter 5 - Prototyping

“A learning experience is one of those things that says, ‘You know that thing you just did? Don’t do that.’”

— Douglas Adams, The Salmon of Doubt
5.1 Why prototypes?

A prototype is an early sample or model built to test a concept or process or to act as an object to be replicated or learned from. This can refer to hardware (i.e. tangible items), but also to software models or simulations. An excel sheet with a model of how a business may develop is also a ‘prototype’. A prototype is anything that is designed specifically to test and validate a new design.

The main reason for prototyping is to give you the ‘oh-I-should-have’ feedback. This is feedback you would like to have before you have the final version of what it is you are building or constructing. For example Fig. 23; let’s say you are building a chair and you are trying a classical connection method using dowels. If I would have created and tested a prototype, I would have realized that the diameter of the dowel is critically important and should not be selected too small. I now have in our living room a chair that is almost perfect, and a constant reminder of the ‘oh-I-should-have’-importance of prototypes.

As the purpose of a prototype is testing, a prototype is not defined by its quality, i.e. the material used, the precision of manufacturing, the choice of colour, the finishing applied etc, provided it serves the purpose of testing. Clearly, the material and manufacturing quality used must be selected based on the purpose of the prototype. For example, if you want to test the maximal load balance of a bridge you will not build a bridge from paper, although a paper version of the bridge would be sufficient to evaluate the aesthetic properties.

Fig. 24 shows a matrix with the generally accepted guidelines on situations in which prototypes are more likely or more appropriate. Basically, this depends on the risk of the final product as well as the cost.
of producing a prototype. The higher the risk, the more likely the design process is supported by prototypes, while higher costs inversely relate to the likeliness of using prototypes throughout the development process.

Types of prototypes are typically split into horizontal and vertical prototypes. A horizontal prototype is one that covers the product or process from start to finish. Typical examples of horizontal prototypes are fire-frames. The purpose of horizontal prototypes is to clarify requirements and to validate the scope. Vertical prototypes, however, focus on a specific aspect of the product and make a working version. The purpose of a vertical prototype is a (technical) proof of concept; to show the design will function under realistic load and use.

5.2 Prototype quality

The quality of the prototype (e.g. finishing, precision, care of creation) often is taken as proxy for the quality of the thinking leading to the prototype. Although those who have built prototypes know this is not necessarily related, but still motivates you to build a presentable prototype for every stage of the development process. However, this sometimes undermines the effectiveness of your prototype as means of testing and validating. Test subjects’ reaction and feedback often depends on the quality of the prototype. They may react differently to a sketch compared to a perfect rendering. With a beautiful rendering you may find them hesitating to even touch or point, while with a sketch they will be immediately look for their pen, even while talking to you. Depending on the phase of development and the
characteristics of the product you are testing, you have to balance quality and finishing to optimize feedback.

I experienced this difference when I was called in to help evaluate a new software prototype. The development team told me they had produced a prototype, which they had evaluated with a few end-users. The feedback collected up to that point was very poor at best. To the users, everything seemed good and perfect. Too good and perfect, which contrasted with the feeling within the team. I participated in one of the evaluation meetings and verified that the end-user had little or no comments about the prototype. Except maybe for the position of the logo and the colours used, all seemed perfect. I am exaggerating a bit, but software, and especially software prototypes, are difficult to prototype for two key reasons. First, it is easy to make a software prototype appear like a finished product. With some artistic skill, basic web technology or even using a simple presentation tool, you can create a prototype running on your iPhone, which you can make to look like a finished App. The prototype from the example here is shown in Fig. 25. It shows two screens, one of which is the prototype (after two weeks of hacking) whereas the other is the real application, which took at least another 6 months to complete. I do not recall anymore which one was which, and at the time the state of development was also not clear to the end-users who were asked for feedback. With prototypes like this it is difficult to understand the state of development. This is less likely to occur with physical products. Take Fig. 26: ‘Prototypes’ of Citroën’s Ami6 and the first ‘release’ (1964).
Fig. 27: A paper model of the Citroen AM6. Try to sell of this ‘prototype’ for a real car.
for example the images in Fig. 26 of the 1963 Citroen Ami6, or the paper model in Fig. 27. Nobody will have difficulties understanding which is a prototype.

Just out of curiosity, I created a new prototype (see Fig. 28); obviously hand-drawn, and went back to a few of the end-users. This prototype, although in terms of structure was a copy of the previous version, it was more clearly in its initial stages of development. By presenting itself for what it was; a first sketch, this prototype invited a completely different type of feedback and discussion. Subjects revealed more flaws and eagerly looked for a pen to make corrections, resulting in a list of issues for the development team to chew on. This is exactly the purpose of prototypes; to invite examination and criticism. At the early stages of development a prototype that clearly shows the state of development, like the sketch in the example, is often more suitable to invite feedback compared to a more polished looking prototype, which may make users reluctant to criticize. Or worse, they may leave with the impression that the product is almost finished. Another risk of polished looking software prototypes is illustrated by the case of a member of the marketing team testing a prototype and then one week later informing us that he already had a potential customer, and inquiring about release dates.

