ANIMATION-BASED SKETCHING

AN EXPLORATIVE STUDY OF HOW ANIMATION-BASED SKETCHING CAN SUPPORT THE CONCEPT DESIGN OF NON-IDIOMATIC DIGITAL TECHNOLOGIES

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PETER VISTISEN

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This linking text uses passages and paraphrases from the papers and book at places where the same arguments has to be presented.

AUTHOR CV

Peter Vistisen received his Master in Interactive Digital Media, from Aalborg University, in 2011. He immediately started working as a part-time teacher, and researcher at Aalborg University, as well as freelance interaction designer doing digital design work for various clients. In 2013, he started as a PhD-student at the Department of Communication & Psycology at Aalborg University, affiliated with the research center for Interactive Digital Media & Experience Design (InDiMedia). His research interest is design thinking, especially in regard to strategic design possibilities with digital technologies with a user-centred design approach. He publishes on topics like 'strategic design', 'design epistemology', 'cross media', 'interaction design', and 'sketching' in international journals, and at international conferences.

During the past 5 years, Peter has been teaching and supervising bachelor and master students at Aalborg University, and at University College Nordjylland. He has disseminated the contributions of his PhD research for both academic peers and industry stakeholders.

In his PhD thesis, Peter studied the use of animation as a sketching approach to explore concept designs of non-idiomatic digital technologies.

ENGLISH SUMMARY

In this thesis, I expand upon using animating as a sketching approach to communicate, and explore interaction and user experience design concepts of technologies, that are hard to grasp via traditional means of sketching. I propose that the sequential, temporal, material, and narrative qualities of animation may sufficiently be considered an extended category of sketching. The subject matter is exploring of the viability and feasibility of new user experiences with so-called non-idiomatic technologies - that is, technologies with few or no established conventions or idioms. In the thesis, it is my hypothesis, that animation can be used as a sketching approach to explore such design situations, before spending resources on building functional versions.

As such the research is guided by the following research question:

How can animation-based sketching support the concept design of non-idiomatic digital technologies?

Through a series of explorative studies, conducted as both a constructive designer, as well as facilitator of other designers, I have experimented with different applications of animation-based sketching. These experiments all build on a pragmatic view on constructive design research (Koskinen et al 2011), and have been conducted in collaboration with outside practices, among them the 'North Sea Oceanarium' aqua zoo, and the design agency 'Tankegang'. A series of workshop experiments, with design students collaborating with more than 30 companies also form a major part of the experimental data in the thesis.

Furthermore, I have sought to clarify the concept of extended sketching capacities to include animation. From a state of art analysis of theory, I define animation-based sketching as *the use of animation to portray a fictional reality, aimed at it becoming a fact of reality.* I have positioned this in regard to static sketching, and functional prototypes, framing animation as a way of *emulating* the dynamic behaviour of proposed interactive technologies.

In the thesis, I have shown how designers, who deal with non-idiomatic digital technologies, can utilise animation-based sketching as a temporal sketching approach. I have proposed animation-based sketching as an extension to previous efforts into using video in sketching, with specifically defining and addressing the qualities animation adds to the representation of interaction and user experience design. I have used the technique 'annotated portfolios' (Gaver 2012) to collect a broad range of animation-based sketches. From purely animated sketches, to live video being augmented with animated overlays. Done

in both high and low visual and temporal fidelity, I argue these portfolios of sketches augment the theoretical claims of the viability, and feasibility of using animation to represent and explore the potential of a proposed idea.

I have shown, how animation-based sketching can be done through different visual and temporal fidelities, enabled by a variety of techniques, materials, and in different software and hardware production environments. These appliances show, how the temporal dynamics of non-idiomatic technologies can be explored from the very earliest idea, to later issues about interaction, context implementation, and potential technical contraints, and pitfalls for the user experience.

My studies contributes with examples of the scope of this specific temporal design approach - from supporting design students exploring their design ideas, to being the driving force in facilitating consensus in multidisciplinary design processes in the industry. These contributions are sought condensed into theoretical frameworks and practice-oriented guidelines, which are grounded in my experiments, and aimed towards qualifying animation as a sketching capacity for designers in practice.

DANSK RESUME

I denne PhD-afhandling søger jeg, at udvide forståelsen for at bruge animation som en skitseringskapacitet i interaktions- og oplevelsesdesignprocesser, omkring designet af teknologier, der er svære at udforske i tradtionelle statiske skitseringsmetoder. Jeg foreslår, at de sekventielle, temporale, materielle og narrative kvaliteter ved animation kan betragtes som en udvidet skitserings-kapacitet indenfor design. Omdrejningspunktet er udforskningen af levedygtigheden og mulighederne for brugeroplevelser med teknologier, der er kendetegnet ved, hvad jeg betegner, 'ikke-idiomatiske'. Det vil sige teknologier, hvor der kun findes få, eller slet ingen, etablerede konventioner eller idiomer for, hvordan interaktion og brugeroplevelse kan designes. I afhandlingen er det min hypotese, at animation kan være særligt brugbart til at skitsere i denne slags design situationer, før der bruges ressourcer på at udvikle omkostningsfulde fungerende versioner.

Afhandlingens undersøgelse har på dette grundlag været styret af følgende overordnede forskningsspørgsmål:

Hvordan kan animations-baseret skitsering understøtte konceptdesignet af ikke-idiomatiske digitale teknologier?

Gennem en række eksplorative studier, foretaget både som konstruerende designer, såvel som facilitator for andre designere, har jeg eksperimenteret med forskellige anvendelser af animations-baseret skitsering. Disse eksperimenter bygger på en pragmatisk tilgang til konstruerende designforskning (Koskinen et al 2011) og er foretaget i praksissamarbejder mellem blandt andet 'Nordsøen Oceanarium' og designbureauet 'Tangegang'. Ydermere udgør en række workshop-eksperimenter, hvor designstuderende har samarbejdet med flere end 30 virksomheder, også en stor del af afhandlingens data.

Jeg har søgt teoretisk at tydeliggøre begrebet om udvidede skitserings-kapaciteter, til at kunne inkludere animation. Baseret på an state-of-art analyse af dets teoretiske bestanddele, definerer jeg animations-baseret skitsering som *brugen af animation til at portrættere en fiktiv virkelighed, men med henblik på dens realisering i praksis*. Jeg har positioneret denne definition ift. statisk skitsering og funktionelle prototyper, hvor jeg udlægger animation som en tilgang til at *emulere* dynamikken af foreslåede interaktive teknologier.

I afhandlingen illustrerer jeg, hvordan designere, der arbejder med ikke-idiomatiske digitale teknologier, kan bruge animations-baseret skitsering som en temporal skitseringskapacitet. Jeg foreslår her animation-baseret skitsering,

som en forlængelse af tidligere bidrags brug af video inden for skitsering, hvor animation tilføjer specifikke kvaliteter ift. at repræsentere interaktions- og brugeroplevelsen af teknologier. Jeg har her brugt metoden 'annoterede porteføljer ' (Gaver 2012) til at indsamle og eksemplificere en bred række af animations-baserede skitser. Disse spænder fra rent animerede skitser, til real video, der understøttes af animerede effekter til at portrættere det foreslåede design. Eksemplerne viser spændevidden mellem høj og lav visuel-, såvel som temporal, detaljegrad i skitserne og jeg argumenterer for, at disse porteføljer understøtter de teoretiske bidrag ved at eksemplificere tilgangens levedygtighed, mulighed og bredde i praksis.

Jeg har således vist, hvordan animations-baseret skitsering kan anvendes i forskellige detaljegrader, med forskellige teknikker og materialer, samt via forskellige typer af software og hardware. Disse anvendelser viser tilsammen, hvordan dynamikken og brugeroplevelsen af ikke-idiomatiske teknologiske koncepter kan udforskes fra den allertidligste idé, frem mod senere mere konkrete spørgsmål omkring interaktion, kontekstimplementering og tekniske begrænsninger.

Mit studie bidrager således med eksempler på bredden af denne specifikke temporal designtilgang - fra at understøtte designstuderendes udforskning af ideer, til at være den drivende faciliterende komponent i flerfaglige designprocesser i industrien. Disse bidrag er forsøgt kondenseret ned i en række teoretiske frameworks, samt praktiske guidelines, der kvalificerer animation-baseret skitsering som en anvendelig designtilgang i praksis.

ACKNOWLEDGEMENTS

When I started working on my PhD project I was told, that being a PhD student was to be an apprentice in the academic practice - learning from collaborating with, and working alongside other researchers. I have been part of the research center for Interactive Digital Media & Experience Design (InDiMedia) - a stimulating community, both academically, as well as socially. Here, I have participated in projects, discussions, as well as seminars, and I am truly grateful for having been part of this community for the last couple of years. My deepest thanks to all my colleagues in InDiMedia.

A special thank you goes to Jens F. Jensen, leader of InDiMedia, who made the PhD project possible, by supporting the project idea, and facilitated the process of funding the project. Without that initial momentum, the project would have never happened - thank you so much!

Thessa Jensen gave me the advice to aspire to become a researcher, now more than 6 years ago, and guided me through the pre-PhD work at Aalborg University, as well as being a constant support and wise mentor throughout the years as a PhD. Thessa, I am forever grateful for the inputs, feedback, critique, collaborations, and not at least the laughs we have had since we started working together.

Søren Bolvig Poulsen, my principal supervisor, has guided me in both the pre-PhD period of defining my project, and has throughout the PhD period been a constant compass needle, helping me maintain focus, and drive the research process forward. We have had many great discussions about a variety of themes; theory, methods, philosophy, gadgets, as well as the hardships and joys of academia. Your always insightful suggestions have enriched the PhD thesis in more ways than I can count, and I am forever grateful for you constant support and believe in my journey towards becoming a researcher. Without your guidance and commitment, I doubt I would have crossed the finishing line. Thank you!

Claus Rosenstand, my co-supervisor, also guided me through the pre-PhD period, by establishing the contact to Nordsøen Oceanarium, and the establishment of their co-funding and collaboration in the project. Throughout our collaborations, both in academia, and in business, you have always provided inspirational and wise advise. Collaboration with practice can often be a challenge, and I am grateful for your guidance along the way.

Jonas Löwgren, from Linköping University in Sweden, agreed to collaborate with me on my theoretical expansion of the role of animation in design sketching. We had a series of very inspiring meetings in Norrköping in 2015. Jonas, you gave me more thought-provoking insights than I could have possible hoped for, which contributed immensely in me wrapping my head around my theories. Thank you so much for the collaboration, with hopes for further collaborations in the future.

To Nordsøen Oceanarium, thank you ever so much for our collaboration on 'Nordsøens Digitale Lag', which has been a major case for learning, contributions and inspiring experiments. Thank you to Karl Henrik Laursen for believing in and co-funding the project. Also many thanks to Vashanth Selvadurai, Sylvia Berglund and Kristina Ydesen, and the rest of the staff at the Oceanarium for the collaboration on making the project a reality, which contributed to both research and practice.

To 'Tankegang' and 'AVV', with whom I collaborated on the project 'Recycling Animation', I want to say thank you for our fun collaboration, in which new insights were made about using animation as a sketching approach in practice. I am grateful for your willingness to experiment with approach, and that you invited me to participate in the project.

To the Animation Hub Network, who provided as major part of the funding for the project, as well as helped me formulate my initial hypothesis. Being part of a national innovation effort has been an honour, and I am grateful for the network making my PhD possible.

Also a big thank you to Ellen Christiansen, head of the HCCI PhD School, for always being kind to me, and guiding me through the formal and informal procedures of being a PhD student.

I also want to thank all my co-facilitators and teachers, with whom I have collaborated throughout the PhD. You have all helped me become a better teacher, supervisor, and researcher, and have made my collection of data possible in a much wider extent than I could have done alone. Also thank you for being more than just academic colleagues, but also providing a socially warm and welcoming workplace. It is a joy working with such talented, and good people.

A special thanks goes to my colleagues in 11.01 - especially my good friends Ramesh and Thomas. You guys make it a joy to go to work every day.

In my PhD, a lot of the data is collected through workshop experiments and project collaborations with my design students. Having your teacher experiment with new setups, tough questions, and demands have not always been easy. I want to thank all the students at Aalborg University, who participated in the project. Thank you for your efforts and patience with me.

A special thanks to the administrative staff at Aalborg University for support and guidance, and always answering my sometimes naive questions with a warm smile. Thank you for your professionalism and good heart. And thank you to Andrew Fish for helping me with a revision of my 'Danglish' english - you ensured others than me will hopefully get the point!

To my dear parents, who have always believed in my goals, supported and guided me in my decisions here in life. I could never have accomplished this feat without the love and support you have always shown me. I will always value all that you two taught me. I look forward to have more time to visit and spend time with you on the other side of this project.

And finally, to my amazing Matilde, the biggest gratitude for your patience, love and understanding through a stormy part of my life. You have been an important reminder that there is more to life than books, papers and design research, and have kept me grounded whenever I disappeared to far into the project. I love you so much, and cannot wait to spend more time with you again.
Du er så uendeligt ok :) dejlig!

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PREFACE

This thesis is based on the results of a three-year long PhD-study at the Department of Communication and Psychology at Aalborg University. The thesis consist of five original papers, a book manuscript submitted to Aalborg University Press, as well as a linking text with the thesis' research questions, research design, and summary of contributions.

In the produced work, I expand upon animation as a sketching approach to communicate, and explore interaction and user experience design concepts that are hard to grasp via traditional means of sketching. I propose that the sequential, temporal, material and narrative qualities of animation may sufficiently be considered an extended capacity of sketching. The subject matter for merging these perspectives is supporting exploration of the viability and feasibility of new user experiences with a proposed technology, before functional versions are build. A series of constructive design research experiments has been carried out, applying animation-based sketching in various contexts and at varying points in the design process. In the studies, I evaluate the viability of the approach, the practical integration into the design process, and map how consensus between stakeholders in design can be established through animation-based sketches. Thus, the scope of this project is practice-inclined, towards qualifying animation as an approach for design sketching in practice.

The original produced materials included in the thesis are:

[B1] **Book 1:** Vistisen, P. (submitted) Sketching with Animation, submitted to Aalborg University Press

[P1] **Paper 1**: Vistisen, P. (2014) Abductive Sensemaking Through Sketching. Academic Quarter Vol 9, Aalborg University Press.

[P2] **Paper 2:** Vistisen, P. (2015) The Roles of Sketching in Design: Mapping the Foundational functions of design sketches. Proceedings of the Nordic Design Conference 2015, Stockholm, Sweden, June 2015.

[P3] **Paper 3:** Vistisen, P. & Poulsen, S.B. (2015) Investigating User Experiences through Animation-based Sketching. Proceedings of the 2nd Motion Design Conference (MODE), Dublin, Ireland, June 2015.

[P4] **Paper 4:** Vistisen, P., Jensen, T. & Poulsen, S.B (2015) Animating the Ethical Demand in Industry Innovation Cases. Computers & Society (online edition), vol 45, no. 3, s. 318-326, ACM

[P5] **Paper 5:** Vistisen, P. & Rosenstand, C.A.F (submitted) Facilitating Consensus in Cooperative Design Processes using Animation-based Sketching, submitted to International Journal of CoCreation in Design & the Arts (CoDesign), Taylor & Francis

Reprints of the papers and the book are included and referenced in this thesis. The materials are resized to fit the layout of the thesis without alterations to the content or layout. The papers are referenced as [P1]-[P5] and the book as [B1], and excerpts are referenced an used throughout this linking text.

THE STRUCTURE OF THIS THESIS

In this linking text, I first present the personal and academic motivation to work with extended sketching capacities in design, and position the use of animation as an extended sketching capacity. This leads to a presentation of the thesis' research questions, which has been studied through a number of individual studies. I then elaborate on the research design, from the different studies in the project, with relations drawn to contemporary design research discourse, grounded in the paradigm of pragmatism. Finally I present a summary of my contributions in correlation with the research questions, before a conclusion is given, which points to future research areas to be explored.

In the linking text the reviewed and discussed theoretical discourses of the research field are presented in a summarised form. The in-depth reviews and theoretical state of art are to be found in paper [P1] and [P2], and part I and part II of [B1].

READING THE THESIS - A ZIG ZAG READERS GUIDE

The thesis is paper-based, and thus the primary contributions to the research field is located in the appended papers [P1-5] and the book [B1]. However, the structure of this linking text take on a slightly different form than a usual paper-based PhD-thesis, due to the role of the book [B1]. A major part of the book had the purpose of reviewing the state or art in the discourses about sketching, non-idiomatic technology, animation, and of course animation as a sketching capacity. Thus, what is normally a chapter in the linking text, the literature review and state-of-art, is in this thesis included as part I and II of the book [B1]. The two theoretical papers [P1] and [P2] elaborate on the the sketching discourse introduced in chapter 1 of [B1]. Paper [P3] and [P4] elaborates and supplements the descriptions of 'experiment 1' in chapter 10 of [B1]. Finally [P5] elaborates and supplements the descriptions of 'case 1' in chapter 11 of [B1].

This structure of course has some consequences for how the thesis is most practically read, since the literature review and state of art would seem to be missing in between chapter 2's research design, and chapter 3's summary of contributions. Furthermore, some passages and themes might seem redundant, since the papers and some of the chapters in the book describes the same studies. That is, if all the content is read in-depth.

Therefore, I propose three possible 'journeys' the thesis can be read through:

> **1) THE FULL JOURNEY:**
> Read the thesis starting with chapter 1 and 2 in this linking text, then move on to read [P1], [P2], and part I and II in [B1], before moving on to read paper [P3], [P4] [P5] and part III of [B1]. Finally read chapter 3, 4, and 5 in the linking text.
>
> **2) THE FASTER JOURNEY:**
> Read the thesis through the structure as the full journey, but only light read chapter 1, 'experiment 1' in chapter 10, and 'case 1' in chapter 11 of [B1].
>
> **3) THE SHORT JOURNEY:**
> Read the linking text's five chapters as a summary of the PhD.

CHAPTER 1: INTRODUCTION

Back in 2009, when studying for my masters in Interactive Digital Media at Aalborg University, I participated in the User-Driven Creative Academy (U-CrAc) workshop (Bolvig & Rosenstand 2009). Here we were introduced to the methods of '*bodystorming*' (Oulasvitra et al 2003) and '*video sketching*' (Mackay & Fayard 1999, Vertelney 1989, Bardram et al 2002, Tikkanen & Cabrera 2008, Zimmerman 2005) as ways of early ideation, and exploration in the design process. I became quite intrigued, having previously experienced various prototyping and development approaches to explore ideas within the domain of digital interaction design. Coding and prototyping were very useful in many design contexts - especially normative contexts, in which the subject matter of design was know, like in web-design or genre typical game design. However, the picture changes, when ideas diverge towards using relatively new technologies. When ideating design proposals, which do not have many pre-exiting conventions or best-practices, we were often limited to represent our ideas in static pen and paper sketches. Sketches are quintessential to the design thinking process, but at some place in the design process of digital technologies, you need to be able to explore the dynamics of the possible user experience with a proposed idea. Realising a prototype, of a an unconventional technology, was often a complex affair, with none or few established patterns to build on, thus often increasing the development time to unfeasible levels. The introduction to video sketching, bodystorming and other temporal, and spatial techniques gave us a tool to experiment with the temporality of the user experience in a radically different way, than what we could gain from static sketching. Furthermore these approaches were still much faster than creating programmed functional prototypes.

Especially through our experiments with video sketching, and through examining the previous research contributions into this approach, we also observed how the practice of animation often found its way into the video sketches. Animation would add not-yet existing artifacts and interactions to the video sketch, often representing the proposed design solution itself, or augment an existing object with animated effects, in order to manipulate it into appearing like a new product. This was true, both in our own produced video sketches in the U-CrAc workshop, as well as in many of the academic contributions.

Figure 1: Still images of an animation-based sketch from the U-CrAc workshop, in which a pervasive computing device in a ‘smart garden’ is animated into live action video, to explore how caretakers in a recreation home can tailor custom experiences in the technological augmented garden.

Strangely however, only a few of these contributions reflected in detail about the role animation played in the video sketched representation of their design proposals. Those who did (e.g. Löwgren 2004, Bonanni & Ishii 2009, Zarin et al 2012, Fallman & Moussette 2011, and Moscovich & Hughes 2003) tended to focus primarily on the specifics of the animation technique (the practical realisation, craftsmanship and aesthetics), and less on the nature of using animation in design sketching in the first place. Others took a more critical view of animation, and to some extent disregarded it as being costly, persuasive and too high fidelity for use in sketching other things than high level visions in big companies (Buxton 2010, Ylirisky & Buur 2007, Dubberly 2007). This made me wonder, what the role of animation actually was, when sketching interaction and user experience design? Viewing my own video sketches it was clear that if stripped of the animation-based elements, the expressive capacity of the sketch would be significantly lower. Without the creation of apparent motion of artificially created graphics, I doubt the sketch would have been effective as either a piece of communication nor as a reflective tool assessing the utility, usability or desirability of our ideas. In other words, animation seemed to play a crucial part of what made video sketches work, but the animation-based aspects was not that well understood.