Prototypes help to ‘ground’ the discussion, to align different views and expectations. This is true not only for discussions with the client, but also between members of the design team, helping to facilitate work across disciplinary borders. A prototype cannot be disputed as a written description can. In this way, prototypes help to get a formal approval at each stage of the process.
Fig. 29: Examples of cubes produced from polystyrene (class of 2009 and 2010, ZHdK).
5.3 **Tools & Materials**

The materials and tools selected impact the prototyping and ideation process. Often, prototyping is a process of searching; to find a way to express the image or idea you have in your mind, maybe not yet very concretely.

Also in the workshop the impact of the material on prototyping is very visible. As described before, during the workshop I request students to build a prototype with the purpose of then testing in a next stage. This has also been a learning experience for me. Initially, during the first few runs of the workshop, students were free to select their tools and materials. This resulted in a wide range of prototypes of different quality, which made any testing beyond the evaluation of the individual prototypes impossible.

With the aim of integrating structured testing, I changed the approach to prototyping. Instead of having to design a ‘product’ the students were given two opposing emotional expressions and a target segment. For example, a student would receive as an assignment calm vs. hasty and casual. That student would then have to design an object that targets casual users (e.g. Diesel, Lee etc.) and that expresses ‘calm’, as well as an object that expresses ‘hasty’, for the same target customers. Students were constrained to using the same materials by starting from a cube of Polystyrene 10 cm x 10 cm x 10 cm large. They were allowed to cut off parts and also reuse the cut off parts. However, they were not allowed to add material (see examples in Fig. 29).

The last part of the assignment was to make two versions of both models, so that they could exchange prototypes and give a wider context to the test to be performed. This validation exercise is described in Chapter 7.

Due to time constraints, polystyrene proved most practical. It allows a sculpting approach to prototyping, meaning that it is possible to begin building starting from an initial vague idea. One year we used paper as base material. The starting point again was a cube, but now one made from paper, with dimensions 65mm x 65mm x 65mm (see paper models in Fig. 31). Fig. 32 gives a few examples of the cubes created.

Working with Polystyrene shows two key differences compared to working with paper. First, the approach is different. With paper, instead of sculpting and slowly approaching the target shape and form (as you can do with Polystyrene), you can only start building after you have defined a finished concept. Naturally, also with polystyrene you can design your concept before prototyping, and many students worked in that way. However, none of the prototypes made from paper had
Fig. 30: Examples of cubes produced from paper (class of 2011, ZHdK Zurich)
the appearance of being sculpted, but instead were the result of various intermediate attempts. Working with polystyrene, only one prototype was created. In general, this means that depending on the material selected, you force a creative process with more iterations.

The second difference between prototyping with paper and polystyrene is the shape of the objects. With polystyrene, prototypes are much more likely to have organic shapes and forms. Paper does not offer itself for freeform design, or only after sufficient practice. This means that the material selected for prototypes constraints or extends the freedom in shape and form.

Fig. 31: A paper model of a cube, used as stating point for the prototyping exercise
Exciting new developments allow you to have much more freedom in the initial prototyping. Software like 123D Catch allows you to create a digital model of any object. For product designers, the opportunity of this is that the initial prototype can be sculpted from any material. The real object has to endure the scanning session. Following the scan, a 3D model is achieved and can be modified further, and then printed in 3D in a variety of materials.

There are several ways of scanning a real object. One way is using a Kinect, which is the motion sensing input device for Microsoft Xbox 360. To create 3D models you can use software applications like Skanect; a low-cost Kinect-based 3D scanning software. It captures views of an object or a room and automatically computes a metric 3D model, in real-time. Skanect can also detect planes, such as floors.
to download App that allows you to create 3D models using an iPhone or an iPad, based on a sequence of maximum 40 photos, which after uploading to the Autodesk® server, are processed into a 3D model. See for example Fig. 33.

Scanning by itself, although interesting, is not enough. As an approach to prototyping you will also need to have the possibility to print in 3D. This is also now up and coming, and will have potentially far-reaching implications on design and the design process. The possibility to print objects directly in 3D can – potentially – mean that local, custom-made goods will replace those produced on assembly lines, effectively creating new business segments. It may bring manufacturing jobs back to the west, and possibly create new opportunities for designers and producers. Imagine that in a near future, instead of going to the shop

Fig. 32: The process of capturing a 3D model via the 123d Catch software. You take pictures from all sides, up to 40 different ones. These are send to the Autodesk® Server where they are compiled into a 3D object, which is send back to your iPad or iPhone.

and walls, and perform automatic ground alignment.

In the mean time Kinect-based scanning tools seem to be overtaken by more advanced camera based solutions like 123D Catch, as released by Autodesk® (see www.123dapp.com). It is a free
I have to show you something. Let me know what you think...

Just a mock-up, but an interesting idea.

Imagine that you can print shapes in 3D directly from your brain. Just by thinking of an object, it will be printed.

You just put this helmet on and think about any object, and...

Voila! Wouldn't that be wonderful? A real chair, printed from thinking about it.

Well, this is just a mock-up.

Not real.

Now the challenge is to develop the technology that can actually realize this. But printing from the brain, wouldn't that be awesome?

What do you think?

Actually, we are doing something similar, but much more simple.

Wit a smart phone...

With a smart phone...

With a smart phone.

Yes, let me explain. Imagine you like to create a new handle for this here hand drill.
NOW I JUST TAKE A BIT OF MOLDING DOWN AND CREATE A NEW VERSION OF THE HANDLE

AND THEN I WILL TAKE PICTURES FROM ALL SIDES OF MY NEW HANDLE

NOW SIMPLY TAKE SOME PICTURES WITH MY SMART PHONE, ABOUT 30, TO CATCH ALL ANGLES AND SIDES.

THE I UPLOAD THE IMAGES TO A WEB-SITE WHERE THEY CAN CREATE A 3D MODEL BASED ON THESE IMAGES.

NOW THAT I HAVE THE 3D MODEL, I CAN ADD THE CONNECTORS SO WE CAN MOUNT IT TO THE DRILL...

OK - NOW COMES THE HARD PART. WE HAVE TO WAIT FOR THE PRINTER TO FINISH...

...NOT THAT THE PRINTER IS SLOW...

...BUT NO MATTER HOW FAST THEY MAKE THESE PRINTERS, IT ALWAYS WILL BE TOO SLOW WHEN YOU ARE WAITING...

AND HERE WE HAVE IT. A FIRST REAL PROTOTYPE WE CAN TEST AND GET USER FEEDBACK ON.

ALL THAT YOU NEED IS SOME OUT-OF-THE-BOX TECHNOLOGY...

TO SET YOUR IMAGINATION FREE.

UNBELIEVABLY ABSOLUTELY WONDERFUL.

WHAT WAS I THINKING...?

...PRINTING A CHAIR FROM MY BRAIN...

...I SHOULD HAVE BEEN MOLDING WITH MY - SH - BOTTOM.

With thanks to Claudio Boër
to buy a pencil, you print it right at home. You might find yourself printing your custom cookies to serve fresh with coffee. The newest toy for your little brother is printed in the shop while you wait. The possibilities are immense.

For the product designer this offers new ways of creating and preparing prototypes; the simplicity at which an object can be scanned and turned into a printable object allows you to use any material to prototype.

Fig. 33: Example of the 3D scanning and printing process. Above you see the real object, and below it the 3D virtual model after scanning with 123D Catch. On the left you see the printed physical model.
Chapter 6 - **Test & Validation**

“11 out of 9 persons do not understand statistics”

- Unknown
6.1 Method of Validation

This chapter gives a brief introduction into research, specifically empirical research. We explore how to test your design, and how to test it early. It is not my intention to make you an expert in testing and experimenting, but to provide you with a basic understanding that helps you to validate your design in a meaningful way. For a detailed overview of conducting empirical research, see for example Leedy & Ormrod (2004).

In this scientific age\(^1\), there is an increasing emphasis on predicting a product’s success, or to tune it to ensure success. You will be expected to test your product and validate user acceptance or usability. One challenge is that at the end of the process, when you have an almost finished product, room (time, budget) for changes is limited. On the other hand, at the beginning of the design process, you have no product yet to test, and you may even lack the overview of either the problem or the solution space. However, at the start of the design phase is when you have to focus on customer needs, action/perception, and usability issues, because at the start of the process you can still influence them.

Today, evidence from experiments is regarded as the most powerful support possible for a given hypothesis. Empirical research is the approach of validating hypotheses through experiment. It is data-based, drawing conclusions based on observation or experiment that can be verified. It is the generally accepted approach to scientific research\(^2\).

The basis for empirical research is the experiment, which is an orderly procedure which establishes a hypothesis and then aims to prove it true or false. This process can be split into a few basic steps, which are illustrated with the example “Broadband, how wide should the pipe be?”, as described on the next pages.

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1 For an excellent and critical reflection on our scientific age, please read “The meaning of it all” from Richard Feynman.

2 Main critique against empirical research is formulated in ‘Two Dogmas of Empiricism’ a paper by Willard Van Orman Quine. Published in 1951. See http://en.wikipedia.org/wiki/Two_Dogmas_of_Empiricism
Broadband: how wide should the pipe be?
Investigating end-user constraints on data accessibility

Broadband is maturing and becoming within reach of every consumer through the development of new technologies to establish internet connections. The connection is commonly referred to as ‘pipe’. In particular, the dimension of the pipe determines the amount of data you have access to per time interval. There are two factors of the pipe influencing the data transmission speed; it’s length (shorter is better) and its width (wider is better). See illustration on the right.