Furthermore, it seemed puzzling to me that the proponents, of using animation techniques in design sketching, rarely did differentiate between when to use animation, and when not to. Instead, animation is argued as being suitable for interaction design, due to the temporal information it generates, enabling sketching of the dynamic interplay between user and system. However, this does raise the question, why all interaction and user experience designers does not use animation in their sketching processes, but often rely on simpler sketching tools, such as pen and paper, wireframes ect?

This wonderment lay dormant for a couple of years. I finished my masters degree, and got a chance to split my time between academia as a teaching assistant, and as digital designer in various freelance involvements. I continued to use video, and especially animation as both tools to think and communicate with. In 2012, I got the opportunity to revisit the U-CrAc workshop - now as a teacher responsible for introducing the students for video sketching. When revisiting the design approach not only from practice, but also didactically, I saw that not much had changed in the theoretical and methodical discourse upon the subject, with only few new contributions, and none with an in-depth discussion on the role of animation in design processes.

What I had seen however, was that more and more industry actors as well as design researchers had begun to take on an interest into the concept of *'design fiction'* - *"...the deliberate use of diegetic prototypes to suspend disbelief about change"* (Sterling 2013). David Kirby (2010) pointed to three aspects that he saw researchers could accomplish through such diegetic prototypes: *"1. necessity of the technology 2. normalcy of the technology and 3. viability of the technology"*. Kirby states that the typical way to start development is to create a functional prototype. But working prototypes - especially with new emerging technologies (Rotolo et al 2015) - are often time consuming, expensive, and require substantial early funding, before the technological concepts can be proven viable or not. Therefore, many diegetic prototypes in the flourishing portfolios of design fiction, in both practice and academia (e.g. Bleecker 2009, Markussen and Knutz 2013, Sterling 2015), used video sketches to portray their scenarios, and often utilised animation as the way to portray the not yet existing technologies. As such, it seemed that the use of animation as a thinking and communication approach, about the potential of technologies, was slowly getting a foothold, but with little research to actually inform or qualify it as a distinctive design approach.

1.1 ANIMATION AS A SKETCHING CAPACITY?

As aforementioned, I found it somewhat strange how little research had been done on the sketching capacities of animation in design. Animation, and, to some degree, traditional video have temporal and emulative qualities which make them ideal for exploring interactions, services, and other experience designs which occur through time, and with new (possible) technologies. Animation researcher Ralph Stephenson has distinguished between mimetic film and animation in a rather precise manner:

> *"The key difference between animations and classic film is that animation offers the producer the ability to have near full control of the material matter, and is not constrained from the context of the physical world which the video media is limited to."*
>
> Stephenson 1973

Stephenson suggests that the illusion of life is potentially much more than making an animated figure come to life, and telling a story or creating an artistic impression. Instead, animation offers us the ability to free ourselves from the contraints of the physical world *as it is* and to *imagine* contexts, situations, and products which do not yet exist in reality. This view on animation makes it an ideal fit with design and design research, also concerned with the creation of possible futures - *what might be* (Kolko 2010, Brown 2010, Zimmerman & Forlizzi 2008).

When exploring possible future states of the world, the archetypical activity in design is broadly acknowledged as sketching (e.g. Jones 1992, Fallman 2003, Buxton 2010). Sketching, often understood as using pen & paper or other 'drawing materials' to think with and communicate with, has been subject to many intriguing studies. As we saw above, some have even gone to the extent of talking about sketching as something, which can also be done with temporal medium like video, or in 3D with clay or foam. Design researcher Bill Buxton popularised this view on sketching, in the community of human-computer interaction, by offering the following claim of the potential width of sketching:

> *"How a technique is used is the ultimate determinant of whether one is sketching or prototyping."*
>
> Buxton 2010, 249

Buxton's idea is that sketching is not a specific *technique*, but rather a specific way of *acting* - and in that way also a special way of *thinking*. Buxton is not alone in seeing sketching as sort of a mindset, since some of the principal studies on design sketching shows how sketching is an expressive capacity enabling the reflective practice of design to unfold (e.g. Goldschmidt 1994, Bilda & Demirkan 2003, Wu et al 2013, Suwa et al 1999). Thus, sketching is considered to be more than pen & paper, and more than just a technique. For me, this just further underscored the opportunity and interest for extending the body of knowledge about animation, as an extended sketching capacity in design.

1.1.1 THE ANIMATION HUB NETWORK

In 2012, I was contacted by the danish innovation network 'Animation Hub', which was formed by the Danish Agency for Science, Technology and Innovation. The network was managed and administered by a consortium consisting of the universities of Aalborg, Aarhus, and Copenhagen as well as The Animation Workshop College in Viborg. The aim of this network, was to lay the grounds for further investigation and practice use of what they labeled *'functional animation'* - that is *"animation aimed at specific purposes outside the domain of* *entertainment*" (en.animationhub.dk). This definition was somewhat drawn from the oral presentations of head of school for the Animation Workshop College, Morten Thorning. Thorning provided an overview of different ways, in which animation could be valuable, besides entertainment and art. Among the areas was; visualising science, news, heath care information, data visualisation, and also process facilitation (Thorning 2014). The Animation Hub network had a special interest in investigating, how animation could be be utilised to facilitate the early phases of innovation projects as a sketching capacity to think about and communicate ideas (Appendix 1.1). As with any rather uncharted territory, a lot of questions about definitions, practices, viability, and technical feasibility followed, which was a perfect fit to my wonderment of the previous lack of scrutiny into this approach.

We saw a common potential for investigating this subject matter as a PhD project, and reached out to a number of industry partners in order to get relevant cases, as well as the last funding needed to make the project become reality. The North Sea Oceanarium - a danish aqua zoo situated in Hirtshals, whom I had previously been doing a project with, stepped in as a project partner, being interested in exploring how to establish a 'digital layer' on top of their physical attractions (Appendix 4.1). Thus, the foundation was laid to explore what I would come to label *'animation-based sketching'* as a distinctive design approach, expanding upon the existing discourses on the subject.

1.1.2 EXPLORING NON-IDIOMATIC TECHNOLOGIES VIA ANIMATION

The inclusion of the North Sea Oceanarium as a project partner, and their desire to explore how to digitally augment the experiences at the aqua zoo, provided an important constraint to the research project. The ambition from the Animation Hub Network was to explore animation as a facilitative tool in 'innovation processes' - a fairly broad ambition, which we knew needed to be constrained. With my background as an interaction designer, it seemed natural to constrain this facilitative aspect towards using animation to facilitate interaction and user experience design processes. However, this would still be rather broad, given how animation could potentially support many different aspects of designing interactive digital media.

Turning the eye back to Kirby's notion of diegetic prototypes, and the term's newfound use in design fiction contributions, I proposed a focus on how animation could enable the exploration of interactive digital media technologies, which had yet to develop established conventions. This was what interaction design researcher Jonas Löwgren had recently discussed as '*non-idiomatic*' technologies (Löwgren 2012). Non-idiomatic technologies lack the idioms - that is, a vocabulary with well-defined semantics for expressing relations (Nardi and Zarmer 1993). Such formalisms are based on simple visual objects such as maps, tables, graphs, plots and panels, and they contain their own semantics instead of metaphorically recreating the semantics of some other domain. Idioms in interaction design would for an example replace the need for fully interactive dynamics, with the designers experiential knowledge. In wireframing a web-design, as an example, this would be the designers experience with the semantics inherent in using a certain visual expression to show how a given interaction with the proposed design might occur. When few or none of said idioms exist, which is often the case with new emerging digital technologies (Lindel 2012, Löwgren 1996, Lowgren & Stolterman 2004) the designer does not have the experiential knowledge needed to fill in the blanks of static representational tools, such as static sketching. Often this results in using functional prototypes to replace sketches in interaction design (Fallman 2003). But functional prototypes (mostly) takes considerable longer time to build, and also runs the risk of becoming more didactic than evocative (Buxton 2010). While functional prototypes hold the immense advantage of being interactive, and thus easier tested, many non-idiomatic technologies has no simple or easy prototyping tools, to shorten the time spent on the prototype. As such, the risk of spending too much time on an idea, which could show to be unviable, is greater when prototyping in a non-idiomatic situation.

This led me to wonder. Would it be sufficient to generate information about the temporal dynamics of the interactive features of the design, at least in the early concept design? If so, could animation possibly be the 'middleground' between static depiction (such as pen & paper sketching), and functional prototyping. That is, an approach to sketching the interaction and user experience design of non-idiomatic technologies?

1.1.3 EXPANDING AN EXISTING FIELD

My ambition with researching this topic is not to claim to have discovered animation as an approach for design sketching. As I have already mentioned, many previous contributions have paved the way, indicating both the potentials, and pitfalls of using animation in the design process. Not all of these are strict academic research contributions, but intriguing examples of organisations experimenting with animation in their own design processes. In fact, already in 1987, Apple's Knowledge Navigator videos made use of animation to portray the future use of technologies - then only on the R&D stage (Buxton 2010, Dubberly 2007). Together with other examples from Tognazzini (1995) and Nokia (Ylirisky & Buur 2007) a programme of using animation in big budget design visions has existed for at least 30 years. In recent years, companies as diverse as e.g. Jaguar, Google, and IKEA has also utilised animation in communicating new daring concepts externally. The recent rekindling of this approach properly owes a lot to the rise of social and viral mediums such as Facebook, Youtube, Twitter and Vimeo. By releasing short videos which often employ animation, to represent an idea of a future use technology, or a novel interaction of existing technologies, companies can generate viral buzz, and gain attention before the product has even become fully technologically feasable.

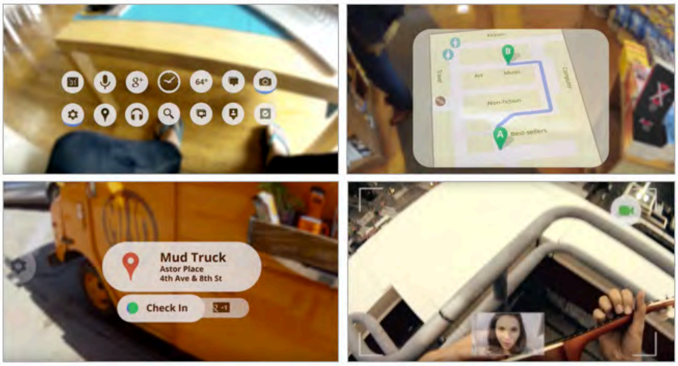


Figure 2: Stills from Google's introduction video to the Project Glass wearable in 2012. The video features heavy use of animation to depict how the day of a user would be augmented by the glasses. The animated overlays feature interface examples, which are purely diegetic, and not renderings from an actual prototype.

It thus seems fair to propose that there exist an incentive in the industry, to use animation to represent the dynamic, and temporal features of new interaction and user experience designs through animation. While most of the existing examples are used primarily as clever pieces of viral marketing, I hypothesise that the potential is bigger than this. Building upon prior research on video sketching and video prototyping, I ask, wether the use of animation might also be applied as an component in the design process - an approach to design sketching?

1.5 A WORKING HYPOTHESIS

The focus on animation as a sketching approach, with non-idiomatic technologies, established the foundation for a the hypothesis explored throughout the last three years:

> ***Animation can be a useful sketching capacity in design processes concerning the dynamics of non-idiomatic technologies, due to the ability to obtain temporal information without having to develop a functional version***

The assumption, inherent in the hypothesis, is that animation can support design at times in the process where creating functional prototypes or coded iterations is not viable or feasable. This can be due to time and budget constraints - not having the sufficient resources to allocate to producing functional prototypes of all possible directions a design project could go. This, of course, implicitly states that animation-based sketching approaches must be simple enough to actually be easier, and faster than coding or using established prototyping tools. Therefore, a second parameter in the hypothesis is the non-idiomatic aspect. The non-idiomatic describe the situations in which the uncertainty, of how a proposed technology would behave in praxis, is high, and where no applicable prototyping tools of frameworks exist to rapidly develop a functional version. In these cases, the risk of going down an unviable branch is high - spending valuable resources, and thus making it unfeasible to explore further design possibilities.

The hypothesis claim that animation has a potential, but also constrains the foci to situations where functional versions of the design proposals are not viable or feasable to produce. As such, the research effort is mostly directed towards what I would label *'concept designs'* - the design proposals which explore the design space, rather than the finalised design iterations towards the end of the design process. Buxton (2010) labels this as the search for the *'right design'*, in comparison to the later *'getting the design right'* - sketching rather than prototyping. Focusing on concept design is to me also best framed through John Heskett's (2005) oft-quoted one sentence description of the ambiguity of design:

> *"Design is to design <u>a design</u> to produce a design"*
>
> Heskett (2005, 3). - my underscoring

In Heskett's notion, before there can be a final designed artifact, be it a product, service, system ect., a conceptual proposal of the idea also precedes it - represented externally or not. It is this conceptual in-between that is the focus of my research, framed by exploring the sketching capacities of animation in design processes concerning non-idiomatic technologies.

A focus on Interaction and user experience design

The studies performed in this research project concern the conceptual design of some instance of a '*product*', which I understand through Buchanan's (2001) broad definition of the term. Buchanan defines a product as being both physical and digital artifacts, but also immaterial phenomenons like services, policies and systems are considered 'products'. In terms of my focus on using animation to explore interaction and user experience design, I am also inspired by Buchanan's rather elegant description of these concepts. Buchanan describes interaction design as the study of "*how human beings relate to other human beings through the mediating influence of products*" (Buchanan 2001). The beauty, of this definition, is how it is free of from the material bias of much of the interaction design discourse, which originates in the domain of digital design and HCI (e.g. Moggridge, 2006 and Kolko, 2011). Buchanan, on the other hand, puts an emphasis on interaction design as a phenomenon first and foremost concerned with how human beings communicate with each other, with specific intents and relations.

This is a broad definition, but at the same time a focused one, since it directs the attention to the purpose of interaction, and not just the instrumental aspects themselves. This makes Buchanan's notion of interaction design overlap with that of '*user experience design*' in which e.g. Hassenzahl & Tractinsky (2011) also point to not just considering the instrumental, and rationalistic aspects of design, but also the subjective, hedonic, and situated aspects. Buchanan argues for seeing the experience of a product as the overall synthesis of the *utility*, *usability* and *desirability* - that is, the content and structure of the *performance*, *affordances* and emotional *voice* of the product (Buchanan 2001, 15). While not explicitly naming this synthesis user experience, it does correspond with what others have discussed as factors in investigating user experience design (e.g. Jensen 2014). Jensen (2014), as well as Hassenzahl & Tractinsky (2011) adds the important addition of 'user context', which Buchanan seems to implicitly take for granted as the external perspective on the internal synthesis of the three factors.

Thus, when I use the term 'product', 'artifact' or 'design proposal', I refer to this broad understanding of the concept, and with special regard to the mediating influence created by their interaction design, and the overall synthesised user experience created.

Animation-based, not animated sketches

An important remark to make is how I use the term 'animation-based sketch' to label the subject matter of my research. I do not refer to *'animated sketches'* but to *'animation-based sketches*' to refer to animation as an approach, which can be used in tandem with other expressive tools, and not as a specific genre or medium per se. As such, an animation-based sketch might very well only be composed by animated elements. But a live video recording, on which a layer of animated elements are added to represent, or augment the expression of a given interaction, and user experience design proposal, is in this regard also an animation-based sketch. This is not an attempt to create a new 'catch all' term, but rather to respect the role animation can play in temporal sketching setups. As such, I do acknowledge that in the optic of sketching, animation is ontologically close to video, it being a temporal approach to sketching. In the thesis' contributions I will address the specific qualities of animation, in comparison to video, which merits that we address animation as an isolated term within temporal sketching.

1.6 RESEARCH QUESTIONS

Based on the hypothesis, and the constraints introduced in the above, the research project has been guided by seeking to contemplate on, and answer the following research question:

How can animation-based sketching support the concept design of non-idiomatic digital technologies?

The research question is examined through an explorative study, experimenting with different setups of using animation-based sketching in actual design processes, concerned with non-idiomatic technologies. To support the research question's examination of the hypothesis further, the question is elaborated into seven sub-questions. These questions are arranged around the theoretical foundation for the research question's practice orientation. The sub-questions are introduced below.

First, the hypothesis informed and constrained the cases I would pursue throughout the project. They had to concern the exploration of using some instance of what could be viewed as a non-idiomatic technology - or at least a non-idiomatic use case for an existing technology. This lead to the sub-question:

- ***What is a non-idiomatic technology?***
  The term existed before I began the work on this thesis, but as it is evident in the sources mentioned above, the term itself is filled with much ambiguity. As such, the question of what the non-idiomatic is, is an important clarification needed to be made.

My question is posed towards regarding animation as a sketching capacity. Thus, I also seek to extent the existing body of knowledge of sketching. Even though design sketching has been a topic of much research in the past, especially in the 1990's (e.g Goldschmidt 1991, 1994, Suwa et al 1998, Goel 1995, Ferguson 1994), there still exist a range of areas which I argue are either vaguely or ambiguously described.

Among them are:

- ***How do we categorise sketching capacities?***
  As briefly touched upon, sketching in design seems to be open for a broader definition than static depiction via pen and paper. To the best of my knowledge however, the discussion, and categorisation of the different capacities of sketching is still limited, and it is thus hard to differentiate between different techniques, materials, and practices in the discourse of sketching.

- ***What is the relation between thinking & communication in sketching?***
  While contributions from e.g. Schön and Wiggins (1992), Goldschmidt (1991, 1994), and Ferguson (1994) offers inspiring insights into the epistemological foundations of sketching, there still seems to be some unclarity to how sketching can be seen as a design thinking activity. This goes to the extent of which logics drives the archetypical sketching process, as well as which functions sketching actually serves in the design process. This includes a clarification of the ambiguous relation between viewing sketching as visual thinking and as visual communication.

- ***What is the difference between sketching and prototyping?***
  Sketching and prototyping is often used interchangeably to describe techniques, tools, materials, and processes resembling each other in design. I argue for a clarification of the two concepts in order to qualify, and position animation-based sketching as opposed to prototypes when designing digital technologies.

The clarifications of concepts regarding design sketching leads to the main research ambition of the project, extending the body of knowledge about animation as a sketching capacity. As such, I seek to extent upon the contributions of video sketching and video prototyping (e.g. Mackay & Fayard 1999, Vertelney 1989, Bardram et al 2002, Tikkanen & Cabrera 2008, Zimmerman 2005, and Ylirisky & Buur 2007), and the contributions examining animation in the design process (e.g. Baecker & Small 1990, Davis et al 2008, Sohn & Choy 2012, Quevedo-Fernández & Martens 2012, Ylirisky & Buur 2007, Buxton 2010, Löwgren 2004, Bonanni & Ishii 2009, Zarin et al 2012, Fallman & Moussette 2011, and Moscovich & Hughes 2003).

In doing so, the following sub-questions aims at broadening the discourse about the animation as a sketching approach:

- ***How does animation fit with design sketching?***
  Animation studies are primarily a research area of interest for either media or film studies into form and content, or technical studies into the production environments and techniques of enabling animation and special effects. Appropriating animation, as an approach to design sketching, needs a clarification of what animation is, and how its qualities can be harnessed as sketching capacities.

- ***What are the archetypical features of using animation in design sketching?***
  In order to define animation-based sketching, the core features of the approach must be identified. As such, the archetypical features of both materials, techniques, structures, and sketching functions of animation-based sketching must be identified.

- ***How is animation different from live action video in design sketching?***
  Finally, the aforementioned tendency to include animation under the umbrella of video sketching or prototyping somewhat limits the insights into harnessing animation as a sketching capacity. Thus, I argue for the necessity of clarifying what the use of animation does to a temporal sketch, and also how the nature of a live video sketch changes when animation is added to the mix.

In the project, focus is directed towards clarifying the theoretical discourse, and experiment in practice with the approach in different setups in an interweaved relation. Thus, the sub-questions, which are mostly theoretical, are qualified by practice experiments exploring the primary research question, and vice versa.

1.7 THE FIVE STUDIES IN THE RESEARCH PROJECT

Answering the research question, and examining my hypothesis, about the qualities of animation-based sketching, has been conducted through five individual studies - see the overview below.

[STUDY A] **Reviewing & clarifying discourse of animation-based sketching**:
Through this study I review the state of art in sketching, animation, non-idiomatic technologies, and temporal sketching in order to define animation-based sketching, and qualify the approach as an extended sketching capacity.

[STUDY B] **The User-Driven Creative Academy - U-CrAc (workshop):**
Through this workshop study, I experiment with introducing animation-based sketching to design students with little or no previous experiences with animation or temporal sketching. In the study, I focus on sampling sketches, and examine their representation of interaction & user experience design aspects.

[STUDY C] **Service Systems Design in Copenhagen (workshop):**
Through this second workshop study, I continue the track of study B, but in a more constrained setting, to explore wether animation-based sketching is viable to apply in constrained settings, with limited introduction and sketching time.

[STUDY D] **Design of the 'North Sea Movie Maker' application:**
Through a year long involvement with the North Sea Oceanarium, I explore animation-based sketching applied in practice, throughout the entire design process, as a facilitative component, in creating consensus about non-idiomatic aspects of a new augmented reality attraction.