The influence of the pipe dimensions on the end-user experience remained unknown. Not surprisingly, technical advances are driving the broadband market, largely ignoring the end-user experience. It is simple to say, ‘wider is better’ but what is ‘wide enough’ in the consumer environment?

What is the effect of pipe dimensions on the end-user experience? As a starting point to evaluate this, we started from pipe dimensions that are commonly found in consumer homes, such as illustrated by the photos on the right.

Prototypes have been developed to systematically explore the influence of pipe dimensions on the end-user experience when it comes to consuming broadband content. We named these prototypes ‘GLobal Information Sensi-tive Experience transducerS (from here on referred to as GLASSES™).

Two parameters were systematically varied; the length of the pipe (long/short) and the width of the pipe (wide/narrow), resulting in the four prototypes as shown in the figure on the right.

An experiment starts with hypothesis, i.e. not an ‘educated guess’, but a possible explanation of an observable phenomenon. **Something** (the independent variable, which you manipulate) causes an **effect** (the dependent variable, measured result). For example, ‘a better Internet connection increases the end-user experience of multimedia content’. You should be able to formulate a hypothesis in the following form; ‘if **<the in dependent variable>** <define change>, then **<dependent variable> will <defined change>**’. For example; ‘If access to data improves, then the end-user experience improves.

The hypothesis is then translated into an experimental design; formulating the specific conditions you are testing. In the example, we identified the distance (pipe-length) to the source and the throughput of data (pipe-diameter) as main factors
Subjects were presented with content, half of which was multi media content, and the other half was plain text. They were instructed to grade the page on a seven point scale, running from highly interesting to extremely dull. There was no time limit.

In total, six subjects participated in the experiment. All subjects were member of the Fantastic Corporation R&D department, who happily volunteered, after making participation part of their MBO.

Stimuli and conditions were randomised for each subject. Measured were the grading of the web pages and the amount of time used viewing the page.

Pipe dimensions were found to effect with multimedia content. For text only pages only a small effect was found if the differences between conditions were extreme (a small and long pipe verses a short and wide one). For the grading of the pages, the best condition was found to be a short and wide pipe. A short and wide pipe results in significantly shorter time usage compared to a long and narrow pipe.

Our interesting findings have motivated to continue this research, specifically to further investigate data filtering by using semi transparent reception, the so-called Partially OccLuding trAnsmission pROtocolair Information Device (also known as POLAROID™, see figure on the left) in comparison to pipe dimensions.
prove you wrong, and indicate what is ‘good’ as well as which of the parameters are most important (i.e. which seem to be the determining factor to explain the results). Even with a few subjects you should be able to discover which parameters are moving the needle.

Both experiment and results inspire next steps and further development, which is our intention right from the start.

Karl Popper radically changed our view on the hypothesis by introducing the concept of doubt or falsifiability; proving a theory or hypothesis false by way of observation. The classical example is the one of white swans. How do you know (or prove) swans are white? Are you testing for the hypothesis: “All swans are white” or are you testing for the alternative hypothesis; “there are no swans that are not white”? In the first case you would go about and count all the white swans you meet, assuming the more you find the more proof you have to support your hypothesis. Popper turned this around through falsification; instead of trying to prove yourself right you should try to proof yourself wrong (and hopefully fail), i.e. test the alternative hypothesis; “there are no swans that are not white”. Thus, you have to count the swans, which are not white. If, despite sufficient effort, you end-up with zero counted, you cannot but conclude that you were right after-all.

Doubt is a fundamental property of modern science based on the belief in the ignorance of experts and researchers. By doubting assumptions it drives progress. With doubt as cornerstone of research, there appears a close relation to the principle of design; both science and design trying to understand and resolve where things go wrong.

In my experience, adopting doubt in the design process, especially during the tests and validation, is highly inspirational for the design process, continuously pushing...
concepts and products to further perfection. Tests are targeted at uncovering how the design fails, how it does not perform as briefed or as intended, up to the point where you have the situation of non-performance.

My experience is also that as a designer, you are somewhat in a luxury position compared to a scientific researcher because you are not aiming for universal truth, just for constructive feedback that helps drive your design in the preferred direction. Take for example Rietveld’s Red and Blue chair (shown in Fig. 23). This is a chair that is designed not for comfort, but to “keep the sitter physically and mentally ‘toned up.’” [Eli Siegel, 1964, see Romeo] as “Rietveld was not interested in conventional ideas of comfort”. As a designer you have the luxury of choosing your criteria based on artistic freedom.