[STUDY E] **Collaboration with external agency about new game design:**
Through this final study, I experiment with introducing animation-based sketching in an existing design practice, and through a case of designing a new mobile game, reflect upon the possible benefits and challenges of integrating the approach into practice.

The research design and considerations about specific methods, and techniques applied in each study are detailed in section 2.5 in the the next chapter.

CHAPTER 2: RESEARCH DESIGN

This chapter details the research design of the project. The function of a research design is to ensure that the data, obtained through the studies, enables the researcher to answer the research questions as clear as possible (Creswell 2003). As such the research design describes the structure of the inquiries I have made during the course of this PhD project.

In organising my research design, I have been using the relation between levels of research aspects, as presented by Dahler-Larsen (2008) as the *'meta and paradigmatic'*, the *'logics of research'*, and the '*techniques and methods*'. Dahler-Larsen describes how these elements constantly interact with each other in the research project. Thus, the techniques applied on the micro level in a specific experiment always stand in relation to the logical structure of the research, as well as the philosophical paradigm the researcher uses as optic upon the researched. I use Dahler-Larsen's framework, to describe the relationship between the different elements of my research design, as presented in this chapter.

As a whole the research design can be expressed in Dahler-Larsen's framework like this:

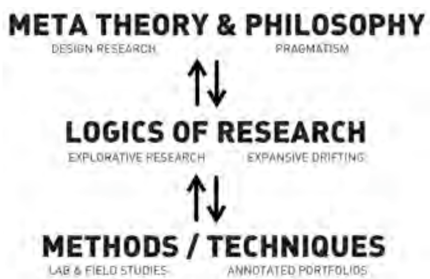


Figure 3: The main components of my research design, shown in Dahler-Larsen's (2008) framework of interactions between research levels.

The two-way arrows in the model shows the interaction between the different levels - how my design research perspective, grounded in pragmatism, interacts with a logical structure of being explorative, and seeking to expand the existing domain of knowledge. This finally interacts with how the specific methods, and techniques of the individual studies - ranging from acting as a constructive design researcher, to facilitating other designers annotated portfolios, relate to the logic and paradigmatic meta level.

This chapter is organised around these three levels, and the interactions between them. I do however choose to start in the middle of the framework, describing the logical structure of the research project as being explorative and expansive. This is, in my view, the most fundamental aspect of the research design; the overall structuring and logics of seeking to answer the research questions.

Following this, I introduce how 'design research' frames and constrains the meta theoretical considerations of the explorative and expansive research efforts. I distinguish between the term *'research design'*, as my general considerations for the setup of this research project, and the term *'design research'* as the meta theoretical field my research design is grounded upon. This perspective is further elaborated in my characterisation of the research project as being grounded in *pragmatism*. Here I describe the criteria of scientific knowledge my studies are evaluated upon, leading to a discussion of the evaluative criteria in design research.

Finally, I describe the research methods and techniques of the five individual studies in the research project, labeled 'study A-E', using variants of annotated portfolios (Gaver 2012) to gather data. In these sections, I seek to show how the studies have been conducted, what data they created, how the data was treated in accordance to the pragmatic paradigm, and how it expands on the body of knowledge of animation-based sketching.

2.1 AN EXPLORATIVE RESEARCH DESIGN

I will categorise my overall research design as a so-called *'exploratory research project'* (Shield & Rangarajan 2013). The aim of exploratory research is not to provide conclusive answers to the research question, but rather to explore the topic with varying depth. This is mostly constructed to explore new problems with few or none previous research contributions present - the territory has so to speak not yet been mapped (Brown, 2006). Thus, the objective of exploratory research is to identify key issues and variables inside the area of interest, which sets it apart from *descriptive* and *explanatory* research efforts where more variables are known (Brown, 2006, 43).

	EXPLORATORY	DESCRIPTIVE	EXPLANATORY
DEGREE OF PROBLEM DEFINITION	Key variables are not defined	Key variables are defined	Key variables and relationships are defined

Figure 4: The difference between explorative, descriptive and explanatory research, being characterised by how well the key variables and their relationship is defined.

The research questions, I propose for the study of animation-based sketching, are thus aimed at identifying some of the key variables needed for more formal studies into the topic. As such, the previous contributions, into using animation in early design, as well as the related contributions from other temporal sketching approaches, form the area of interest, which my research projects seeks to *'expand'*. During the PhD course *'The Role of Hypothesis in Constructive Design Research'*, which I attended at the School of Architecture in Aarhus in (2013), me and my fellow PhD students, discussed different ways of articulating these kinds of explorative research design within the field of design research. Based on the discussions, the facilitators of the course, Krogh et al (2015), later developed a typology of different logics in research designs, whereas one of them describe the aforementioned '*expansive*' logic of my project.

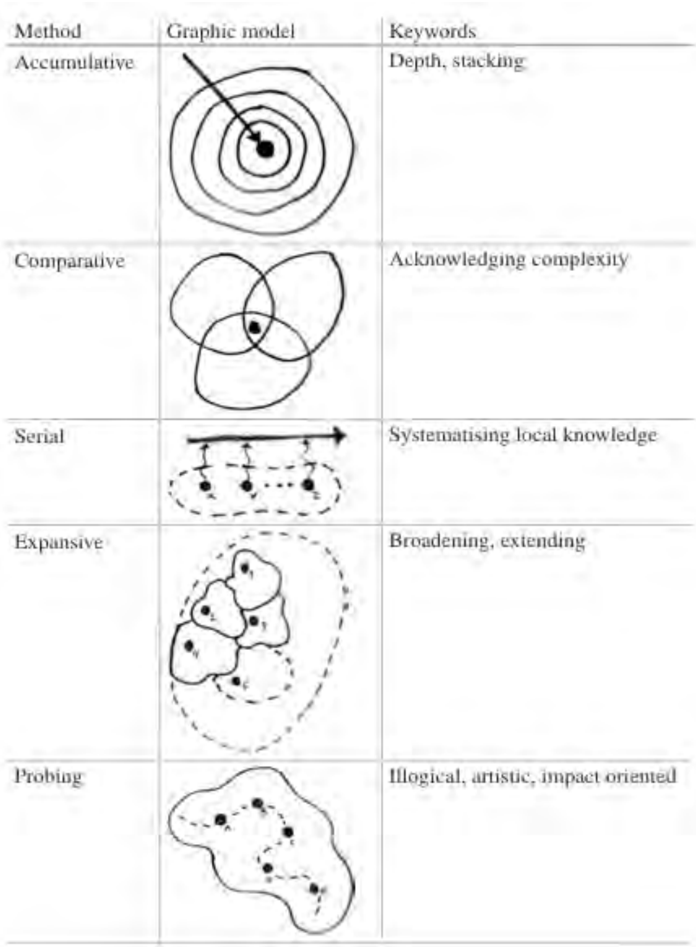


Figure 5: Krogh et al's (2015) categorisation of logic structures typically seen in design research.

The expansive mode of inquiry articulates the identification of as-yet uncovered aspects of a research area - undefined key variables. Unlike for an example a serial logic of inquiry, an expansive inquiry has no strict linear or successive order between the individual research activities in a project. Experiments are created, and hypotheses are developed along with exploring the area, while there is no strict adherence to where the research starts, the type of activities, and how they are linked. Thus, an expansive inquiry defines a way of *broadening* the scope of the area of interest, rather than *deepening* our knowledge of the domain. Instead, expansive research focus on uncovering the concerns we should include when further examining the field.

2.1.1 MY EXPANSIVE INQUIRY

The studies in traditional design sketching are quite comprehensive, as I detail in [P2], and part I of [B1]. Likewise, the studies of animation as genre of film making and storytelling is also comprehensive, and has to some degree also been investigated in terms of facilitation inside the domain of learning [B1]. Finally the studies, into approaches for exploring new digital technologies, has also been a research interest for multiple research fields - among them design research (Buchanan 2001).

However, as I briefly mentioned in the introduction, the studies into the role and potential of animation, in design sketching, has only been scarcely addressed in previous contributions. This is either as studies of one specific animation technique, or a broader critical view on animation as being mostly useful for big budget future visions. As such, I argue that we are to consider the area of animation-based sketching a territory which has yet to be understood in its width, and thus would benefit from an exploratory study with an expansive logic. The previous contributions has drawn a starting point of reference for the study, like using animation and video in the envisonment of future technologies - starting with the Apple Knowledge Navigator video (Buxton 2010) in 1987, with later contributions indicating animations sketching potential. This PhD now extends upon this tradition, by broadening to scope of what sketching capacities animation-based sketching holds.

Thus, the studies conducted through the course of the PhD project can be described as continuous exploration of the key variables of animation-based sketching, with no strict linear order or seriality between the individual studies. The coherence between the studies is first established by viewing the individual fragments as a whole, which maps to the expanded scope of the previous unmapped territory. This does not ensure a complete mapping of all relevant knowledge about using animation in design sketching. Rather, it serves to draw a more precise map of a previously largely unchartered territory, with new insights and lessons learned to support further exploration.

Even though the primary logic of this projects inquiry is expansive, it does not necessitate that all the individual studies also adhere to the broadening scope alone. Some of the studies operate locally from a serial logic, while other operate from a more comparative logic. However, the contributions to the domain of animation-based sketching as a whole needs to viewed in regard to how the individual studies, fit together as an expansion of the field.

2.2 DESIGN RESEARCH - A META THEORY

Compared to classic fields of research, like natural sciences, liberal arts and social sciences, design research is a much younger discipline. Buchanan (2001) noted that in the academic scene, the creation of *'artificial things'* was overall ignored as a subject of research, except to the extent that the designs played a role in the investigation of the natural sciences. This resonates with the dominating paradigm of *positivism* in the sciences of the early 20th century, where the natural sciences made hallmark discoveries, which created a greater an greater unified description of the world. The design of artificial things were reduced to a '*craft*', and not a science, and only survived in academia as the subject of study in literary, and liberal arts in the humanities, mainly for historical inquiries.

That being said, Bayazit (2004) reviewed the research interest in design to go back more than 40 years - now more than 50 years. Originating in the early 1960's, as a reaction to industry interest in optimising the *'human factors*' of new product developments, the first conferences and publications upon '*design methods*' emerged. Christopher Alexander's '*Notes on the Synthesis of Form*' (Alexander 1964) became among the first PhD level research into the field of design methods, clearing the way for considering design a field of research within architecture and industrial design. Rationalists like Herbert Simon argued for merging science and technology in design. In the *'Science of the artificial'*- which gave us the oft-quoted concept of design as "*...devising courses of action aimed at changing the existing situation into the preferred ones*" (Simon 1996). Simon argued for rationalistic thought as the basis of studying, and teaching design based on scientific knowledge and rational practice.

In the following decade Rittel & Weber (1973) suggested the concept of *'wicked problems'* as the characteristics for most design problems, which are so complex that no correct solutions exist a priori. This created a shift in the discourse of design research, towards emphasising the intertwined relationship between problem and solution in design. Opposing the rationalistic tradition in design research, Donald Schön proposed the concept of design as *reflective practice*, in which the designers reflect in and back on the actions taken in '*design moves*' (Schön 1983). Schön's work, and later contributions, formed the basis for re-attaching the craftsmanship of design, with the inquiry into designing the preferable states.

As a research field evolves, new intellectual issues come into focus, and the practice of research becomes more focused. According to Bayazit, modern design researchers describe the field as *"...the study, research, and investigation of the artificial made by human beings, and the way these activities have been directed either in academic studies or manufacturing organisations."* (Bayazit 2004, 16).

2.2.1 DIFFERENT TYPES OF DESIGN RESEARCH

In 1993, Christopher Frayling wrote an oft-quoted suggestion to further distinguish between three types of design research, focusing the domain into specific areas of interest visible in the body of existing discourse of design research (Frayling 1993). The three types of design research are: *research into design, research for design, and research through design* (Frayling 1993, 3). Frayling's concepts have become widely acknowledged in the design research community as evident in the use of, or reference to, the concepts in the oft-quoted literature on design research (e.g. Zimmerman et al 2007, Zimmerman & Forlizzi 2008, Forlizzi et al 2009, Bang et al 2012, Gaver 2012, Binder & Redström 2006).

I will shortly sum up the three perspectives below:

Research *on* Design

Research on design is the most widely applied of Frayling's perspectives, and a recent survey by Forlizzi et al (2009) confirmed this tendency. Maybe this is not that strange, since research *on* design also arguably is the most traditional field of design research - stemming from the original design research ambitions of the 1960's. The ambition for of this kind of research is to develop a detailed understanding of the human activity of design, or related activities such as creativity and art. Schön's work on reflective practice (Schön, 1983) is the prime example on this type of design research, and properly also the most influential. Nigel Cross' analyses of *design thinking*, practice and research are also examples of this type of research into the epistemology and ontology of design (Cross 1999 & 2001).

Research *for* Design

The second perspective is by Frayling described as *thorny* in that its ambition is to contribute to use designs as unique examples - what Stolterman (2008) calls the '*ultimate particulars*'. The designer move iteratively, making sketches, and prototypes along the way to produce an ultimate particular in the form of an artefact that suggests a future state of the world - a design solution. However, the ambition here is not to use the designed artefact to research how to solve a problem in practice, but rather as an archetype of principles, or frameworks, applicable in the the practice of design. Forlizzi et al (2009) notes this has become a 'catchall' for several different kinds of produced design theory that all have been produced with the intention of being applied, or at least provide an example of the application of the framework, in practice. As such, this perspective seeks to develop the frameworks, and methods of design, while also extracting the knowledge to guide the appliance of them. It does however not necessarily focus on how the artefact *solves* the problem in practice, but rather how the design practice is *evolved* by the specific way of creating the artefact.

Research *through* Design

The third perspective has gained a significant momentum in the last decade, with a growing interest on researching *through* designing. Research *through* design leverages on the design process as a method of academic inquiry (Forlizzi et al 2009). In line with research *for* design, it is based on the constructive element of designing the ultimate particulars, however with a higher emphasis on the role of the design as a solution to a specific problem. Nigel Cross (1999) suggested that design knowledge actually resides in the artefact, and not from theories used in the process. The most critical aspect of this is that it allows researchers to engage with the wicked problems of design (Rittel & Weber 1973), becoming active involved in the design process, as they attempt to make *'the right thing'* (Zimmerman et al 2007). In doing so, the research integrate the '*true*' knowledge of classic behavioural science, with the '*how*' knowledge of engineering, towards proposing the '*ideal*' truth of the problem space. The output of this research is an articulation of the preferred state through some instance of a sketches, models, prototypes or finished artifact. Put most importantly, research *through* design seeks to capture and document the reflections - allowing for what Schön characterised as '*conversations with the materials*' (Schön, 1983). One of the challenges that Zimmerman & Forlizzi (2008) point to of research through design, is to build theory - *unified propositions* - when involved in the creation of an ultimate particular. Furthermore, the level of involvement in the research-*through*-design process itself limits the researcher's ability to capture and document events, thus making it harder to validate, and obtain structured data. However, in Stolterman's notion of the ultimate particular of design research, he argues that the unique artefact has "*The same dignity and importance as truth in science*" (Stolterman 2008, 59). As such, in research-*through*-design, the design processes is to be seen through Buchanan's view on on hypotheses which informs "*...what will be investigated and sets the relation of causes that will become the themes of subsequent inquiry*" (Buchanan 2001, 11). The output of the design process, the ultimate particular, thus becomes the natural embodiment of the theory developed by unfolding the inquiry.

To sum up the three perspectives on design research: Research *on* design focus on producing theory that describes the process of design. Research *for* design focus on the outcome of different design activities to form theories that may improve or support design practice. Finally research *through* design employs the design process as a method of inquiry about getting the 'right design' of preferred future states.

2.2.2 DRIFTING IN MY RESEARCH PROJECT

When conducting design research, it seems fair to argue that my research project is to be positioned in regard to the three dominating perspectives on design research. However, this has been a somewhat challenging task to do, since the subject matter of the project is also one of the main methods of inquiry in the project: sketching! As such, the research aim is to qualify animation-based sketching as a distinctive design approach, while making animation-based sketches is also the primary source of analytical data in the research project. Thus, animation-based sketching is both *method* and *object* of my study. This creates sort of an ambivalence in terms of which design research perspective I can be said to have in this project.

It would be obvious to claim that my research aim corresponds with that of research *for* design: refocusing the discourse and further qualifying the frameworks of using animation-based sketching in design practice. From this perspective, the aim is to produce design theory about animation-based sketching as an approach, and provide examples of the application of this framework in practice.

However, said process would be very deductive in its nature, following a string of programmatic propositions to be challenged. I would argue this would run the risk of only elaborating the existing body of knowledge, about using animation in design sketching. Instead, the logic which has driven this research project has been characterised by examining a qualitatively informed hypothesis through *'abductive reasoning'* (Peirce 1994). The abductive mode of inference has driven the projects individual parts to be *loosely coupled* - that is, that the examination of animation-based sketching has been subject to continuous learning from the findings in the individual studies, which has adjusted the causes of action along the way. Thus, the journey through the five individual studies in my research has no strict cohesion, but rather expand upon areas of interest about animation-based sketching which seemed disparate when conducting the studies. Connecting the dots afterwards, trace lines between the studies did however emerge, and the contributions from the five studies could be seen as an accumulated expansion of the body of knowledge about animation-based sketching.

In this way the abductive inference of *'qualified guesses'* has driven the process of '*drifting*' between areas of interest inside the territory of my research. Traditional, or classic processes of science, regard 'drifting' as a failure (Krogh et al 2015), since measures and grounds of evaluation are governed by more randomness and inconsistency than in strict inductive or deductive projects. Krogh et al (2015) however agues, that in design, drifting can be a quality measure, which tells a story about the research process, governed by the same abductive, and thus illogical, mode of inquiry as the archetypical design process itself. In other words, you seem to often take 'your own medicine' as a design researcher - confronted with the same challenge of articulating the design process transparently, as in a traditional design project (e.g. Kolko 2009, Martin 2009, Cross 1999). In a traditional scientific sense, design research happens in a less-than-ideal way with process loops where hypothesis, experiments, and insights concurrently affect each other, and cause the research focus to drift, which necessitates continued adjustment of the research design to stabilise the research (Krogh et al 2015).

Drifting from focusing on 'sketching' to 'sketches'

A major drift in my research happened in 2013, when we had planned an extensive observational setup of the design students in the U-CrAc workshop of study B. We had the idea, that the best way to learn about the viability of animation-based sketching was to observe the *sketching* process itself, and capture the reflection-in-action (Schön 1986). However, it became apparent that the research setup would take us on the track of detailed interaction studies of the students interacting with different digital production environments. This would risk saying more about a specific piece of software and hardware, than about animation-based sketching as a whole. Furthermore, it became evident, that to enable animation-based sketching, the students were constantly on the move, making new components in paper, clay, LEGO ect., and filmed live actors on a green screen, before jumping back to their computers to sketch a new sequence. Thus, the observational setup was also challenged by the natural unfolding of the animation-based sketching process.

This left me with a dilemma. The research design did not generate the type of data I had sought, and the data was in many ways too 'noisy' to be analysed through in-depth interaction analysis. Thus, I made the choice of not adjusting the observational setup for the 2014 edition of the U-CrAc workshop, but instead focused on systematically collecting animation-based sketches through a web-platform - coming to act as an *'annotated portfolio'* (Gaver 2012). This was a radical shift, since it refocused the research effort from observing *sketching* directly, to rather observe it indirectly by examining the output *sketches.* I thus had to accommodate for not capturing reflection-*in*-action anymore, but rather the output sketches, and the annotations on them as reflections-*on*-action.

This drift radically changed the research design going on forward, and was the driving force for me focusing on collecting as many different, and varying animation-based sketches as possible in the following two years. It did not however change the research question of how animation-based sketching could support the concept design of non-idiomatic technologies. Instead, the drift altered the data material, and thus also the analytical contributions to be more detailed around showing the variances, and qualities of sketches, and reflect upon how these variances reflected the possibilities of applying animation-based sketching in design.

Drifting from ***through*** to ***for*** design

This drifting nature of design research was also in play in the overall research design. The research question and working hypothesis initially put me on a research *for* design path, seeking to abstract principles, and lessons learned about the supportive qualities of animation-based sketching. However, in order to generate enough data to actually abstract anything about animation-based sketching, I also had to experiment actively with using the approach in various settings, in which questions of interaction and user experience design with non-idiomatic technologies were posed. From the get go, my involvement with the North Sea Oceanarium (Study D) ensured such experiences to be made, as well as the opportunity to facilitate design students using the methods in the U-CrAc workshops (Study B). These activities in the front end of the project resembled activities more akin research *through* design, and provided insights into the practice of using animation-based sketching, which I had not realised up front. These were issues surrounding elements such as:

1) *The role of the fidelity of animation-based sketches.*
2) *What was required to make animation-based sketches.*
3) *The time needed to produce animation-based sketches for non-animation schooled designers.*

These questions, which became apparent in the first year of the research project, made me realise that I had to restructure some of the setups in the project, and even pursue new empirical sources in order to get experience with, and obtain data about these issues. As such, the research-*through*-design activities, created insights about the holes in the current knowledge needed in order to abstract principles for my research-*for*-design aim of the research project, and thus caused the research design to drift towards new and unplanned ventures.

In the model on the opposing page (figure 7), I have mapped my design research activities from the pre-project period in late 2012 until early 2016. I have separated the activities in three tracks: *observing*, *facilitating* and *participating*. The research *through* design activities are more or less ubiquitous throughout the project, and thus the facilitative activities were all based on facilitating other designers, and thus the research was still centred around the design of animation-based sketches. The research *for* design aspect are what happens in the lines between the individual of studies, in which new principles, lesson learned, and methodological corrections are abstracted to be used in the later studies. When the lines are solid, the progression was planned, and when the lines are dashed, the progression was more akin to a drift, based on an interesting opportunity, or the need to further qualify the study.

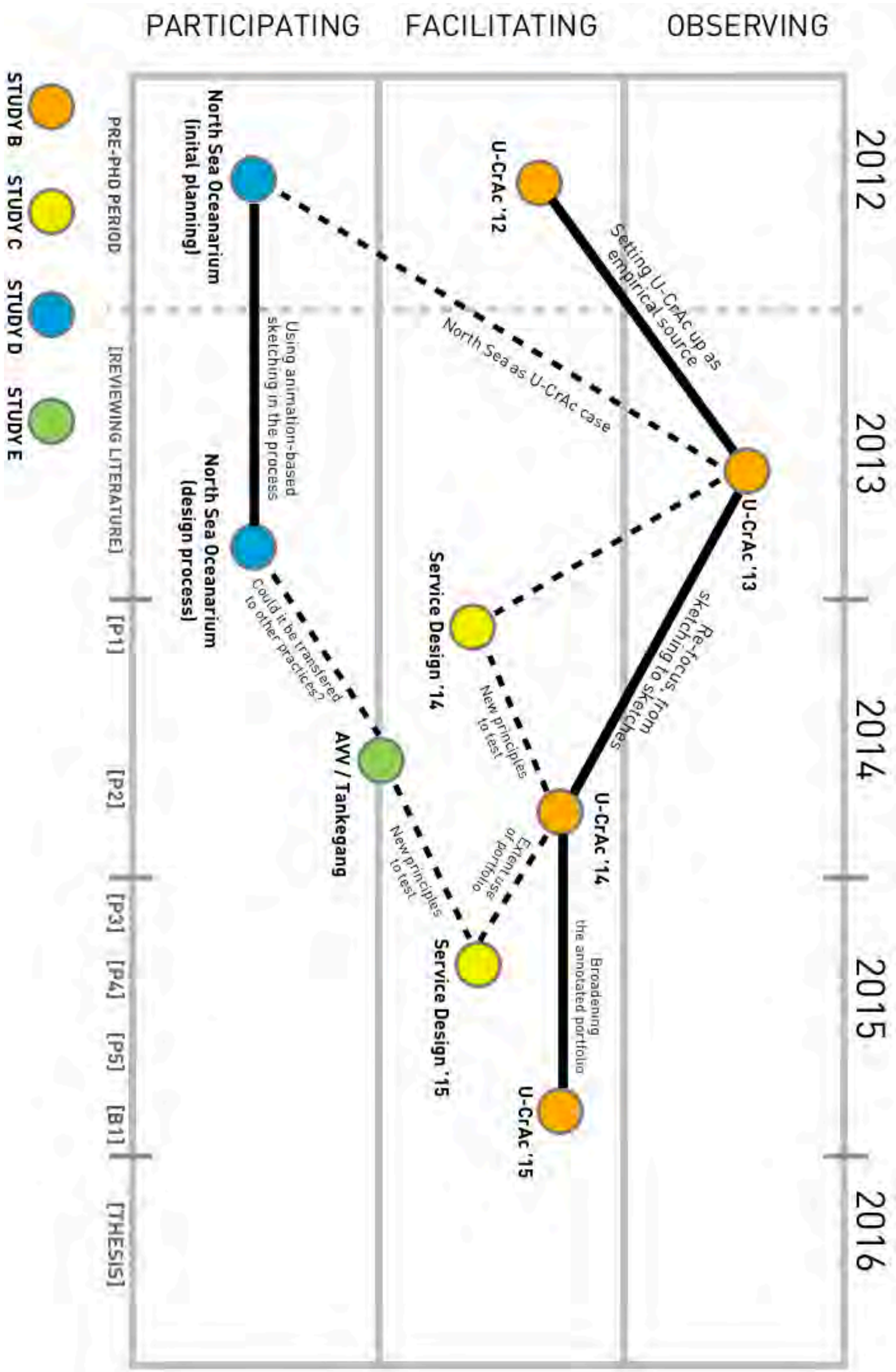


Figure 7: Overview of the research process, between planned progression (solid lines) and the drifting (dashed lines) between activities. Study A's theoretical study of reviewing the state of art is not mapped, but was an ongoing effort throughout the project, concluded with writing [B1] in autumn of 2015.

My experiments, which I describe in detail in section 2.6, where arranged around exploring multiple aspects of animation-based sketching, where one experiment revealed new unexplored areas to be uncovered, setting the stage for a new experiment. These experiments were all concerned with the design of a specific digital product - an ultimate particular, and the design process thus also sought to frame and solve a problem. Thus, the design experiments took on the nature of research *through* design - employing animation-based sketching as a method of inquiry about getting the 'right design' of a preferred future state. Throughout these experiments, we could not ignore this role of the designed output, even though my research interest was more concerned with *how* animation supported the exploration, rather than *what* the specific represented future state was. I argue this also shows a pattern of drifting in the research design overall - from an initial research *through* design, which acted as *vehicle* for generating empirical material for later evaluating the animation-based sketching *outcome* as a research *for* design contribution:

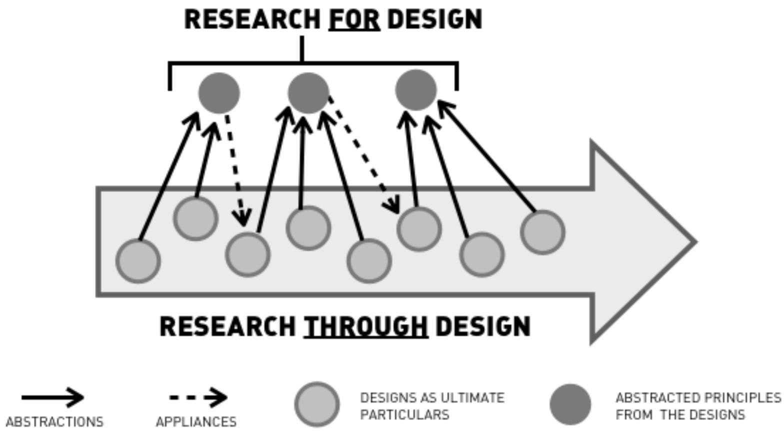


Figure 6: The insights from the ultimate particulars of research through design are abstracted to accumulated principles as research for design frameworks, and the same frameworks are applied in the further research through design activities.

Krogh et al (2015) argues that there is a tendency in design research to be interested mostly in the final artefact - heralded by Cross' notion of how knowledge resides in the artefact (Cross 1999). However it has also recently been argued in multiple contributions, that how the design project drifted through, and gained insights unintended by the initial pursuit, is an equal if not even greater contribution to the design research discourse (Gaver 2012, Krog et al 2015, Godin & Zahedi 2014, Zimmerman et al 2007). The drifting of my research project, further adds to this tradition of design research. While my experiments assess and evaluate aspects of the design outcomes, like the user experience factors in [P3], and the ethical user dispositions in [P4], we do not seek to analyse the final product in-depth as a contribution to the specific problem domain. Instead I seek to assess and analyse, how animation-based sketching can represent aspects of the ultimate particular - as a means to get to the final artefact. In fact Forlizzi et al (2009) actually argues that research *through* design can lead to the production of theories in the area of research *for* design.

Thus, the drifting between the two meta perspectives are not unheard of, and the movement between them are perhaps actually more a symptom of some natural overlaps. This is evident from the way the two perspectives often mix when design researchers discuss their research approach. An example is when Gaver (2012) describes:

> *The output of research through design takes the form, primarily, of artefacts and systems, sometimes with associated accounts of how these are used in field tests, but increasingly includes a variety of methods, conceptual frameworks and theories presented separately from accounts of practice.*
>
> Gaver 2012, 940

Gaver notes how there is an increased focus on not just the artefacts, but also the abstracted concepts of theory, frameworks, and methods, which are not ultimate particulars for the individual design case. The lines are clearly blurred, which might be due to the natural drift, between designing the ultimate particular, and abstracting the frameworks, which describe how the design researcher got their. Wensveen & Matthews approximated a similar conclusion in their assessment that: "*...the main contribution of constructive design research is the prototypes and the frameworks that explain them*" (Wensveen & Matthews 2015). Here they use the notion of '*constructive design research*' in line with the co-authors of the oft-quoted *'Design Research Through Practice'* (Koskinen et al 2011), to describe all types of design research where construction is the key means of producing knowledge.

In essence, this means that my research is to be characterised as a constructive design research project, which drifts from researching *through* design, to contributing with a research *for* design perspective on animation-based sketching as an approach which supports exploring the ultimate particulars of design.

2.3 A PARADIGM FOR DESIGN RESEARCH?

Despite the otherwise comprehensive discourse on design research, especially in regard to the constructive genres of research *through* and *for* design (e.g. Koskinen et al 2011, Zimmerman et al 2007, Jonas 2015, Gaver 2012, Stolterman 2008) few actually considers or focus much on the ontological paradigmatic position of design research. In this sense, design research act as a meta theoretical perspective. It grounds my research within a set of conditions, which we have discussed are akin to the epistemology of the design process itself. However, in order to establish a clearer position of the project, we must ask ourselves, what kind of philosophy of science belongs to the activities conducted under the meta theoretical frame of design research?

A philosophy of science is the systematic treatment of the methods of inquiry dominating a research area (Mautner 2005). When attempting to systemise the methods of inquiry, and their conditions within the domain of design research, the researchers often have to '*borrow*' from other conceptual fields, and discuss their applicability in design (Gaver 2012). This forces the design researcher to act like what Louridas (1999) calls *'theoretical bricoleurs'*. Cross has warned that this tends to '*swamp*' the design domain with research cultures not necessarily beneficial for design research (Cross 2007, 55). Cross further suggested that the designerly ways of knowing, thinking and acting constituted an entirely different paradigm besides traditional science, and the arts. But is design research really a philosophical paradigm in itself, and if it is, what are its criteria's of scientific knowledge?

Falsification vs. research programmes

One of the most influential accounts of scientific knowledge is Popper's *critical rationalism*, which values a theory's scientific status based on *falsifiability* (Popper 2002). Gaver (2012) holds that constructive design research clearly is unscientific if the criterion of falsifiability is accepted. Due to the aforementioned abductive mode of inquiry in design research, where synthesis is done by filling out gaps of knowledge, by connecting experiential knowledge with factual results, falsification becomes unrepresentative of the ways design research tends to drift between intended and unintended efforts. Furthermore, in the natural sciences there is a presumption that the object of study is a single unitary world, independent of its observers (Gaver 2012). In contrast, design research does not seek to describe the world *as it is* (at least not as its final contribution), but generatively investigates how the world *could be* (Zimmerman et al 2007). As such design argues for the enactment on the world through research, as Law & Urry argues:

> *"...different research practices might be making multiple worlds, and that such worlds might be equally valid, equally true, but simply unlike one another.'*
>
> Law & Urry 2011, 397

To this end, the synthetic and generative nature of design is not compatible with the controlled experiments and theory testing in a Popperian sense. According to Gaver, the difficulty of verifying design theory through falsification, is not a flaw for design research if we follow the notion of *'research programmes'* from Lakatos (1976). Lakatos proposed an alternative account of scientific inquiry, where scientific programmes are characterised by a 'hard core' of theory, surrounded by a 'belt' of auxiliary hypotheses, and a 'mechanism' for making inquires.

Gaver argues that even though design research is hard to capture in the traditional paradigms of science, considered as a specific research program a set of core propositions can be identified:

> *"...most pursue some variation on user-centred design, agreeing that some contact with the potential audiences for the things we make is desirable before, during or after design work itself. Most of us assume that exploring a wide space of potential designs, whether through sketching, scenarios, narratives or design proposals, is crucial in achieving a good outcome. Most of us appreciate the value of craft and detail in our work. Most fundamentally, most of us agree that the practice of making is a route to discovery, and that the synthetic nature of design allows for richer and more situated understandings than those produced through more analytic means."*
>
> Gaver 2012, 942

These propositions can further be seen together with an auxiliary of oft-quoted theories *on* design - like Schön's (1983) *reflective practice*, Weber & Rittel's (1973) *wicked problems,* and the notion of *abductive reasoning* (Cross 2001, Dorst 2006, Martin 2009, Kolko 2009). Together with the perspectives of research *for* and *through* design, the epistemological mechanisms of producing knowledge seem to complete a picture of design research as a distinctive research programme on its own right. It cannot be evaluated on the same terms as natural sciences, but has its own conditions for what is considered 'true'. This, Gaver argues, goes to show that the goal of theories in design research is *"not to develop theories that are never wrong, it is to create theories that are sometimes right"* (Gaver 2012, 940). What Popper's critical rationalism would reject as only confirmatory evidence, is testimony to the viability of the overarching theory's applicability in the given practice.

2.2.2 PRAGMATISM AS A DESIGN RESEARCH PARADIGM

In line with the divide, between design research and traditional science, we need to address, how I consider the ontological question of *'what is true?'* in my research project. This brings us to a paradigmatic discussion of the philosophy of science, which the my meta theory of design research can be grounded upon. A number of contributions in the recent years, e.g. Buchanan[1] (1992), Goldkuhl (2012), Rylander (2012), Dalsgaard (2007), Hevner & Chatterjee (2010), and Godin & (2014) has suggested that design research can be grounded in the philosophical tradition of '*pragmatism*'. Pragmatism is a school of thought originating from american philosophers like Peirce (1994), James (1992) and Dewey (1938) in the late nineteenth century. The philosophy in general holds that a *proposition* (e.g. a

[1] Buchanan does not limit design research to pragmatism, but divides between theory for design as neo-positivitic, and design practice as pragmatic. He further argues that all design has an inherent phenomenological quality, which can be seen related to pragmatism, through its emphasis on the life-world of practice, and the intentionality of the subject.

theory) is true if it works satisfactorily - that is, the meaning is to be found in the practical consequences (Rylander 2012). In traditional science, 'truth' is considered towards cause-and-effect patterns about 'what-is' in the world (Goldkuhl 2012). The pragmatic account of truth, which it would describes as '*justified theory*', is instead intertwined with the concept of '*utility*' - that something is effective. Utility is considered a feature in the scientific concepts themselves, which Goldkuhl (2012) and Dalsgaard (2007) argues can be transferred to the utility of the designed artifact as a specific instantiation of a theory, linking the current state of the world with a proposed, preferred state. Thus, viewing design research through the lens of pragmatism means the conversion of a problematic situation into a satisfactory one through the design of artifacts.

However, the pragmatic philosophy is not one unified school of thought, and have to some extent incongruent assumptions between its contributors. Therefore, in the following I will account for some of the key pragmatic concepts that I base my paradigmatic grounding of the research project upon. These perspectives are mostly based on the pragmatic philosophy of John Dewey (1938, 2005, 2004), with auxiliary links to contemporary design researchers use of pragmatism in design.

Theory and practice

The most basic concept of pragmatism originates from Charles Sanders Peirce's '*Pragmatic Maxim*' (Pierce 1994), which holds that the basis of evaluation is the consequences, and implications upon *practice*. Thus, the value of theories relies on how well they helps us act upon practice as it is. This means that a theory might be meaningful in the present practice or the present situation, but may not be so under an alternative or future circumstances (Dalsgaard 2007). As such, the pragmatic philosophy discounts the notion of a transcendental truth, outside of our experience in practice, as being meaningless.

It is not hard to see the links between this fundamental assumption, and that of design research. The entire notion of the ultimate particular, and the drifting of the design process itself can be connected to this train of thought - seeing theories of design as *instantiations of possible futures* (Zimmerman & Forlizzi 2008). This further shows, that even though pragmatic theories are tentative, it does not necessitate a relativism in which everything is valid. They must be evaluated upon their utility in practice, which can further establish a temporary stability to the before problematic situation. The important aspect here is the temporary nature of 'truth' in pragmatism, which regards the world as being '*emergent*' and never fully realised (Shalin 1989).

In my research, this intertwined relationship, between theory and practice, has been a constant factor. The measure of the studies have been an evaluation towards how animation-based sketching supports design processes in practice - in other words its utility. As such, the lessons learned, principles, and analytical results are all based upon an evaluation of the consequences of the approach's interaction with practice. The validity - or the true facts - about animation-based sketching are thus situated in the practices, in which it enables the instantiation of a proposed future state of the world. This means, that through the examinations of animation-based sketching in this research project, I have sought to establish a temporary stability to the approach's potential.

I am acknowledging that this stability is not a final nor universal claim, but one which may change as the discourse of design research, and the technological landscape, changes over time.

Inquiry of the indeterminate situation

The temporary stabile nature of my research follows the lines of Dewey's notion of how no issue can be understood outside of a specific '*situation*' (Dewey 1938). The concept of a 'situation' in pragmatism is important, described by Shalin as "*brimming with indeterminacy, pregnant with possibilities, waiting to be completed and operationalised*" (Shalin, 1989,10). An *indeterminate* situation is one in which Dewey describes that the "*...constituents do not hang together*" (Dewey 1938, 109). The indeterminacy of a situation is to be seen as a perceived tension, which qualifies the initiation of an inquiry. This is were pragmatism gives rise to abductive sensemaking, seeking a qualified explanation of the surprising un-ordered state of the situation. As such, pragmatism favours an explanation clarifying what was before surprising (Rylander 2012).

In this regard, pragmatic inquiry is the way the researcher approaches the world, with the aim of transforming it. Dewey's (1938) argues:

> *"Inquiry is the controlled or directed transformation of an indeterminate situation into one that is so determinate in its constituents distinctions and relations as to convert the elements of the original situation into a unified whole"*
>
> Dewey 1938, 108.

Thus, a lot like in design, inquiry starts with recognising the problematic state of the situation, motivating the researcher to intervene through *transforming* it. This is done by seeking to identify the elements that causes the indeterminacy - what design researchers would label as *'framing the problem setting'*. From hereon the researcher can begin to form conceptualisations of how the situation could be transformed towards determination (Dalsgaard 2007). This is what designers do when creating externalisations like sketches to reduce uncertainty about the possibilities of the framed problem setting. The final part of the pragmatic inquiry is trying out the new concepts to see if they move the indeterminate towards being more determinate. The important notion here is, that if the new concept prove useful, in moving the practice towards determinacy, they are no longer just an hypothesis, but a temporary *'fact of existence'* (Dalsgaard 2007). That is to say, knowledge has been generated about how to bring temporary stability to a certain framed setting, and is thus the pragmatic version of *the scientific process.*

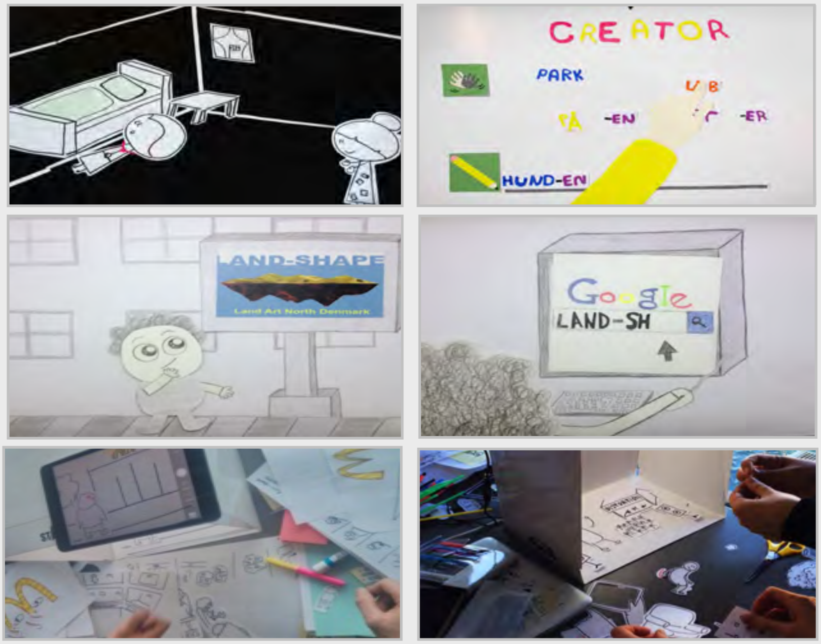
My inquiry of animation-based sketching can be understood in regard to this pragmatic process of generating knowledge. The activities conducted in the research project all relate to a problematic situation in practice - representing and exploring non-idiomatic technologies in a design process. This indeterminate situation is handled, by experimenting with using the temporal, and dynamic qualities of animation to sketch design alternatives. This research-*through*-design activity is in itself akin to a pragmatic inquiry, but so is the process of applying animation-based sketching in first place. By assessing how animation-based sketching supported different aspects of proposed design concepts - future preferred states - the inquiry into animation-based sketching rests on the pragmatic maxim, with practice or practice-oriented experiments as a test-bed for its value towards resolving the indeterminacy of the design problem.