Likert scales

We all know Likert scales from questionnaires, where you have to indicate to what degree you agree or disagree with a statement on a scale from one to 10. Such scales are known as Likert scales. Likert scales are named after its inventor; the psychologist Rensis Likert. A typical Likert scale is “Strongly Agree - Agree - Undecided - Disagree or Strongly Disagree”.

Often there is a debate about the number of items the subject can select from. Should it be a 4 point scale, a 5 point scale or even a 10 point scale? If you search literature you find that at least three points should be used (Cohen, 1983), but not more than 9 points (Bass, Cascio, & O’Connor, 1974). I like to stick to 5 or 7 point scales. Less than 5 (meaning 3) offers the subject very limited options; either ‘agreed’, ‘not agreed’ or ‘no opinion’. It makes it more difficult to find difference between questions/measures (i.e. you need more subjects to find significant differences). I prefer to use at least a 5 point scale. With 7, and especially 9 or more, I have the impression subjects have more difficult to differentiate between the options.

I prefer to use a scale that has a center-point, to allow subjects to indicate indifference. Forcing a decision by using a scale without center-point only makes the analysis less intuitive and more difficult to explain. Also, if they are indifferent, often I would like to know that.

Scales need to be clear so your subjects can easily make their selection. Labels such as “often” or “sometimes” often result in inaccurate responses.
In the case of a small sample (few subjects/few responses), as a simple guideline, I basically ignore more than two points. For example, if your sample is comparatively large, you can resort to a Chi-square test or a parametric test (e.g. ANOVA). In any case; check.

6.3 Significant?

Assume you need to compare the effectiveness between two design options; Design A allows subjects to perform the task in 2 minutes. The same subjects performing the same task but with design B take only 1 minute and 45 seconds. If the goal is to minimize the time to perform the task, is design B better than Design A? In other words, is the difference significant, i.e. due to the variations in the designs, or is the difference the result of chance? Differences that (most likely) are the result from your test conditions are labelled as “Significant” whereas differences that are (more likely) to be the result of chance are labelled “Not significant”.

This is not the place to go into depth about statistics, and I am not the person to do it. What you should understand however is that a numerical difference found may or may not be significant.

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1 The one-point difference guideline once was mentioned to me by someone with more than average knowledge of statistics and experience working with small samples. However, I did not manage to find any reference to this.
6.4 Overview of methods

There are a large number of usability and test methods that can be instrumental during the design process especially to investigate function-related needs and requirements. These methods differ in the quality of information they provide and in which development phase they are most applicable.

The quality of information provided by test methods ranges from what you can observe, opinions and actions. As product design is inherently about function, the most useful information driving development are methods, that give you information about what people do, how they act, and why they act in the way they do.

The development process can be split into phases. For simplicity reasons, I have split it into three phases; the analysis phase, the design phase and the evaluation phase.

The information qualities and the development phases together shape a matrix that may be instrumental in selecting the most appropriate test/analysis method.

The table on the right (page 85) gives an overview of most commonly used test/evaluation methods. For detailed descriptions please refer to for example Dumas et al (1993), Mayhew (1999) or www.usabilityfirst.com

“A Fool with a Tool is Still a Fool”

Grady Booch
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<tr>
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Questionnaires

A questionnaire is a ‘tool’, a structured approach, for collecting data about a particular issue of interest.

The questionnaire was invented by Sir Francis Galton. Questionnaires have advantages over some other types of surveys in that they are cheap, do not require as much effort from the questioner as verbal or telephone surveys, and often have standardized answers that make it simple to compile useful data. However, such standardized answers may frustrate users. Questionnaires are also limited by the fact that respondents must be able to read the questions and respond to them, which means you have to take special care about construction and wording.

Personally, I take a sceptically view of questionnaires, mainly because they deal with what people say, and not with what people do, which for all kinds of reasons, may be different.

If you do find yourself resorting to questionnaires, remember the most fundamental rule for developing questionnaires: don’t.

Do not develop a new questionnaire unless you absolutely have to. Developing one takes expertise time and effort to make sure that it is reliable and valid. You are better off using an existing one, that has been used before, than developing a new one from scratch. If you end-up developing a questionnaire, make sure to read the many hints and guidelines on what to consider when developing and conducting questionnaires available on the web. Also, make sure to test it. A good questionnaire will include some questions that permit a validation of the questionnaire itself.

Two aspects to test a questionnaire for are reliability and validity. Both concepts are illustrated in Fig. 34. ‘Validity’ has to do with how well you are able to measure what you set out to measure. For example, if your questionnaire evaluates the public opinion of JUMBO do you measure the opinion about the toy maker

“Present somebody with a questionnaire clipboard, and they lie. A friend of mine once had a job preparing a questionnaire for people to fill in on the Web. He said the information they got back was enormously heartening about the state of the world. For instance, did you know that almost 90 percent of the population are CEOs of their own companies and earn over a million dollars a year?”