Animation-based sketching as a pragmatic 'technology'

The research through design process of applying animation-based sketching, can result in contributions of research *for* design, by generating 'facts of existence' about how the approach works under a series of interventions in practice. In fact, Dewey's account of '*technology*' in pragmatism can actually further support this proposition. Dewey's concept of technology is broader than the general discourse, since it covers the broad use of instruments to facilitate intervention into the situation (Dewey 2004). Thus, technology frames the understanding of the situation, and also facilitates the reconstruction of it. By applying animation-based sketching to a design problem, the approach as a technology frames the problem setting as one dealing with temporal, and dynamic information. The technology justifies its utility if it works in the way hypothesised - if the temporal information generated actually reduces uncertainty about the non-idiomatic aspects.

Beyond the scope of the individual design project, Dalsgaard (2007) further argues that we might accumulate how technologically supported approaches are integrated into designers' repertoires. Thus, through a pragmatic perspective on design approaches, like animation based sketching, enables us to look at the sketching output as a growing portfolio of experiential knowledge of how they supported the stabilisation of different situations in practice.

Thus, I view my studies of animation-based sketching as a process of pragmatic experimentation with multiple indeterminate design situations, which accumulated also form an indeterminate situation about animation-based sketching as a design approach in itself. Through experimenting with the indeterminacy of the individual design problems, the indeterminacy of animation-based sketching is gradually qualified as determinate facts of experience. These facts become operational as they are used to further test the and develop the concepts - like when the proposal transcend into prototyping, or animation-based sketching principles are used in new design experiments. This 'interaction' between the research *through* and *for* design perspectives form the basis of transforming the indeterminate into an ordered whole of 'trail facts', gradually building what Dewey calls a '*universe of experience*' (Dewey 2005). Rather than generating universal propositions, the pragmatic approach into constructive design research becomes a hermeneutic process of interpretation, and creation of new meaning, where I iteratively interpret the effects of animation-based sketching on the situation (Coyne & Snodgrass 1991).



Multiple instances of the same stop motion technique applied in different animation-based sketches. The physical cardboard stander is mounted with LED lightning inside, and a smartphone or tablet is fixed on top to ensure easy and stable capturing. Cut out models in paper and cardboard are gradually moved and captured on the lit scene.

From gathering the different examples of research-*through*-design, a more determinate situation reveals itself about the practice of using this animation approach to create sketches with low visual and temporal fidelity, but with a relative fast sketching cadence. This abstraction is an example of research-*for*-design.

Figure 8: An example of the interaction between research through- and research-for design as a way of transforming the indeterminate about animation-based sketching into a more ordered state.

2.3.3 CONSTRUCTIVE DESIGN GROUNDED IN PRAGMATISM

Though I have argued for viewing design research through a pragmatic optic, I do acknowledge that other philosophies like phenomenology, neo-positivism and constructivism (e.g. Fallman 2003, Cross 1999, Buchanan 1992) also can act as a frame of reference for design research. However, I agree with the arguments of the proponents of seeing pragmatism as the basis paradigm for design research - at least for design research which emphasises the constructive aspects of design practice. Constructive design research blurs the line between the role of research and design, and is thus right at home in pragmatism. Dewey argued against *'the spectator theory of knowledge'* (Dewey 2005); that is, that knowledge comes from passive observation of the world without interaction. Furthermore, as both Goldkuhl (2012), Rylander (2012), and Dalsgaard (2007) points out, a lot of the foundational theories of design research has roots in pragmatism, such as Schön's reflective practice (1983) links to Dewey's theory of inquiry, and Rittel & Weber's wicked problems (1973) relate to the indeterminacy of problematic situations.

The difference between pragmatic research inquiries, and the inquiry of design practice is essentially differentiated by the level of rigor and critical reflection, through which the researcher accumulates a corpus of experiential knowledge gained from practice experimentation (Dalsgaard 2007). This promotes a research attitude, which involves the application of critical scrutiny into the practical problems of design, but to which the classic concepts of scientific research, such as *reliability* and *validity* have other conditions in pragmatic design research (Rylander 2012).

In the next section I will discuss some of the evaluative criteria, which have been proposed for evaluating the scientific contributions of constructive design research activities, and how I have sought to use these criteria in my research.

2.4 EVALUATING THE OUTCOME OF DESIGN RESEARCH

We have already discussed the role of design research as the meta theory of my research, with pragmatism acting as the primary philosophical paradigm. John Creswell describes how a research design must be grounded in such paradigmatic discussion to set the foundation for both the epistemology - *how we know what we know* - and the ontology - *what is real* - in the research design (Creswell 2003, 21). In a research design, ontology and epistemology exist in an interplay to describe the underlying conditions for the research, as well how reasonable the propositions are.

How a scientific proposition is evaluated as reasonable is one of the core discussions between different research programs and schools of thought (Gaver 2012, Koskinen et al 2011). One core concept is that of '*correspon-*

dence' (Langergaard et al 2006) - how well does the proposition correspond to the reality it describes? Some propositions might be true without much immediate correspondence to any objective reality. This is often true for design research, which produces insights about e.g. aspects like an '*experience*', which does not exist without reference to other concepts, such as that of '*a user*' in a '*context*'. Thus, a proposition is also evaluated by its logic '*cohesion*' with other propositions of truth without contradictions (Langergaard et al 2006).

Finally, from a pragmatic paradigm, the ontological foundation is the aforementioned maxim of '*practical effect*' - reality is the practical effects of an idea. This is in stark contrast to the natural sciences' '*positivistic*' ontology of an objective reality, which can be understood by uncovering the universal laws governing it (Langergaard et al 2006). From this ontology, positivistic research is evaluated epistemologically upon the *reliability* and *validity* of the research contribution (Rylander 2012). This means, that if research should be evaluated as reasonable, one must be able to arrive at the same results at different times, and with different researchers, and based on exact and accurate measurements. Numerous contributions has pointed to these two evaluative criteria as the core challenges of design research in regard to constructing the ultimate particular, as wells as developing frameworks for design (e.g Buchanan 2001, Gaver 2012, Löwgren 2007, Godin & Zahedi 2014, Rylander 2012, Goldkuhl 2012, Zimmerman et al 2007, Krogh et al 2015, Stolterman 2008). As we have discussed above, design research favours a continuous conversation with the material, based on design moves, to engage the wicked problems of design, establishing principles, and seldom general theories. Godin & Zahedi (2014) realigns this issue with that of action researchers, who has a research interest in the social construction of, and intervention into, practice, and which cannot deliver the absolute reliability criteria in science. They hold, that akin to action research, wether design research is valid cannot be assessed based on reliability. Instead they argue we must follow the action researchers focus on *recoverability*, which means that "*the process is recoverable by anyone interested in subjecting the research to critical scrutiny*" (McNiff 1988, 18). As such, it is not the total sum of results from the research which should be reproducible, but rather the research process itself.

2.4.1 RIGOR IN DESIGN RESEARCH

Making the research process recoverable, rather than making the results strictly reproducible, is essentially to say that the scientific contribution from design research can be framed as what Löwgren (2007) labels '*semi abstractions*'. That is, a contribution which is intended to be appropriated by others, but with no claims of the contribution holding a universal claim. It also would mean that it requires a certain amount of work in reporting foundations, sources, reasoning, and research setups for the researcher to actually describe the research process fully enough to be appropriated and reproduced. Zimmerman et al (2007) argues that this is where we find the primary difference in evaluation between design research, and design practice. The intent of research is to *contribute with knowledge* for the research and practice communities, and in practice the aim is (mostly) to *make a commercially viable product.* The constructive outputs of design research can thus take form as *'pre-patterns'* (Chung et al 2004) of the practice-oriented design patterns (Alexander et al 1977).

This leads us to the criteria of *rigor,* again borrowed from action research, which is emphasised by Forlizzi al (2009), Godin & Zahedi (2014), Zimmerman et al (2007), Gaver (2012) and by Löwgren (2007) as the foundation of making research *criticizable.* Biggs and Bütchler describe rigor as "*...the strength of the chain of reasoning...*" (2007, 69) and is thus a matter of how the design research is captured and organised for others to be recovered. Rigor is thus the enabler of recoverability. If others can recover the design research process, and assess its chain of thoughts, the research is to be considered rigorous. While not being equal to the measure of '*validity*' in traditional science, there is clear links between the two according to Biggs and Bütchler: *"We say the process was rigorous, and therefore validates the claims of the outcome"* (Biggs & Bütchler 2007, 67). Validation is then not on a *global scale*, but on a *local scale* of how the process could be claimed to have resulted in the designed artifacts and the abstracted frameworks.

As such, I agree with the conception of design research as being more aligned with the social and humanities than the natural sciences - at least in regard to how the knowledge is grounded. The natural sciences traditionally seeks *nomothetic* knowledge (Langergaard et al 2006), which is grounded in precise measures of large quantities, while the the humanities in other end of the spectrum favour *idiographic* knowledge (ibid), grounded in qualitative descriptions and interpretations of few samples. With the concept of recoverability as the validity factor in design research, the research practice is thus determined by the efforts of the researcher to capture the process.

Owain Pedgley (2007) provided a set of best practices for research designs, which aims to ensure the recoverability of design-based efforts:

> *Chronology: "Describe work in the same sequence that it occurred, ideally as bullet- points"*
>
> *Clarity: "Keep entries intelligible, insightful and honest"*
>
> *Focus: "Keep entries succinct: they should not be a crafted essay"*

Record images: "Record still and moving images of developing and completed physical models"

Out of hours: "Account for instances of 'out of hours' designing in the next day's diary"

Diary admin: "Ensure that all diary sheets are numbered and dated"

*Modelling admin: "Ensure that all modelling outputs are numbered and dated to aid
cross-referencing"*

Pedgley 2007, 473

Pedgley's best practice principles are evidently aimed at research projects in the nature of research *through* design, where the ultimate particular of a single specific design project is in focus. Accounting for instances of out of hours, and keeping a strict diary, or auto-ethnographical account of events are practices effectively used when the research focus is to generate the most rigorous possible data about the design process. However, I argue that the remainder of Pedgley's principles are applicable in a research design, which encompass multiple design projects, and which does not put much emphasis on the final designs, but rather on the way a specific approach supported the design process. Pedgley's principles apply in such research *for* design contexts by providing a set of common guidelines for handling data in different design projects, in which my role differed, and in which the contextual circumstances also differed greatly.

Even with a set of guiding principles, I have experienced the challenge of generating coherent and rigorous data from conducting constructive design research. Below I will point to some specific challenges, which me and my fellow researchers have met in the studies in this project.

Keeping structure as an active designer in a design research project

Considering how the design researcher is often engaged in design, and not just observing design, it becomes a challenge to capture and document the processes coherently. I kept field notes, recorded photos and videos, and logged other types of data, like project plans, meeting summary's ect. from the design processes. However, I could not escape the fact that sometimes the involvement as a designer, or in other cases facilitator, at times overtook the involvement as a researcher, rigorously collecting data. Even in a constrained context, such as in study B and C, which featured a constrained workshop setting, acting as facilitator of other designers using animation-based sketching (section 2.6.2 and 2.6.3). I saw that the role of facilitator made it hard to act as an observer of the process conducted, and not act actively in it. When for an example a break down occurred for a group of design students, using animation-based sketching, it would have been tempting to stay in the background, and observe the situation. However, as facilitator of the specific design workshop, and being responsible for driving the introduction of animation-based sketching, this simply was not an option, and I had to step in to coach the students in getting their process back on track. This serves to show one of the challenges of conducting design experiments in educational settings. While having the benefit of being easy to setup, uniform in terms of competencies, and motivations in the participants, the design researcher also carries two roles, which at some points overlap in unpractical ways.

This challenge as been recognised by multiple design researchers - e.g. Koskinen et al (2011), Pedgley (2007), Dorst (2006), and Frayling's (1993) original text on the three types of design research. Being both a participant, and a design researcher at the same time, simply requires a different dynamic, than if only having one role.

In an attempt to address this challenge, I have been inspired by how Basballe & Halskov (2012) describes the design researcher as '*intertwined*' with the process. They distinguish between three dynamics: '*Coupling*' (uniting research and design interests with research questions, setups ect.), '*Interweaving*' (activities influencing each other through the process, in which design activities are forefront, while mindful of that it is not traditional design, but a research project), and finally '*Decoupling*' (refocusing back on the research material, to determine what to examine through the analytical research lenses).

In terms of coupling, the constructive studies of B-E all involved a clarification of how my research, into animation-based sketching, could be united with the practice of the given situation. In the the two workshops in study B and C, this was a question of aligning the study regulations of the design students, with the research questions, and hypotheses I wanted to explore. In the two practice involvements in study D & E, the coupling sought to align my practical responsibility as a designer, and my time spent documenting the design process.

During the following interweaving of the actual studies, I saw the challenges arise of actually sticking to the setup aligned in the coupling. During the workshops, the aforementioned need of my facilitation and coaching took time away from observing. This left much of the data to be collected either through gathering the students sketches afterwards, or me taking field notes and photographical documentation as situations arose. The same was true for the practice studies, in which especially issues of responsibility, as a designer, often took time away from documenting. Even though the coupling had set specific roles in our teams, it was evident, that the participating company stakeholders expected more actual design work done by the design researchers, than we had allocated in the project plan. As a consequence, this demand influenced how data was captured, getting more a character of post-design reflections, written in summaries and photo collections of the design sprints.

These challenges, from being interweaved in practice, while doing research made for what I initially saw as quite '*messy*' data, since it had seemed hard to keep up with Pedgley's (2007) guidelines due the drifts of the interweaving. However, as I begun to sort the data material from both the workshops, and the practice involvements, it was evident, that Basballe & Halskov's (2012) principle of 'decoupling' actually supported the reestablishment of rigor in the data. In trying to refocus what data I actually had to analyse upon, I followed Pedgley's guidelines, and ordered my material chronologically, combined the overlapping entries, and categorised the material in accordance with relevant steps in the studies. As an example in the design process of the North Sea Movie Maker app in study D, I categorised all the data in accordance with the 'design sprints' we did together with the rest of the development team. With the workshops, it was a matter of categorising the produced animation-based sketches in accordance to when they were created, the applied techniques, and how they represented interaction and user experience design aspects. Thus, much like transcribing an interview is seen as the first step in a qualitative analysis (Brinkmann & Kvale 2014), my *retracing,* and arrangement of the materials from the studies became my first, and a major, step in my analytical reflections. From thereon, structure was given to the materials, enabling me to pick elements out of the whole for analysis, grounded in how it related to the other pieces of data, which I argue established at least some level of rigor and recoverability in the data.

Working with Basballe & Halskov's three dynamics, I experienced how the interweaving middle part of design research is often a messy process, in which design and research goals influence each other. Moreover, the decoupling aspect of how analysis can be conducted by the participating designer also shows, that the analytical foci might actually first reveal themselves when the designer has gotten the design process on some distance, and begins to bring order to the 'messy' process of design. Through the decoupling dynamic, the researcher is able to reconstruct, and trace the drifts of the interweaved design research - connecting the dots as the first steps of the analytical treatment of data.

Reflection in- vs. reflection on actions

As discussed previously, one of the early drifts, in my research design, was the changing focus from examining the animation-based sketching *process* to the animation-based sketching *output.* To focus on the nature of how animation-based sketching can support concept designs in multiple instances of the design process, a choice was made to focus on primarily documenting the animation-based sketches. Thus, the sketching process itself was not captured, and categorised with the same rigor as the sketched output. Of course, the two are interweaved - there can be no sketch without sketching, and vice versa. What the constraint however served to do was to constrain, which aspects of the reflective practice of design my research would focus upon.

Reflective practice can occur in two different timeframes according to the principal work by Schön (1983). *Reflection-in-action* happens in-situ of the design practice, for example, when a unforeseen consequence of a design move occurs, causing the designer to reframe the situation. *Reflection-on-action* often happens post-design, as the designer thinks back about what and why something was done or decided the way it was done. The original ambition in my studies was a focus on mapping the reflection-in-action. But, related to the mobility and software/ hardware dependency issues mentioned earlier, I soon realised that animation-based sketching in the context of the design processes, in which I conducted my experiments, were ill-suited to capture the reflection-in-action in detail.

A study of the reflection-in-action would either require me to take less part in the design processes, to follow along, and capture the entirety of the animation-based sketching process. Another approach would have been to conduct smaller scale, and more controlled animation-based sketching experiments, in which the participants would be restricted to a specific material, technique, production environment, and design problem to explore. Such laboratory contexts (Koskinen et al 2011) would enable a more controlled observation of the designers reflection-in-action while using animation-based sketching. However, I do also argue that this would provide more limited results in terms of expanding the knowledge about animation-based sketching as broad approach, and not just a specific set of techniques within a specific production environment. Thus, the choice to retain the focus on practice-based design experiments, engaging with real-world settings and stakeholders was based upon a practice-inclined ambition combined with a technologically provoked approach (Bang et al 2012) to explore animation-based sketching in as close to natural design settings.

This did limit most of the documentation in the studies to have the nature of being reflections-on-action - reflections made post-design, or at least in the small interludes within the design process. This creates another type of documentation than observations in-situ, and may provide less reliability, but still support the recoverability of the results. Basballe & Halskov's (2012) dynamics of the design research phases can again serve to show how reflection-on-action can act as the decoupling of the reflection-in-action carried out during the design process. The validity of the insights, and lessons learned from said decoupling is then determined by the pragmatic maxim of how the results - the animation-based sketching - ended up as design deliverables to be utilised in practice. This leads us to discuss the role of '*relevance*' when evaluating design research.

2.4.2 NOVELTY AND RELEVANCE

Jonas Löwgren (2007) suggest that that since much design research is carried out by constructing artifacts, another criteria for evaluation should be its '*novelty*'. That is, in the sense that the concept, or artifact, created is a genuinely new contribution to the body of knowledge, within the research programme. This is of course a criteria for scientific practice in general - producing new insights rather than reproducing old ones. In design research it might be more precise to talk of novelty in the sense of Zimmerman et al's (2007) notion of '*invention*' - that is, that the design researcher has created a novel insight, approach or artifact to address a specific situation. In this sense, the design researcher must both frame results within the current state of the world, but also frame the preferred state their design experiments propose, as wells as argue for why peers should considers this state to be preferred.

The inventiveness of the produced research must further be deemed '*relevant*' by the scientific community of design research. In fact, Zimmerman et al (2007) even holds that relevance is the primary evaluative factor in design research, since the aforementioned concept of 'validity' is unsuitable as a benchmark in the science of the artificial. Thus, if two designers given the same design problem, there is little change they will produce identical, or even very similar design proposals. I argue the same is true for using design approaches like animation-based sketching: not two designers will be using the techniques, materials, and procedures of the approach in the same way, and we thus must evaluate the approach upon how it supports the generation of relevant design knowledge gradually. The design researcher is using the design process as the source for data collection, and the validity of the research results comes with the success of the design projects (Godin & Zahedi 2014). That is to say, if animation-based sketching works, and supports the design process, within the subject matter of non-idiomatic technologies, then knowledge produced through the process is valid in the pragmatic sense of making the indeterminate more ordered. Thus, if the contribution works, and adds knowledge, the insights are relevant in a pragmatic optic on design research.

2.4.3 EXTENSIBILITY OF RESULTS

Adding to the evaluative criteria of relevance, and due to the pragmatic grounding, I also draw upon Löwgren's (2007) division between what is internally relevant for the academic design community alone, and that which is externally relevant in design practice. These too may - and should ideally - overlap, but it also goes to show that what design researchers consider the foundation for a given practice-oriented insight, might itself only be internally relevant as a academic insight. This is true in my studies in respect to [P1] and [P2], and their elaborations in part I of [B1], where I discuss and extent upon the general discussion of the epistemology, and practice of design sketching. While I argue these studies are needed in order to ground the later explorations of animation-based sketching as a 4-dimensional sketching capacity, the insights themselves do little to advance the practice of design. Simply put, these insights are mainly internally relevant to the design research community. They do however establish the foundation for extending the discourse and practice experimentation with animation-based sketching, as done in [P3-5] and part III of [B1] - both of which can thus be considered both internally and externally relevant.

Moving beyond the distinction between internal and external relevance comes Zimmerman et al's (2007) evaluative criteria of '*extensibility*' of design research. Extensibility is defined as *"...the ability to build on the resulting out-comes"* (Zimmerman et al 2007, 8). That research results are extendable means that is has been documented, analysed and presented in a manner that enables peers to leverage the insights. In this regard, the criteria of extensibility points back towards both the principles of rigor and recoverability, as well as the initial notion of evaluating a theory based on its correspondence, and cohesion with other theories within the research field. Since design research can rarely be deemed completely valid or reliable, but is better understood through its pragmatic contribution, extensibility in design is assessed by how the insights can be *applied* or *appropriated* for a future design case, or how a framework derived from the research can lead to new design principles outside the specific design case.