Douglas Adams
Most importantly, testing means checking that the questionnaire delivers actionable results. Can you do something with the data collected? The purpose of a questionnaire is collecting data based on which you can draw conclusions and define actions. This is what you have to test. Therefore, testing means using the questionnaire to collect information and trying to draw conclusions, and checking if the questionnaire gives you the answers you are looking for. The next example is based on my experience when Rucky Zambrano asked me to validate the impact of the insole on the performance of a golf shoe. At the time Rucky was developing a new Golf shoe, insoles. He had a few ones lined up, had tried them, but had no empirical basis on which to base his choice. We decided to check whether a user (golfer) could perceive the difference between the selected insoles considered. What we needed were test subjects (able to play golf) and metrics to compare fitting of shoes. Following the previously stated guidelines, and knowing within the shoe department that regular fitting tests were being performed, we first checked if within the company there was already a check list or questionnaire to support fitting tests. Inspection revealed that, yes there was a check-list, but no, it did not appear to be appropriate. It looked like the checklist was used to document the result from fitting tests, but that the collected data were not further analysed. As a first step, we developed the check-list. This involved updating the list

Did it matter? What difference does an insole make? Would you even notice the differences while swinging a golf club?

Fig. 34: Validity and reliability are important concepts to remember when choosing or developing a questionnaire

or will the results say something about the newly born elephant in the local Zoo? ‘Reliability’ has to do with the consistency of the results. For example, when you sample the same group multiple times using the same questionnaire under conditions where the opinion has had no reason to have changed, to what extend will you arrive at the same results?

---

1 Team Leader Creative Management within the shoe & accessories department of a major fashion company
based on input from shoe experts on what parameters to survey for, to judge quality of fitting. Next, we used the updated check-list in a fitting test; a number of persons trying and evaluating a large set of prototype shoes. The collected data was analysed, for consistency and reliability, as well as for detecting differences in fitting and comfort. Analysing the data collected - thus, testing the check-list - revealed a number of issues and weaknesses, and it took two more fitting tests before we were confident the check-list was reliable and accurate, at least reliable and accurate enough.

Armed with the improved form, a set of prototype golf shoes and a set of differently dimensioned insoles, we headed to the green and performed a small experiment, and collected information needed to select the most appropriate insole to be used. We learned that during swinging, the difference of a few millimetres in insole height was noticeable. We also learned that we were performing the wrong test; swinging and hitting the ball may not be the most important part of playing gold, it covers only a minor proportion of the time spent on the green. Most time is spent walking, going from one hole to the next. Therefore, primarily, the shoe has to be comfortable while walking. Based on the data collected, both via the check-list as well as by talking to the subjects, the most comfortable insole was selected and later used in the final shoe.

This experience showed the value of properly testing the check-list/questionnaire before using, and also the importance of talking to the end users in person, and not only via the checklist or questionnaire. At least, until you know the limitations of the check-list you are using.
6.6 **Wizard of Oz**

The Wizard of Oz is a wonderful approach to validate interactive products early in the design phase, basically before any of the interaction is actually working (technically).

The Wizard of Oz approach is named after a character from the movie with the same name. In the movie, the main character named Dorothy embarks on a quest to find the Wizard of Oz, to help her find her way back home. When she finally finds the wizard, she discovers he is actually a fake. All of his ‘wizardry’ is staged by machines which he operated from behind a curtain. The ‘Wizard of Oz’ method applies this fake wizardry to testing interactions.

A ‘wizard’ operates controls to make the illusion of the existence of a fully functional product, or at least the interaction under investigation.

An effective way to demonstrate this principle and to test Wizard of Oz approach in a workshop, is by testing different forms and shapes of computer mice. Assume, for example, that the cup shown in Fig. 36 is a new kind of mouse. You can test this by having a ‘wizard’ copying with a real mouse each and every movement made with cup. The person moving the cup will ‘experience’ the cup as mouse (even if the control may not be perfect).

![Fig. 36: Plastic cup used as computer mouse in a wizard of Oz experiment](image)
To make this a bit more challenging, you can use a wide range of objects. For example a photo camera, sun glasses, a toy fork-lift truck. Workshop participants first have to decide/design how to make the functions of a mouse on the object received. How would you map the functions of a mouse on a sunglasses? Or on a photo camera? Working in groups, they have to define and document the mapping. Also, they have to practice playing the wizard. Second, a random member of the workshop is given the task use the ‘mouse’, to find out how it needs to be operated, then use the mouse to make a specific drawing in a paint application (see Fig. 37). The task of the wizard is to make sure the mouse reacts as previously defined.