2.4.4 CONTRIBUTIONS IN DESIGN RESEARCH

In regard to the extensibility, Löwgren (2007) also argued for the importance of being able to distill the insights in a way that guides towards future appropriators. Löwgren suggest that it is the responsibility of the contributor - the design researcher - to help the appropriator by discussing the scope of the research contribution, and outline the different situations - both in practice and in theory - where they would be appropriate to contribute. I regard this as an issue of *classification* - mapping for *whom* and for *what* a research contribution extent upon the established body of knowledge, but also *how* it can be applied.

I view this in regard to Nigel Cross' proposal for categories we should expect design research to contribute within:

> *1) "Design epistemology – study of designerly ways of knowing"*
>
> *2) "Design praxiology – study of the practices and processes of design"*
>
> *3) "Design phenomenology – study of the form and configuration of artefacts"*
>
> Based on Cross (1999, 6)

In [P1] I discuss the concept of sketching in relation to the epistemology of design thinking - especially how we can regard sketching as a way of making abductive sensemaking manifest. This discussion adds to the design epistemology, by suggesting a framework for sketching capacities grounded in which dimensions (ranging from 1D to 4D) the sketching approach can generate information within.

I elaborate on this call for extended sketching capacities in [P2], which reviews the discourse of sketching studies, categorised between *'visual thinking'* and *'visual communication'*, and appropriate the terminology from Olofsson & Sjölen (2007) into a framework. This contribution is again primarily situated in design epistemology, but also carries over into design praxiology, showing that sketching serves several functions, and change functions over time.

Design praxiology is also the primary category to which the results of [P3-5] contribute in terms of extendable results. In [P3], we analyse that no clear link between visual fidelity and expression of user experience aspects could be found, showing that the decisive factor in animation-based sketches is the narrative, and that animation ties the non-idiomatic technology to the narrative via temporal information. In [P4] we show how animation enables stakeholders to reflect not just on technology, but also the ethical user impact of the technology, through emulating user scenarios with temporal information from animation.

Finally the study with the North Sea Oceanarium in [P5] showed how animation could be used to create relevant information to reduce the uncertainty, and establish consensus in a design team, when designing a non-idiomatic augmented reality application. The book [B1] contemplates further on both the theoretical, and praxiology contributions, and attempts to distill them into a series of 'lessons learned' aimed to be extendable insights, with the individual studies serving to guide for which types of situations they might be appropriated within.

As to Cross' last category of design phenomenology, the study of *form*, my research has by intention steered away from contemplating much on the specifics of the design artifacts proposed in the studies. Instead the foci has been on how animation-based sketching supported the exploration, and commu-nication of the proposed artifacts - creating form. As such, my results provide little guidance on how to design the best user experience with a specific technology, but rather how a specific design approach can create deliverables, which enables designers and stakeholders to reflect upon the phenomenological aspects of a design. However, one could argue, that the discussions made in especially in part II of [B1], about the anatomy of animation-based sketches, as well as how animation acan be appropriated for design sketching, holds elements of design phenomenology. When analysing how different narrative discourses, storytelling perspectives, sketching functions, and digital production techniques come together to form animation-based sketches, I am essentially contributing to the phenomenological description of animation-based sketching. The animation-based sketch is as such not just the proposed design itself, but rather the *design* to produce *another design* in the notion of John Heskett (2005).

We have now established *rigor*, *recoverability*, *novelty*, *relevance* and *extendability* as core evaluative criteria for my constructive design research process. The next section describes my considerations about doing design experiments, before diving into the individual studies.

2.5 DOING DESIGN EXPERIMENTS AS DATA GATHERING

As a matter of definition most constructive design research has its foundations in some sort of design practice (Binder & Redström 2006, Koskinen et al 2011, Fallman 2003). This section provides an overview of how my research can be seen as design experiments, taking place in varying design practices in both industry, and educational settings. I initiate by introducing the methodological framework, and the data sampling technique of annotated portfolios, before diving into describing their applications in the individual studies.

2.5.1 LAB, FIELD & SHOWROOM AS RESEARCH CONTEXTS

Design research as a field blends methodologies from many disciplines - from sociology, software, engineering, psychology, philosophy, industrial design, and HCI (Koskinen et al 2011, Krippendorf 2005, Zimmerman et al 2007). Thus, many sources exist describing concrete research frameworks, and methodologies for design research, starting from their own separate point of view. However Koskinen et al (2011) recently argued, with support from both Bang et al (2012), Krogh et al (2015), and Redström & Binder (2006) that few contributions successfully bridges the gap between design research and design practice. While approximations can be made through examining a design research project through the optics of pragmatism as in this project, I agree that on the local scale of the individual studies, a more concrete framework of methodologies has been needed to guide how knowledge has been generated and evaluated.

From the PhD-courses *'The Role of Hypothesis in Constructive Design Research'* at the design and architectural schools in Aarhus and Kolding in 2013-2014, I was introduced to the previously mentioned notion of the Koskinen et al's (2011) framing of *'constructive design research'* - which we have defined, and discussed previously in this chapter as a broader way of examining research *through* and research *for* design. I discovered the value in examining all the constructive activities in my research design as different variations of *'experiments'* - inspired greatly by the concepts by Bang et al (2012). In design, constructive experimental activities are at the core akin to the way observational or participatory studies are core to the social scientists, the text analysis in the humanities, and the controlled experiments in the natural sciences. I build on how Koskinen et al (2011) break down design experiments as being explored through three methodological contexts: *Lab*, *Field* and *Showroom* - quite similar to categories proposed by e.g. Fallman (2008).

The Lab approach is not necessary meant as literal laboratory work, but rather the practice of taking the object of study out of real world settings into a more controlled setup. This type of approach is often rooted in a pre-defined discourse of theory, and has a relational character, which enables the researcher to compare either different variables, or make bulk observations of multiple cases. In short, a lab approach seeks to decontextualise its phenomenon to focus on isolated variables with less 'noise'.

In contrast to the decontextualisation of the lab, the goal of the field approach is to contextualise. It draws upon methods, and practices of social science, with a focus on how design affects the social context. Koskinen et al. argue for the field approach's research contribution to traditional social sciences descriptive analysis as "*… unless these narrative methods are grounded in real data, they easily reflect only the wants and preferences of researchers. At worst, they become just devices of persuasion*" (Koskinen et al 2011, 114). The field approach turns away from the carefully (and artificially) constructed lab setting, and priorities first hand experience of context over strict fact-finding. The authors do the important observation, that the data generated from a field approach often take on a more descriptive account, rather than an theoretically informed interpretation.

Finally, the Showroom approach builds on the tradition of arts and craft rather than science, and draws its methodology on art discourses. These issues are described as being either broader or more abstract, than the Field or Lab approaches, and the constructed artifacts are often laden with assumptions and ambiguous agendas, asking more questions than they answer. This is often related to the domain of *'critical design'* and explores how *"design can be used as a critical medium for reflecting on the cultural, social, and ethical impact of technology"* (Koskinen et al 2011, 116). Thus, the showroom approach carries on what Gaver (2012) calls *'ontological politics'* - a clear statement or message, which sets contributions in a borderland between research and subjective perspectives.

All three design research contexts calls for an active dialogue with the practice they seek to transform. That is, how the context influence the experiment, and how the experiments affects the context. I have attempted to establish said dialogue by assessing which contexts my individual studies have been conducted within, and how this affects the evaluation, and the possible contributions from the studies. As such, when describing the research methods of the individual studies below (section 2.6) I use Koskinen et al's (2011) notion of lab, field and showroom to classify the studies.

Before describing the specifics of the studies, we need to address the data collecting technique shared in some variant throughout study B-E's constructive design research activities.

2.5.2 ANNOTATED PORTFOLIOS AS DATA SOURCE

Koskinen et al (2011) claims that design research is not a very theoretical discipline in regard to generating broad theories usable outside design. Since design itself is a broad field, the contributions instead serve to generate frameworks to understand, and carry out specific issues of design. These frameworks are typically based on reflections that come after the design - reflections-on-action. They are formed by the auxiliary theories used, the debates, and the interweaved design process. As such, when working with constructive design research, reflection-on-action is the epistemological foundation for creating theories of design.

Gaver (2012) agrees, and refers to Koskinen et al's (2011) debate about the lack of substantial theories derived from constructive design research. Gaver however, takes on a different course than mapping the context of research, and instead contemplates how theories are made within the *'design space'*, which a designed artifact creates around itself (Gaver 2011). When a single design occupies a point in said space, multiple designs by the same designer(s) establishes a design *portfolio* as an area inside the space. Comparing different designs in such portfolios can reveal what the designer(s) saw as relevant, the conceptual dimensions of the solution, and the designers opinion about possible configurations, and appropriations of the same idea. In this way, the notion of design portfolios as data gathering devices enable the researcher to articulate both the dimensions of the choices, and the invariances among them.

Theory as annotations on artefacts

In the case of design portfolios, Gaver holds that instead of theories predominating as the research interest, with the designs serving only as illustrations, design theory should rather be considered as '*annotations*' explaining the features and purpose of the 'ultimate particulars' of design. To this end, and again with a pragmatic foundation, the design outcome augments principles, and frameworks as what Gaver calls the the *'truths in design'*. Gaver, together with John Bowers labels this approach *'annotated portfolios'* (Gaver & Bowers 2012). In several respects this idea is the converse of the pattern language methodology pioneered by Alexander et al (1977). The annotated portfolio is not intended to abstract regular patterns of repeated use, but rather maintain the particularity of the individual examples, while articulating the frameworks and ideas that join them together. In the instance of my research project these frameworks are not about the genre or type of designed artifacts in the portfolio, but rather about the multiple ways animation-based sketching showed to be applicable to support representing the artifacts. As such, my use of annotated portfolios contains a collection of often disparate design concepts, but with resemblance in how animation supported the expression of interaction and user experience design questions in the designs.

Thus, annotated portfolios is a means to capture relations, and resemblances in a collection of particulars, and engage them in a broader frame of concerns. To this end, Gaver argues the annotated portfolio respects the ultimate particular of design, while still seeking to provide rigorous, extendable, and relevant design knowledge. Gaver uses Dieter Rams '*10 principles of good design*' as further examples of annotated portfolios (Gaver 2012, Bowers 2012). Rams' short passages are too limited to serve as substantiated theory and contributions by themselves, but with his industrial design portfolio, a strong design philosophy emerges (see Ueki-Polet & Klemp 2009).

This makes annotated portfolios a fitting technique to capture the particulars of the research *through* design process I have conducted in my studies, while arranging the results into a portfolios expressing research *for* design contributions. The different design concepts explored by me, as wells as the designers I have facilitated, are thus the ultimate particulars, while the abstracted lessons about animation-based sketching is the annotations. As the designed artefacts are to the theoretical annotation, the design portfolio is to the overall research programme. In my research project this means, that the portfolio of appliances of animation-based sketching informs the program of using animation in the design process, augmenting the theoretical feasibility and recoverability of the approach. Gaver (2012) however continues, that the annotations need not to be in absolute constrained form as Rams' principles, but might also take form as an illustrated essay or in a showroom context as posters. I propose we take this idea further, and see design-oriented research papers as possible annotated portfolio documentation as well - an idea shared to some extent with Bowers (2012). Here, written reflections, photo documentation, process descriptions ect. have an *indexical* character - pointing to, and connecting features of interest from designing the ultimate particular. The design case, be it in a lab, field or showroom context, is presented together with prior work, and then the design process of the ultimate particular is unfolded, with lessons learned, and new frameworks synthesised. My point is, that Gaver's notion of annotated portfolios can be extended to a multitude of formats, as long as they enable the gathering of particular examples to reveal the broader strokes of theoretical, and methodological developments from the research process.

My studies as annotated portfolios

In the individual studies of my research project, the design of artifacts are the fundamental output of the studies, while the principles, lessons learned, and conclusion can be considered annotations about how animation-based sketching have supported those design processes. I have sought to address this in the description of the individual studies, together with the aforementioned metaphorical contexts' derived from Koskinen et al (2011). Viewing the different data gathering methods, and the design processes themselves, through Gaver's (2012) perspective of the annotated portfolio, I have sought to balance between the concepts representation of a specific interaction and user experience design proposal, and the abstracted insights into using animation-based sketching to represent such concepts.

I argue, that annotated portfolios in this manner can support maintaining rigor and some level of standard procedure in design research, since multiple instances of particular designs are abstracted through the same type of theoretical annotations. While it cannot be considered as valid falsifiable data, annotated portfolios respect the limited rationality of the design process - designing ultimate particulars. They are contingent, while still providing a mechanism for abstracting more general principles in what we in a pragmatic sense could call a '*universe of experience*' (Dewey 2005). It is this mechanism, abstracting between the particular, and the resemblance between a portfolio of particulars, that I argue is the strength of the annotated portfolio technique.

As an example, besides using the technique in the individual studies to gather data, my analysis of the common archetypical traits of animation-based sketches discourse, perspective and fidelities in part II of [B1] are also examples of an annotated portfolio. The sketching examples used in the book to exemplify the induced principles serve as multiple design particulars, augmenting the theoretical annotation, rather than theory augmenting the design itself.

While the portfolio vehicles have differed in each of the studies, the epistemological foundation of reflecting on the action of the design process is a constant. The relationship between the the animation-based sketches, as ultimate design particulars, and the abstracted frameworks are made through the notion of the frameworks as annotations upon the sketches. In the next section I will discuss each of the five individual studies conducted in the research project, and describe how the annotated portfolio technique has been applied in different variations in the constructive parts of the studies. Here I will also offer my critique of the technique, based on the experiences with applying it in multiple cases.

2.6 THE METHODS OF THE INDIVIDUAL STUDIES

This section will introduce the methods, and techniques applied in the five individual studies conducted in the research project. Study A is primarily a theoretical study of the phenomenon of animation-based sketching, while study B-E are constructive design research inquiries, in which I either acted as active designer or as the facilitator of other designers.

A summary of the individual studies, my role, the design research context, the annotated portfolio variant, and the expansive contribution of the study is presented in the diagram below.

STUDY	MY ROLE (PRIMARY/ SECONDARY)	CONTEXT	ANNOTATED PORTFOLIO	EXPANSIVE ELEMENT
Study A: Reviewing & clarifying the discourse of animation-based sketching	Reviewing theory	Desk research	N/A	Expanding the scope of what we can define as 'a sketch' and 'sketching' - proposing a 1D-4D taxonomy of expressive dimensions [P1], as wells as four axis continuum of sketching functions [P2], that also separate sketches from prototypes based on the information they generate or reduce. [B1] builds upon these to expand the existing discourse on using animation in design, by defining animation-based sketching.
Study B: User-Driven Creative Academy (U-CrAc) workshop	Facilitator	Lab	Student generated Web-portfolio, [P3] & [P4]	Expanding upon the role of visual and temporal fidelity in animation-based sketches ability to express interaction and user experience aspects [P3]. These insights are further elaborated based on how animation-based sketches can support exploration the user dispositions and ethical consequences in a new proposed use of a technology [P4]. Furthermore [B1] contemplates on the competencies required by the design students in order to apply the approach.
Study C: Service System Design in Copenhagen	Facilitator	Lab / Showroom	Student written short papers, [B1]	Expands upon how animation-based sketching works under time constraints and with limited introduction in [B1]. The study also expands upon how simple animation techniques can still provide viable temporal information.
Study D: Design of 'North Sea Movie Maker'	Designer / Researcher	Field	Sprint logs, process reports, [P5], and [B1]	Expands upon the body of knowledge about applying animation as a facilitative component in design practice, showing how the animation-based sketches mediated consensus at important decision points in a multi-disciplinary design team, working under strict economical and time constraints [P5].
Study E: Design collaboration with external agency	Facilitator / Designer	Field	Process reports, process video, and [B1]	Expands upon the body of knowledge of implementing animation-based sketching in a design practice unfamiliar with animation [B1]. I show how the designers adopt the approach, create animation-based sketches, and use them as foundations for the next iterations of design concepts in their design process in a efficient pipeline.

Figure 9: Overview of the individual studies in the research project, with their design research context, their annotated portfolio element, as well as their expansive scope.

The following sections below elaborate on the considerations about method and techniques, with relation back to the logical structure, and paradigm of the research design.

2.5.1 STUDY A - REVIEWING THE DISCOURSE

A central challenge with expanding the body of knowledge about a phenomenon is to map its state of art. Different terms of the same phenomenon, conflicting conclusions, and auxiliary perspectives often exist, and must be put under scrutiny to clarify the phenomenon, and the potential gaps in knowledge (Lyngaard in Brinkmann & Tanggaard 2010). In terms of animation-based sketching, I reviewed the foundations for defining the term, as well as the epistemological and ontological foundations in [B1], [P1], and [P2]. The two papers primarily reviews the current discourse in sketching studies, and argues for an intertwined optic on both visual communication and visual thinking, as well as seeing sketching as being something which be done in a number of expressive dimensions. In [B1], a more substantial literature review of the traditions, and potential merger of sketching, animation, and non-idiomatic technologies is presented, and used to define animation-based sketching.

I used the literature review strategy presented by Torfing (2004) as the *'snowball method'*. This builds upon the idea of continuous following links, and references between sources, until the point at which no more sources or only sources with secondary relevance to the research topic are uncovered. This process starts with identifying what Andersen (1999) labels *'monumental texts'*, which are nearly ominously referenced by the other mapped texts. Examples of such monumental texts are Gabriella Goldschmidt's (1991, 1994, 2003) texts on design sketching, Donald Schön's (1983) writing's on reflective practice, Johnston's & Thomas (1995) contribution to understand the principles of animation, and Bill Buxton's (2010) seminal work on sketching within the domain of user experience design. Torfing (2004) describes that when following the links from these texts, the review should in principles end when the references become redundant. However, in praxis the author also notes, that is the researcher who ultimately judges when the review cycle of the literature snowball ends.

On the opposing page, I have condensed an overview of the primary topics of my literature review, the variances of the concepts, and examples of some of the oft-quoted works on the topic (figure 10).

TOPIC	VARIANTS	EXAMPLES OF MAJOR WORKS USED IN REVIEW
Sketching	Drawing, depiction, visual expression, externalization, paper prototype, Low-fidelity prototype	Goldschmidt (1991, 1994, 2003), Suwa & Tversky (1997), Suwa et al 1998, Buxton (2010), Goel (1995), Cross (2006), Jones (1992), Lugt (2005), Ferguson (1994), Olofsson & Sjölen (2007), Tversky 2002, Hutchins (1995), McCloud (1994), Verstijnen et al (1998)
Animation	Apparent motion, motion graphic, cartoon, CGI, Special effects,	Johnston & Thomas (1995), Ward (2003), Wells (1998, 2002, 2006), Wells & Hardstaff (2008) Wertheimer (1912), Wells (2011), Stephenson (1973), Crafton (1993), Furniss (1998), Solomon (1987), McLaren in Sifianos (1995), Sheets-Johnstone (2011), Frasca (2003)
Video prototyping	Video sketching, vision video, envisionment video, video artifacts, virtual prototype	Ylirisky & Buur (2007), Mackay (1988), Mackay et al (2000), Mackay & Fayard (1999), Hill & Houde in Helander et al (1997), Zimmernan (2005), Vertelney (1989), Bardram et al (2002), Young & Greenlee (1992), Buxton (2010), Tikkannen & Cabrera (2008)
Non-idiomatic technology	Emerging technology, new media, disruptive technology, idioms, pattern-less	Löwgren (2004) Löwgren (1996), Löwgren & Stolterman (2004), Cooper et al (2012), Gamma et al (1994), Alexander et al (1977), Tidwell (2005), Fällmann (2003), Lindel (2012), Rotolo et al (2015), Pine & Korn (2009)
Animation in design	motion design, pre-viz, pre-visualization, animated sketch	Baecker (1969), Moschovich & Hughes (2003), Davis et al (2008), Sohn % Choy 2012), Quevedo-Fernandez & Martens (2012), Löwgren (2004), Buxton (2010), Ylirisky & Buur (2007), Block (2007), Tversky et al (2002), Betrancourt in Mayer (2005), Bonanni & Ushii (2009), Zarin et al (2012), Fallman & Mousette (2011), Baecker and Small in Laurel (1990), Chang & Ungar (1993)

Figure 10: Overview of the primary topics of my literature review, with the variations identified, and examples of the works used from each topic. Note that this only includes the major works, and not necessarily all the used material.

2.5.2 STUDY B - USER-DRIVEN CREATIVE ACADEMY (U-CRAC)

In this design experiment, I co-facilitated three editions of the User-driven Creative Academy workshop (U-CrAc). The workshops originated from the LUDINNO research project, which was founded by 'The Nordic Research Council', and initiated by a research group led by Nicola Morelli (Morelli & Bolvig 2010). The objective of LUDINNO was to establish designerly collaboration among participating companies, and consultants with students and researchers through user-oriented laboratories. The intention was not to take a subservient role, but instead engage as an influential actor, and equal partner in a Triple Helix constellation with industry, and public organisations (Etzkowitz 2003).