What you see during these experiments are two things. First, with respect to playing the wizard, everybody immediately grasps the concept and all mouses turn

Fig. 37: Overview of a Wizard of Oz experiment, as used to verify the affordances of existing products. On the left you see two examples of images drawn with the different ‘mouses’
into fully functional prototypes without problems. Second, in terms of mapping functionality, there emerge two approaches. One is the ‘it is just a mouse’ approach; independent of the type of object or its shape, the object is just a mouse meaning the user will place his/her hand on it and start moving it like a normal mouse, ignoring the specific features and functionality offered by the object. Second is the ‘it is an object’ approach, where the use of the object are mapped on the functions of the mouse. For example, you wear sunglasses, therefore sunglasses as a mouse are worn and you point the cursor by looking at a location. A camera is for pointing, therefore as a mouse you point and ‘shoot’ (see e.g. Fig. 37). Fig. 38 shows the instructions of a mapping of a Rubic’s cube, where the ability to turn is mapped on the mouse functions.

The test showed that the ability to turn was ignored by the subjects,

**Fig. 38:** Example of an ‘it’s an object’ mapping; the functional properties of a Rubic’s Cube as a cube are mapped on the functions of a mouse.
Fig. 39: With glasses two approaches are frequently seen; as object on the table (as here) where the movement possibilities are mapped on those of a mouse, or as glasses you need to wear. (example created by Nando Schmidlin & Roman Schnell)

Fig. 40: Also scissors offer a very prominent handling, which can be mapped on the functions of a mouse (example Lorena Linke).
Fig. 41: Using a calculator as a mouse. Main challenge is the mapping of the large number of buttons on the mouse functionality (example by Salome Fuchs, Lorenz Wipf and Lorenz Schibler).

Fig. 42: A kitchen spoon. Users tend to try it as a pen. In preparation the mouse-function is mapped in a more creative way (example by Khanh Tran, and Samuel Beer).
who instead moved the cube as a whole.
Performing this exercise at the beginning of the workshop sometimes inspires adaptation during the prototyping part in the following days. Francesca Riva (Class of 2006, SUPSI Lugano) who was tasked with designing an intrusive egg timer (see Fig. 43) showed a nice example of testing a rich interaction by simple mean. The egg timer was designed to emit an intensive light while producing an intruding sound. To validate the impact and effectiveness a prototype was created to include a lamp with a remote switch, and for the sound a mobile phone with a carefully selected ring tone. Invisible for the user, after the indicated time had passed, Francesca would call the mobile phone, and in the time the connection was established, switch the light on. In combination it created an impressive effect, even for the prepared/experienced user.

Fig. 43: Egg timer, designed by Francesca Riva (Class of 2006, SUPSI Lugano). When going off it was designed to show an intensive light and produce an intrusive sound. It was tested using the Wizard of Oz approach, by including a lamp with a remote switch, and by including a mobile phone.
Task performance

Task performance is a method used to obtain quantitative data, which is most useful in doing comparative testing, or testing against predefined benchmarks; you obtain numbers to easily compare conditions. With task performance - as the name says - you let a subject perform a task, and measure the outcome. See for the example on the right (see Voorhorst et al. 2000). Developing an interface for an augmented reality system we were challenged with the design of a fitting menu structure. We designed various options (conditions) and had subjects perform a simple task under each of the conditions while measuring time and as well as menu interaction. After analysing the test results we found that the difference of how menus were

Tangible Menus - Beyond the desktop metaphor

Build-It [Rauterberg et al. 1997] is an AR based planning tool based on intuitive manipulation for the support of planning and configuration tasks. It has a so-called graspable user interface. With build-it, the interaction proceeds by means of rectangular bricks that are tracked using an infra red detection system using a video camera. One of the potentials of this technical set-up is the possibility to take the menus beyond the desktop metaphor, as allows for looking at hardware solutions such as a real catalogue, from which objects can be selected directly (see Figure 1). Implementation only requires a unique code on the page of the catalogue, that can be picked-up by the system’s infra red device. Potentially, the page layout itself can serve as coding.

The experiment was performed using a mock-up Build-it system, consisting of a cardboard frame on top of a table, and four real menus with real objects. The area below and extending beyond the borders of the frame represents the virtual environment (VE) and the area above the frame is the real environment (RE). Four menus were used each with different objects (rectangular, triangle, square or bar). Subjects were shown a configuration which they were asked to rebuild as accurately as possible.

The four menus used in the experiment (left) and an example of the configuration to recreate (right)

Subjects were asked to perform as good as possible, not as fast as possible. Although, it was expected that the time needed to be less for easy conditions compared to difficult conditions, no time differences were found. However, results did indicate two types of strategies. Strategy 1 is the optimization of menu access and is used when menus are difficult accessible. Subjects optimize the number of changes between menus by accessing each menu only once. Strategy 2 is the optimization of task performance and is used when menus are easily accessible. Subjects selected freely from different menus, depending on the menu item that is needed.
constructed had no impact on task completion, but did impact the strategy adopted to perform the task. Even though this technique is aimed at collecting quantitative data, it should be noticed that it is very important to collect qualitative data to uncover the user’s mental processes driving the quantitative data and to take them into account while drawing the conclusions.