Since the original U-CrAc workshop in 2009, the format has undergone several changes, especially in regard to the subject matter, which started in the service and experience industry, was changed to focus on health and social care, and now in the latest two iterations has taken a broader spectre of cases from both health care, service and experience economy. The workshop is divided into three phases; *Fieldwork*, *Ideation* and *Concept development*. Each phase had a dedicated week. The students performed ethnographic user studies in the first week, and interpreted the observations into what we phrase *innovation tracks*. These innovation tracks became the starting point for the following two weeks of applying animation-based sketching in ideation and concept development, which is the empirical focus of my experiments. The design student's goal was to both explore new ideas as well as anticipate how these new ideas might affect the user experience. The students were instructed to explore their concepts via some instance of temporal sketching, introducing them both to video sketching, as wells as animation-based sketching. While animation-based sketching was not mandatory - it had to make sense for the students to use animation in order for the data not to become too artificial - the majority of cases used animation-based sketching at some point in their ideation and concept communication. A broad range of animation fidelities were used at different stages in the three-week workshop, ranging from animated storyboards (animatics), stop motion, and video sketches with animated effects.

U-CrAc as a lab context

I see the U-CrAc workshop context as an example of the lab approach to constructive design research. While the students engaged with real world cases, and stakeholders from outside the world of academia, the workshop context established semi-controlled constraints in terms of time, methods, and design freedom. Through the setting, we had the opportunity to collect a large amount of animation-based sketches with the same or similar preconditions - creating a broad spectre for comparison, and to assess the scope of animation-based sketching from.

I facilitated, and participated in the workshop four times, but the lab approach was primarily applied in the U-CrAc 2014 edition, and thus acts as my primary empirical source for [P3] and [P4]. The 2013 edition was used to test the initial observation setup, as discussed previously (section 2.4.1), which we abandoned in refocusing the research from reflection-*in* to reflection-*on*-action. The lessons learned from the setup influenced the 2014 setup in favour of more strict and constrained data gathering method, which prioritised capturing the ultimate particulars of the different animation-based sketches. The focus of the 2014 edition was to explore the factors determining how animation-based sketches expressed interaction and user experience aspects. The same setup from 2014 was used in the latest 2015 edition of the workshop, which focused on collecting more examples of animation-based sketches to be used in [B1], and future studies of animation-based sketching.

Figure 11: Images from the U-CrAc workshop, in which more than 200 students used animation-based sketching to explore new design ideas, with a wide variety of techniques, materials and fidelities applied.

A total of 36 design oriented cases from the private as well as the public sector participated as stakeholders. These cases were given to groups of multidisciplinary design students from interaction design, experience design, industrial design, entrepreneurship design, and cultural service design. In 2014, a total of 203 students participated. I instructed the students to take an online questionnaire about their prior experiences with topics like animation, sketching, design processes ect. (Appendix 2.2) to better determine the competence level of the participants in the design experiment, and to know as many of the preconditions as possible. This step was also an attempt to heighten the recoverability of this experiment, ensuring a more rigorous classification of the participating design students. 79% of the students had none or limited experience with video and animation, and 48% had only limited experience with traditional sketching and prototyping (Appendix 2.3). As such, I argue that the majority of participating students could be characterised as *novices* (Dreyfuss & Dreyfuss 1980). In this way the setup provided a basis for experimenting with introducing animation-based sketching to designers with little or no preconditions for using the approach. As such the design experiment explored wether animation-based sketching was viable in the short workshop context and for novices.

Web-portfolio as data sampling method

In order to capture the animation-based sketches in a way which would made it possible to examine their relational qualities (e.g. when in the workshop were they made, for what purpose ect.), I used an online platform, which I had previously co-developed (www.urac.dk). The platform used a modified Wordpress content management system (CMS) to create a multiuser system, where each group of design students received access to their own individual 'concept' page to communicate their ideas and process. I created a very strict template, categorising the students sketches, and reflections in accordance to the phases of the workshop, and with specific topics needed to be filled by the students. I view this approach as being akin to Hutchinson et al's (2003) notion of *'technology probes'*, installed to collect data about the use, and reflection, of a specific phenomena. The original use of the concept is as a field approach to understanding users in context, but I argue that the concept also fittingly describes using an implemented technology (the CMS), to capture the use of a tool (animation-based sketching), in a professional context (a design process). Via the CMS, the students were given a constrained set of possibilities to upload material into a set of predefined sub-tabs for the different phases in the workshop. This constrained approach again added to the invariance of how the data was gathered, and the comparability between the different uses of animation-based sketching in the workshop. This setup is again underscoring the lab approach of this study.

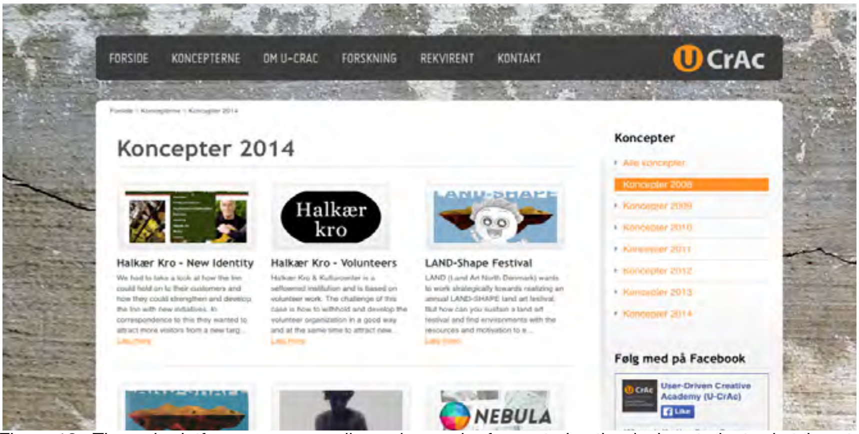


Figure 12: The web-platform www.ucrac.dk used as probe for capturing the design students sketches, to become an annotated portfolio of how to use animation-based sketching to express interaction & user experience design aspects.

Especially the decision to ask the students to categorise their animation-based sketches based on the ones made during ideation, and the ones produced during their last week of concept synthesis was important. This was done in an attempt to separate the sketches aimed at investigation and exploration in the ideation phase, from the explanatory and persuasive sketches in the synthesis phase. The categories were in accordance to the framework of sketching functions I propose in [P2]. Via the CMS the students were given a constrained set of possibilities to upload material into a set of predefined sub-tabs for the different phases in the workshop. Furthermore, I argue this type of platform can be understood as an annotated portfolio - collecting a wide collection of ultimate particulars occupying the same design space of the workshop context. In this way the lessons learned, as described in part III of [B1], and in [P3] and [P4] are in essence theoretical annotations on top of the animation-based sketches, with the sketch itself being a knowledge contribution on its own term - showcasing the potential of animation-based sketching in the situation.

Watching and categorising the portfolios of animation-based sketches

During the workshop I spent most of the time as a facilitator of both practical, theoretical, and methodical issues regarding using animation, and video in the students design processes. I took field notes from this process in order to identify groups of special interest in regard to applied animation techniques, interesting new issues and possibilities revealed, and used these notes to take special notice of the observed elements when examining the final material after the workshop.

After three weeks, in 2014, a total of 158 animation-based sketches were produced. The first 'reading' of the material came through watching all the sketches - replaying elements of special interest, and taking notes. Afterwards I sorted the sketches based on a qualitative identification of the interaction and user experience design aspects represented in the sketch - the utility, usability, desirability, and context. The aspects were derived from my previous considerations, and framing of how I understand interaction and user experience in accordance to Buchanan (2001), Hazzenshal & Tractinsky (2006), and Jensen (2013). I cross examined this, by mapping, which techniques, or combinations of techniques, the students had applied in each produced sketch (Appendix 2.4).

GROUP 4 - AskCody	VIDEO	STOP MOTION	ANIMATIC	PURE KEY FRAMES	MOTION OVERLAYS	3D ANIMATION	PRE-MADE	UTILLITY	USABILITY	AESTHETICS	CONTEXT	NARRATIVE
Sketch 1		X						X	o		X	X
Sketch 2		X						o		o	X	X
Sketch 3		X						o			o	o
Final Sketch	X		X		X			X	X	o	o	X
GROUP 5 - LandShape	**VIDEO**	**STOP MOTION**	**ANIMATIC**	**PURE KEY FRAMES**	**MOTION OVERLAYS**	**3D ANIMATION**	**PRE-MADE**	**UTILLITY**	**USABILITY**	**AESTHETICS**	**CONTEXT**	**NARRATIVE**
Sketch 1	X	X			X						o	o
Sketch 2		X									o	o
Sketch 3		X						o			o	o
Sketch 4	X		X				X	o		X	X	o
Final Sketch		X						X		o	X	o
GROUP 6 - LandShape	**VIDEO**	**STOP MOTION**	**ANIMATIC**	**PURE KEY FRAMES**	**MOTION OVERLAYS**	**3D ANIMATION**	**PRE-MADE**	**UTILLITY**	**USABILITY**	**AESTHETICS**	**CONTEXT**	**NARRATIVE**
Sketch 1		X							o			X
Sketch 2			X			X		o	X		o	X
Final Sketch	X				X			X	o	o	X	X
GROUP 7 - HjørringLIVE	**VIDEO**	**STOP MOTION**	**ANIMATIC**	**PURE KEY FRAMES**	**MOTION OVERLAYS**	**3D ANIMATION**	**PRE-MADE**	**UTILLITY**	**USABILITY**	**AESTHETICS**	**CONTEXT**	**NARRATIVE**
Sketch 1 - ikke tilgængelig												
Sketch 2		X					X	X		X	o	o
Sketch 3				X			X	X	X	X		o
Final Sketch	X			X			X	X	X	X	o	X

Figure 13: The mapping of animation techniques applied in the sketches, crossed with which interaction and user experience design aspects the sketches expressed. See appendix 2.4 for the entire mapping.

The mapping is based on my analytical deductions, based identifying which animation techniques are used, and which interaction and user experience aspects are represented. Of course the identification of especially the user experience aspects could be criticised for being too subjective, since they are based solely on my analytical identification. I have however, sought to make the entries in accordance to Pedgley's (2007) guideline of *'modelling administration'*, by ensuring that there is an overview over the corresponding animation-based sketches, and easy access the sketch. In doing so, I argue the mapping is recoverable for others to put under scrutiny, and further assess the quality of the mapping.

The original hypothesis, causing me to do this mapping, was that we would be able to see a correlation between the use of animation techniques with higher visual and/or temporal fidelity, and the expression of user experience aspects. It did however turn out to be quite different, with no clear correlation observed. Instead, the narrative presentation of the animated diegetic designs indicated to be what decided the degree of representing user experience aspects. I illustrate this insight in [P3] and further elaborate on the role of narratives as ways of anchoring proposed concepts to a certain user disposition in [P4], as well as in part III of [B1].

2.5.3 STUDY C - SERVICE SYSTEM DESIGN IN COPENHAGEN

The municipality of Copenhagen organised a call for service design proposals for the near future of the city. The proposals were to be submitted as part of a public planning process in 2014-2016. In the wake of this initiative, Aalborg University Copenhagen organised an intensive 5-day design workshop for graduate service design students. I facilitated this workshop for two years, and introduced the service design students to animation-based sketching, and instructed them to create different speculative design scenarios for creating smart city solutions to the deal with the design brief.

Figure 14: Stills from the workshop with the service design students, working with different techniques and fidelities of animation-based sketching.

This case was an experiment in using animation-based sketching as an explorative tool, with a workshop setting similar to that of the U-CrAc workshop in study B. However, in this study I changed the parameter of the practical feasibility of animation-based sketching, by experimenting with how much we could teach a team of novices in only a five day design sprint - compared to the double in study B. Thus, the same constrained lab approach was preserved, while the time constraints was tightened. To further constrain the types of data material produced from the workshop, I required the students to produce a minimum of five animation-based sketches framing the design space, and their initial conceptual ideas, before narrowing down their idea in a final animation-based sketch. I did this in an attempt to provoke the sketching mindset, which I reflect upon in [P1] and [P2], to avoid their use of animation-based sketching to just be used as visual communication, but also for visual thinking about the temporal, and interactive aspects of their design proposals.

Student papers as annotations on sketches

Even though the research design of the service design workshop shared many features with the U-CrAc workshop, one important aspect was the smaller scale of the workshop - having only between 20-30 students each year. This was ideal for the purpose of testing some more specific aspects of introducing animation-based sketching to novices, than was possible when facilitating a workshop for 200+ participants as in the U-CrAc setup. Among other things, I made an effort to get the service design students to experiment with different ways of optimising the design of graphism (the elements to be animated), by establishing a pipeline of reusable sketching elements. Furthermore I urged the students to experiment with different materials, mediums, and tools when creating their sketches. This resulted in of more rigorous observations of applying animation-based sketching in constrained setups, which I describe in part III of [B1].

However, a consequence of the smaller format in this workshop was that we did not have time, or resources, to build an entire web-portfolio platform as we did with the U-CrAc workshop. To capture the reflection-on-action, about the specifics of this design experiment, I instead choose to assign the service design students with the task of writing an academic short paper as their final deliverable after the workshop. I created a template, which combined the layout, and content structure of a traditional academic paper, with specific guidelines for focusing on reflecting upon the produced animation-based sketches, and how they had influenced the design process (Appendix 3.3). Before giving the students the paper assignment, I arranged an all day critique session, in which the animation-based sketches, and the design process was presented by the groups of students, with feedback from other students, and participating academics. In this way, the context was for a moment changed from the lab approach during the workshop, to a showroom context, in which the design students experienced how their produced sketches invoked reflections from peers. The main idea was, that this shift would kick start their own reflections on their sketching process, and thus also the creation of their annotated portfolios.


FROM FICTION TO SERVICE

Figure 15: Examples of the student short papers, acting as annotated portfolios of the student's various applications of animation-based sketching from the workshop. See appendix 3.2 to access the papers.

The short papers acted as the annotated portfolios of this design experiment - a variant which proved useful to gather the sketches in a similar form, but still maintain the diverse reflections made on the individual sketches. Complemented by my own notes, and captured imagery, this approach of using annotated portfolios showed to be an useful way to capture reflections-on-action. While the web-portfolio approach in the U-CrAc workshop might provide a lower barrier for others to reflect on and 'read' the portfolio, the short paper based portfolios provide a more systemised annotation to the designed, making them more rigorous for academic design research in my experience.

2.5.4 STUDY D - DESIGN OF THE NORTH SEA MOVIE MAKER

This study was the one with the most deep design involvement from me, since I participated as active constructive design researcher throughout a year long digital design process with the aqua zoo, The North Sea Oceanarium. The North Sea Oceanarium is a state-recognised zoo with an annual subsidy from the Danish Ministry of Culture, supplemented by income from ticket sales, and other activities. The aim of the zoo is to inform visitors about the North Sea through edutainment activities (Appendix 4.1). Their topics range from underwater nature, and animal life to sustainable exploitation of the seas, and the oceanarium displays a wide selection of living creatures and plants.

In 2012, as part of the zoo's 2020 strategy (Appendix 4.1), the organisation began to focus on creating digital extensions of the physical experiences at the zoo. In this project I participated in a multidisciplinary design team concerning the development of a mobile augmented reality application, the *'North Sea Movie Maker'* (Huge Lawn 2013).

Figure 16: Still images of some of the animation-based sketches produced throughout the research-through-design activities of study D.

In the study, my research aim was to explore how animation could facilitate decision making, and create consensus among the stakeholders from widely different domains, by generating temporal information about the non-idiomatic aspects of the interaction and user experience design possibilities with different types of augmented reality.

A research *through* design project in the field

This study was a clear manifestation of the archetypical research *through* design process, since my role actively required me to engage in the reflective practice of framing the design space, sketching possible solutions, and become interweaved in all the wicked complexity of the design process. Furthermore, this study took on a clear field approach in terms of design experimentation (Koskinen et al 2011), given how the design research took part in the contextualised setting of the zoo, together with team members working there. As such, this was *'design in the wild'*, and made it unfeasible to make a constrained observation setup, and instead relied on photo documenting design activities, as well as producing field notes with observations akin to that of auto ethnography (Baarts in Brinkmann & Tanggaard 2010). In doing so, I attempted to follow the guiding principles of Pedgley (2007) as we discussed previously (section 2.4.1). These reflections, captured imagery, and the multiple sketches (both static as wells as animation-based) are ordered chronologically in a series of sprints (Appendix 4.4, 4.5, and 4.6). These reflections have also been gathered in two danish reports (Vistisen 2014, Vistisen 2015, or Appendix 4.8), which sums up the entire research collaboration with the North Sea Oceanarium, including studies not included in the thesis.

Figure 17: Stills from the design process. From initial brainstorming (left), mocking up a physical context to later augment with animation (middle), and live bodystorming which would later become content in a series of animation-based sketches. See appendix 4.5, 4.6, and 4.7 for more process material.

The data gathering from the design process, with animation-based sketching, formed the basis of analysing the establishment of consensus between stakeholders in [P5], and in chapter 11 of [B1]. The paper and book acts as annotated portfolios of the multitude of different fidelities, and formats of animation-based sketches produced throughout the design process. Thus, the designs themselves stand as ultimate particulars not only of the proposed concepts, but also as ultimate particulars of using animation as a sketching approach. In the analytical construction of these annotated portfolios, I have sought rigor in terms of describing the different animation-based sketches chronologically, as well as mapping which points of debate they were introduced to facilitate consensus about. These decision points were identified as when the stakeholders in the project raised questions about the design, which could not be answered sufficiently without temporal information. This was also done in order to reflect on the pragmatic value of this use of animation-based sketching, with each chronological step being a point of evaluation in terms of the sketch's practical value.

This mapping was done by arranging the sketches in accordance to the 'design sprints' in the project plan, which we shared between the North Sea Oceanarium, and the development team. I organised the material in sprints combined different types of data, like meeting summaries, photographs of the process, and of course the animation-based sketches. This 'decoupling' (Basballe & Halskov 2012) was where the auto ethnographically captured material was giving structure through reflecting back upon the process, when reviewing the material. As such, the chronology, and ordering of the materials from the process are locally grounded in my presence in the situation, and thus also my experience of the process. I have sought to include as much of my captured material, and the summaries has been shared between the stakeholders, to reach a level of inter-subjectivity in the data. Even so, the decoupling can never fully escape the subjectivity of me as a participating designer, assessing and evaluating the role animation-based sketching played in facilitating consensus. In line with the pragmatic paradigm, and the expansive logic of the research design, it does however make sense to differentiate between seeking absolute objectivity, and pragmatically adjust and guide practice towards a desireable outcome. That is, in this case, making decisions about design possibilities in the design space, which results in a final artifact implemented successfully. In this regard, the annotated portfolio of animation-based sketches serve as documentation for this pragmatic inquiry into the design space, and as the fossilised decisions made towards the final ultimate particular.

2.5.5 STUDY E - COLLABORATION WITH EXTERNAL AGENCY ON GAME DESIGN

The final study in the research project was also the shortest, and the one in which my role and involvement was least intensive. Together with a local waste management company 'AVV' (Affaldsselskab for Brønderslev & Hjørring) the design and communication agency 'Tankegang' (2016) had received a grant aimed at exploring how new mobile technologies could be used to communicate sustainability to young audiences. The project was entitled *'Recycling Animation'*, and organised as an internal R&D project towards understanding the non-idiomatic aspects of a new game design, which combined elements of augmented reality and the endless runner game genre.

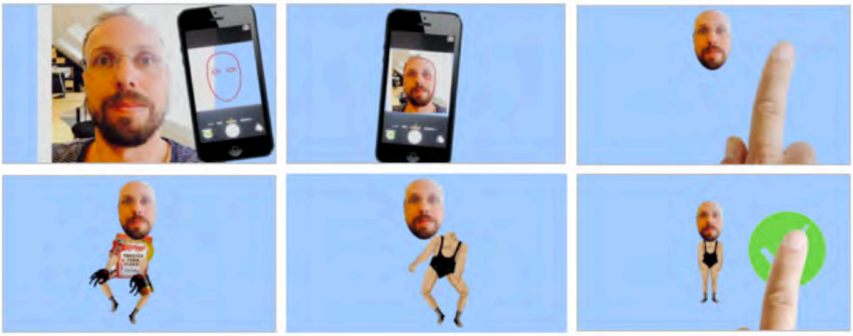


Figure 18: Stills from one of the late animation-based sketches, exploring the dynamics of using a smartphone to create a player avatar, which would later be manipulated in a end-less runner style game.

Based on my results from the North Sea Oceanarium collaboration, I was invited to participate in this projects ideation phase, in which I introduced the tools and techniques of animation-based sketching to practitioners not schooled in either animation or non-idiomatic design problems. This gave me the possibility, to observe how the production and sharing of animation-based sketches could create externalisations of a projects vision in an existing practice context. Thus, the involvement in this study is an example of the 'drifting', which Krogh et al (2015) spoke of as typical in design research - new areas of interest are uncovered as the constructive activity of design reveals new boundaries and territories, which the researcher can pursue.