6.8 **Heuristic evaluation**

Heuristic evaluation is a (usability) inspection method originally developed for computer software. The idea is to have experts discuss the software and try to identify problems in the user interface based on their knowledge and experience; i.e. “heuristics”. (see Nielsen & Molich, 1990). Research indicated that a group of 5 experts reveal 75% of issues (Nielsen & Landauer, 1993).

The advantage of Heuristic evaluation is that you can apply it to the initial stages of the development process, i.e. having the experts discussing early prototypes or product sketches. All it takes are a few experienced users, a room, some good pizza and drinks.
NOTES
Chapter 7 - In practice...

“It doesn’t matter how beautiful your theory is, it doesn’t matter how smart you are. If it doesn't agree with experiment, it’s wrong.”

Richard P. Feynman
Putting into practice

How can we combine the topics discussed so far into a one week workshop? The challenge is to put all of this together to define an assignment in such a way that a full iteration can be completed from moodboard, prototype, test and design in a short time. After several evolutions, this was achieved by focussing the assignment on three aspects of the product design canvas, while ignoring four other aspects.

The aspects defined are: the product, the task/objective, and the quality of interaction (a property of action/perception);

- A quality of interaction. To focus the design assignment on expression, beyond function and usability, each of the participants or teams receive a set of emotions. These emotions are grouped into opposites, each of which have to be addressed. For example; Delicate and Robust, Intrusive and Bland, or Frustrated and Relaxed.
- A customer segment. What works effectively are the following 3 segments; fashion, business and casual. Of these, casual is often the most difficult to understand, which I always find funny as most students dress and act as casual as it gets.
- The product. The requirements for the product to be designed are quite simple; it should have more than one function. If it only has one function the final designs inherently end-up having one big red button, so ‘the interaction is clear, right?’ No. The type of products addressed includes items such as egg timers, light dimmers, car key (with integrated alarm), or thermostat.

The next pages show a number of examples from the work produced during the workshops.
7.2 Intrusive Egg-timer

An intrusive Egg-timer designed by Francesca Riva (Class of 2006, SUPSI Lugano): “If you would like a joke this eggs timer is perfect for you, because it is explosive and funny. You can put inside the bomb what ever you want, for example a many small beads or flour or water. Then simply pull the chord and the timer is on. It then ticks away until the final hour.”
7.3 **Gentle light-dimmer**

Proposals for a *gentle* light-dimmer by Mara Drago (Class of 2006, SUPSI Lugano), and an overview of findings from an initial test, as well as corrections based on this.
7.4 **Intrusive Light dimmer**

Prototypes for an ‘intrusive light-dimmer’, by Gunita Bogdane (Class of 2006, SUPSI Lugano).

Here, selecting the preferred light colour dims the light. You can select the colour of the light (dim the light) by selecting the sphere with the colour of your choice.

**USER MANUAL:**

1. Turn light on: press on any light globule you like and you’ll have the same light in your room as the pressed little ball is.
2. Turn light off: press white ball.
7.5 **Water-kettle**

Water-kettle, interface designs and final impression by Alischer Makarow and Christian Kuhn (Class of 2009, ZHdK Zürich).
7.6 **Dull car-alarm**

Proposals for car alarms, designed by Björn Olssen (Class of 2007, ZHdK Zürich), based on the dull/exciting theme. Shown here are the on/off states. The image below is the designer’s impression of a more elaborated design.
7.7 Taxing iPod

Proposal for a ‘taxing’ iPod, designed by Karin Meier (Class of 2007, ZHdK Zürich). Exploring contrasts, also two ‘easy’ versions were created.
7.8 **Fashion/Delicate Lightdimmer**

Barbara Steiner and Fiona Knecht (Class of 2008, ZHdK Zürich) were tasked with the design of a Fashion / Fragile Light-dimmer, and managed to complete the process of creating a moodboard, validating expression of Delicate/Robust/Intrusive/Bland through cubes, and elaborating information collected into a first design, within the timespan of one workshop.
7.9 **Fashion doorstopper**

Fashion companies dress their offices like they dress their customers; stylish, qualitative and with eye for detail. Except for the door-stoppers (see Fig. 45), which made an interesting workshop assignment.

![Fashion doorstopper](image)

**Fig. 45:** Inspiration: a pair of beautiful feet, nice shoes and a plain - out of place - wooden door stopper.

**Fig. 44:** Models created by the class of 2012, ZHdK Zürich; reto berger, pete patrick bürgy, angela forster, fritz gräber, philipp langenbacher, lorena linke, myriam marti, ivo mauch, stefan pfister, nando linus schmidlin, roman schnell, luiz schumacher, livia weder, and kristina weimer.
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