Back in the field, facilitating and co-designing

The participation in this project took a clear field approach (Koskinen et al 2011), contextualised around a series of meetings, workshops, and design sprints at both Tankegang and AVV. At the first ideation meeting was arranged as a brainstorm session, in which many loosely related ideas were generated. Some of these were quickly sketched on paper, but most ideas where just described in written text. I primarily focused on getting to know the stakeholders, and especially map wether any of the participants had prior experience with design sketching, or using animation as a facilitative design tool. When it was clear these competencies where not existing among the participants, me and a co-facilitator suggested to experiment with animation-based sketching, as a possible approach to make the many fluffy ideas more concrete. A short 30 minutes intro to animation techniques was given; showcasing animatics, stop motion, and simple keyframe animation. Tankegang now choose to continue working on the ideas, using the animation-based sketching approach, and present the results at the next meeting between the stakeholders.

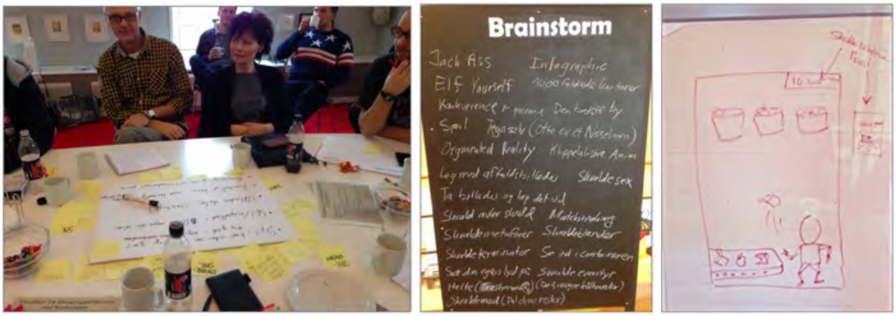


Figure 19: Stills from the meetings, brainstorm and ideation with AVV and Tankegang about ways of merging user-generated avatars into a game design about sustainability.

At the following meetings, I could observe how the bureau's employees had successfully created multiple different concept proposals as animation-based sketches, which had enabled them to discuss the interactive behaviour of the game concepts among the co-workers. To capture these discussions, I sampled the produced sketches, as wells as wrote summaries of the meetings. Tankegang and AVV also contributed to this documentation, by co-writing a 'lessons learned' report (Appendix 5.2), and by producing a process video (Appendix 5.4), documenting the process of exploring the game concepts.

However, as an annotated portfolio, the sporadic involvement in this case is evident in the rigor of the possible annotations made on the animation-based sketches. The drift into this project contributed with insights about the viability of using animation-based sketching in practice without any preconditions, and the possible pitfalls of the approach - described in part III of [B1]. However, my findings was clearly lower in this study, than in the previous. As such, I argue, that while drifting might be a natural part of constructive design research, especially research through design, it does also run the risk of producing less rigorous and ordered data. This might be because, that when one design experience (the North Sea case) leads into a new one, the lack of a formalised research design leaves the design researcher to induce patterns while 'hitting the ground running'. As such, I do not diminish the results I did obtain from participating in this study, but learned the risk of drifting into a research engagement without a clear research design in place at start.

An interesting observation revealed through this study was, how the continuous use of annotated portfolios gradually begins to form the basis of stronger and stronger theoretical arguments. When introducing animation-based sketching as an approach, it was not a theoretical deductive logic which convinced the stakeholders. Instead, it was the portfolio of existing animation-based sketches from the North Sea Oceanarium involvement, which had enough resemblance and familiarity, that the stakeholders could see the potential benefit of applying the approach in this design process. Thus, just as Gaver (2012) describes it - the ultimate particulars (the North Sea sketches) augmented the general appeal of the theory (the viability of using the approach in this project). Thus, animation-based sketches from a disparate study could act as pragmatic basis for qualifying the potential of using animation-based sketching in non-idiomatic design cases in a more general perspective.

2.7 SUMMING UP - USING ANNOTATED PORTFOLIOS

In this chapter, I have introduced and discussed my research design, organised around Dahler-Larsen's (2008) framing of interactions between different levels in a research design. I have introduced my research as exploratory research, with an expansive logic towards broadening the body of knowledge about the use of animation in design sketching. This has been grounded in the meta theoretical domain of design research, more specifically constructive design research, in which my project uses research-*through*-design to produce contributions with the character of research-*for*-design. I have further discussed, how I view my research through a pragmatic paradigm, as an inquiry into the effects in practice of using animation-based sketching to support design processes with non-idiomatic technologies. The individual studies are thus organised as pragmatic inquires that are primarily situated in either a lab or field context. The primary data output from these inquiries is collected as different variations of annotated portfolios, using the ultimate particulars of individual animation-based sketches to abstract theoretical lesson learned about the approach.

Especially the use of annotated portfolios has been a substantial element of my research. The technique has been a fruitful way of establishing some level of common ground as to how I collected, and grouped the many animation-based sketches produced and facilitated throughout the project. Wether being collected through a web-based probe, short academic papers, or as collections organised through design sprints, the logic of organising theoretical insights around the portfolios' has been the constant in the project. As such, it has also been my experience, that this way of gathering, and using animation-based sketches, as data, also creates a self-consciousness about the limits of the theories produced. Any annotation is based on one ultimate particular representation, and is furthermore only one perspective, open for further annotations. The portfolios are thus not characterised as reliable data, as they have a relative weak predictive power in and on themselves. Rather, they are based on induced family resemblances between local sketches. They are to that fashion, descriptive, rather than explanatory, and index past experiences to be generative, and to inspire future uses through recovering the sketching approaches used in the sketches.

This descriptive, and generative logic is argued to be one of the strengths of annotated portfolios since it supports the scientific use of artifacts produced by designers (Bowers 2012).

However, it is also my experience, that the insights are very provisional, and do not hold the same level of generality, as if I had sought to distill a pattern language (Alexander et al 1977) of reusable forms and animation practices to be used in animation based sketching. To this end, the induced theoretical insights from annotated portfolios are too closely attached to the ultimate particulars in the portfolio. Whenever I use one of the lessons learned derived in [B1], or discuss the findings from the papers, I end up using the individual animation-based sketches of the portfolio as indexical basis for the argument. Thus, when using annotated portfolios, I assess that it is with some caution that the design researcher can reach beyond the individual examples, and attempt generalisations. At best, these generalisations will be abductive speculative hypotheses. As such, the driver of making rigorous, and relevant theoretical abstractions from annotated portfolios must be to continuously develop, and expand the portfolios of resembling animation-based sketches. That is, in the words of Dewey (2005), gradually building *'a universe of experience'* to qualify the practice of applying animation-based sketching.

With these final reflections on annotated portfolios, the next chapter will summarise and discuss the contributions from the studies. As aforementioned in the introduction to this linking text, I highly recommend reading part I and II of [B1], and the papers [P1] and [P2] prior to reading further. These contributions provide the theoretical literature reviews and state of art descriptions of the thesis' theory, leading up to defining animation-based sketching. Papers [P3-5] and part III of [B1] describes the various expansive experiments in detail, which the next chapter summaries.

CHAPTER 3: SUMMARY OF CONTRIBUTIONS

This chapter will summarise, comment and reflect on the findings from my research contributions in [P1]-[P5], as well as [B1] in correlation to the research questions posed in chapter 1. In the summary, syntactical redundancy from the individual papers and the book will occur, as I condense the insights and lessons learned into this chapters shortened versions. I refer to this in the beginning of each section, by stating which of the appended works the contributions derive from. For a brief overview, the contributions are summed up in the end of the chapter (section 3.9).

Each of the contributions portrays different endeavours into expanding the body of knowledge, about using animation as a sketching capacity when dealing with non-idiomatic technologies. Seeing the contributions with a little distance it is evident to me that this expansive study have followed two main tracks. [P1], [P2], and the first two parts of [B1] has been contributing to the theoretical discourse of design sketching. This is combined with the domains of animation and non-idiomatic technologies, towards contributing with a definition of animation-based sketching as a distinctive design approach. I wrote [P1] and [P2] in the beginning of the project, reviewing the discourse about design sketching at the time. The more detailed review of literature and theory building presented in [B1] was formed in the final year of the project, summarising and to some extent also adjusting the insights from the two papers. Furthermore it presented my insights from reviewing the discourse on animation, non-idiomatic technologies, and the previous efforts in applying animation in design.

The papers [P3], [P4], and [P5] are all written throughout the second and third year of the project, and thus report specific experiments with using animation-based sketching in practice. These papers are briefly summed up, and referenced to in part III of [B1], which also includes two new experiments, and further contemplation on the three papers. Together, the experimental part of the studies contribute to assessing the pragmatic feasibility and viability of using animation-based sketching in actual design processes.

3.1 SKETCHING - THINK 4-DIMENSIONALLY

In [P1] I discuss the epistemology of design thinking, around the discourse presented by e.g. Cross (2006), Simon (1996), Buchanan (1992) and Gaver (2012). I assess how sketching supports what Kolko (2010), together with Brown (2009), and Martin (2009), labels *'the abductive sensemaking'* of design. It is here proposed, that sketching is the archetypical manner of which designers manifest the speculative sensemaking behind asking 'what if?' questions. This is in the continuos dialectic between problem setting and problem solving (Schön 1983).

Kolko describes how the lived experiences, of the individual designer is left as evident marks in everything designed (Kolko 2010), is also evident in early sketched renderings. By making an externalisation of the abductive 'what if' question, the the designer adds data into the existing parameters of the problem setting. Into this notion I add the proposal by e.g. Buxton (2010), that not only pen & paper enable this abductive sensemaking, and that sketching, as a mode of thinking, is much broader. My contribution is a more strict way of categorising the different sketching capacities, through the optic of which spatial and temporal dimensions they involve. I here appropriate Gillian Smith's (Smith in Moggridge 2006) categorisation of dimensions in interaction design, set between 1D-4D, as a proposal for dimensions in which a designer can be said to be 'sketching'.

A 1-dimensional sketching capacity is e.g. a thought experiments, or formalised further into 'principal sentences' as guiding concepts for early design, as proposed by Lerdahl (2001). Sketching in pen & paper would be the obvious examples of the following 2-dimensional capacity, but digital sketching is often seen remediating aspects of pen & paper as well. 3-dimensional sketching on the other hand broadens the scope into domains such as 3D-printing (Hopkinson et al 2006) and mock ups in other materials (Ehn & Kyng 1992), but also includes physical manipulation via sandplay as in 'material storytelling (Jørgensen & Strand 2014). Finally I discuss the obvious addition of the temporal 4th dimension as a sketching capacity. This category of *'temporal sketching'* is already inhabited by embodied approaches such as 'bodystorming' (Oulasvitra et al 2003), enactments (Arvola & Artman 2006), and video (e.g. Ylirisky & Buur 2007, Mackay et al 2000, Zimmerman 2005). The temporal 4-D sketching capacity does not just capture the stages of an idea, but also expresses the transition between stages. These transitions are what I argue in [P1], in conjunction with Buxton (2010), is where the experiential qualities in interactive design are expressed. Thus, I build upon this categorisation in proposing a further focus on animation as a temporal sketching approach, capable of achieving what Stephenson (1973) proposes a *'near full control'* of the expressive possibilities. From this proposal came a tentative question, for my further studies, about how animation could be appropriated from traditional animation into animation-based sketching.

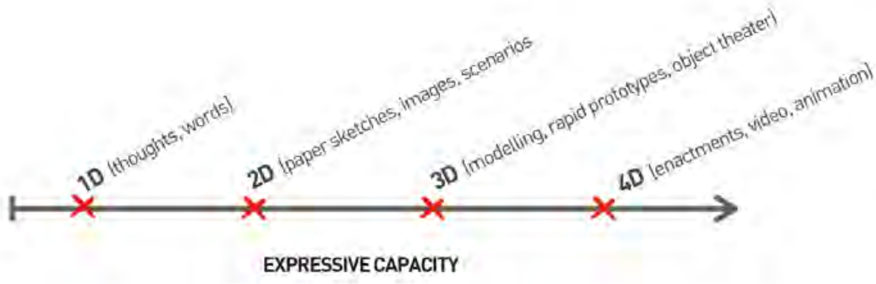


Figure 20: Scale of expressive capacities in sketching, from 1-dimensional thoughts and words to 4-dimensional temporal capacities like video and animation.

The contribution of the 1D-4D typology of sketching capacities is thus my approximation to answering the sub-question posed in chapter 1:

How do we categorise sketching capacities?

In design, the designer is faced with contingent choices, of how to explore and represent a design proposal. The proposed typology of sketching dimensions provides a way to compare expressive capacities of different approaches. Any sketching capacity can essentially say something about anything. The challenge is to qualify which dimension to sketch in to get the feedback needed when asking a specific 'what if?' question. Since few design processes has resources to explore an idea throughout all four sketching dimensions, this is a challenge. Furthermore, all capacities are seldom needed - it is all about what questions are being posed at the given time. Thus, the relevance of [P1]'s categorisation is a clearer discourse for evaluating which dimensions to operate in, when exploring a given design idea.

3.2 THE MULTIPLE FUNCTIONS OF SKETCHING

In [P2], I contributed by reviewing the state of art in the design sketching discourse. I identify that most studies can be sorted in one of two common perspectives on the roles of sketching in design processes. The largest quantity of contributions, has observed and analysed the reflective practice of sketching as a *'visual thinking'* approach - e.g. Goldschmidt (1991, 1994, 2002), Goel (1995), Schön & Wiggins (1992), Suwa & Tversky (1997), Fish & Scrivener (1990), Buxton (2010) and Ferguson (1994). Less dominantly is the studies of sketches as *'visual communication'* for either external or internal use in the design process - eg. Hutchins (1995), Lugt (2005), Nolte (2001), Buxton (2010), and Ferguson (1992). Evidently a few studies, like the ones made by Ferguson (1994) and Buxton (2010) consider both perspectives, and Buxton further suggests, that it is the specific intentionality of an approach, which determines wether it is a sketch or not.

I followed this notion, that sketches were determined by specific intents, and proposed that the two positions in praxis are intertwined. To illustrate this, I turned to Olofsson & Sjölen (2007), who used a set of four genres as headlines for their book on design sketches: *investigation*, *exploration*, *explanation* and *persuasion*. The investigative sketches are tightly connected to the early phase of the design process, when examining the problem setting - a visual thinking perspective of sketching. Explorative sketches are used when proposals of design solutions are expressed in order to be evaluated, and seldom make much sense for others than the people directly involved in the design process - a mix between thinking and communicating through sketching. Explanatory sketches, on the other hand, are about communicating clearly to others to gather feedback, and reach consensus - in other words primarily a visual communications perspective. Finally, persuasive sketches are used in a more rhetorical manner, showing less ambiguity, and more details than the other types. Here, the intent is to 'sell' the proposed design concept to influential stakeholders, with little intent to 'think' more about the proposed concept.

Olofsson & Sjölen used the four genres to index their book, but did not reflect further about the interaction between the genres of sketching in the design process. That is, other than the investigative sketches are the earliest, and the persuasive are the last to occur in the design process.

I took their genres a bit further, and organised them into a continuum, shaped in a matrix grid:

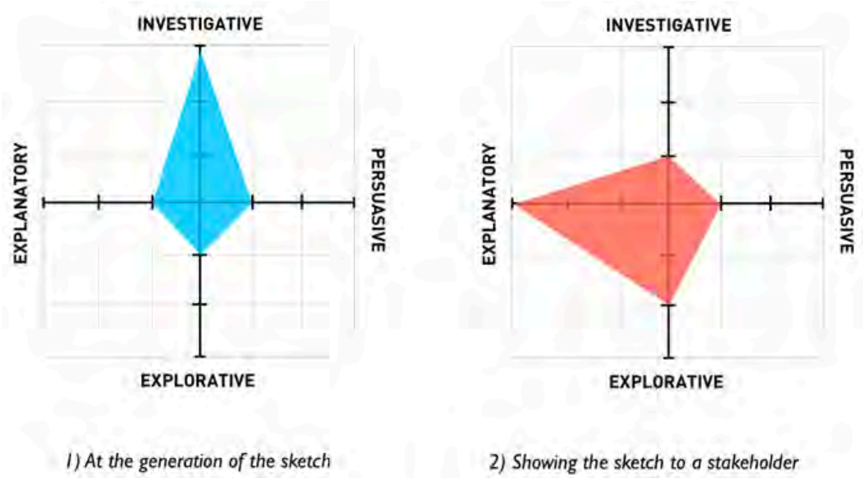


Figure 21: An example of mapping in the sketching matrix, depicting how the same sketch takes on different functions over the course of time in the design process.

The four genres by, Olofsson & Sjöflen, were appropriated to reflect the different intents a sketch can possible take in the design process, and how this intent, and thus the function of the sketch, can change over the course of time. I used the notion of a 'tension' about this changeable nature. A sketch initially used to explore as visual thinking, might later (with or without alterations) be used to gather feedback from other stakeholders, communicating the idea, with the intent of further explorations. At other times, a rough investigative sketch might be included in a sales pitch, to underscore the width of ideas used to reach the final proposal. This changes the sketch into a persuasive sketch. As such, the tension field is my approximation of clarifying the sub-question of:

What is the relation between thinking and communication in sketching?

Viewing sketching as an intertwined relationship, between thinking visually when sketching, and communicating with the output sketch, with shifting intents, contributes with an integrated perspective on design sketching. It serves to show, that while we might set out to study the process of sketching, we cannot ignore the external and communicate nature of the output sketches, and how their roles potentially change throughout the process.

3.3 SKETCHES VS. PROTOTYPES

From writing [P2]'s reflection on the function sketching and sketches, a question continued to remain unanswered in the sketching discourse. The difference between sketches and prototypes. While several distinctive definitions also exist on prototypes and prototyping (e.g Wensveen & Matthews 2015, Rogers et al 2011, Lim et al 2008), many literature examples use the two terms interchangeably. This is evident as an example in the concepts of 'video prototyping' (e.g. Mackay & Fayard 1999, Vertelney 1989, Bardram et al 2002, Tikkanen & Cabrera 2008, and Ylirisky & Buur 2007) and 'video sketches' (Zimmerman 2005, Poulsen & Botin 2015), which in essence describes the same design approach, with little variations, but uses both sketching and prototyping as classification. To me, this ambiguity stood as a problem of actually speaking about animation-based sketching: If it is unclear when which is what, then how could I sufficiently claim what I focus on is sketching and not prototyping?

It could be argued that the confusion arises due to differences between the fields of origin. Design sketching originated academically in the design discourse of architecture and industrial design (Schön 1992), and prototyping originated from computer science and engineering (Ferguson 1994). But the history of the two terms still does not clarify '*what they are*' and '*how they differ*'. Some scholars have illustrated the difference indirectly by proposing various principles and techniques for creating different types of design sketches (Ferguson 1994, Olofsson & Sjölen 2007, Buxton 2010), and other principles and techniques for variations of prototypes (Lim et al 2008, Wensveen & Matthews 2015, Hill & Houde in Helander et al 1997). While such principles are helpful, when it comes to applying a specific technique, they still lack the formality of a definition and may be criticised for still being interchangeable. Buxton (2010), for one, should be credited for his efforts in creating a set of characteristics between the two. He approximated a definition that sketching in design is concerned with *'getting the right design'* and prototyping within usability engineering is concerned with *'getting the design right'* (Buxton 2010). In other words, we might say that sketching asks 'what is the problem and how might we solve it?', whereas prototyping asks 'which solutions is most feasable?' This distinction works well in a discussion of the aim of sketches and prototypes, but it hardly addresses the formal difference of what they are.

My colleague, Claus Rosenstand, and I took a different approach, which I described in [P2] and [P5] and in further detail in [B1], based on Herbert Simon's information theory of bounded rationality (Simon 1973). We argue that sketching and prototyping can be differentiated in regard to how they deal with *uncertainty* or *complexity*. Uncertainty is to be understood as a negative measure of available information – a lack of information. This is opposed to complexity, which is a positive measure of available information – information at hand. Our proposal is, to use this as a more formal definition of the difference between sketching and prototyping. Sketching is concerned with the reduction of uncertainty, by generating information, and prototyping is concerned with the reduction of complexity, by testing information among alternatives.

Thus, this information-based definition approximates an answer to my sub-question of:

What is the difference between sketching and prototyping?

I argue this distinction makes describing the fundamental qualities of sketching and prototyping both easier and more precise, and it articulates the difference between the two activities. The definition furthermore supports the understanding of typical design process models (e.g. Boehm 2000, ISO 9241-210:2010), in which sketching is typically dominant in the front-end, due to the lack information at the beginning of the project - an uncertain situation. This uncertainty creates the need to use a fitting technique to sketch design proposals that can inform further decisions. Once design proposals have been created, we now have more information than needed - multiple design concepts. This creates the need to choose between the different alternatives, by putting them to the test. In other words, complexity has to be reduced through prototyping.

3.3.1 DEPICTION, SIMULATION AND EMULATION

Following our work on defining the difference between sketching and prototyping, we quickly realised how we only had one half of the answer in dividing the two terms. We still had to assess, how the concept of using animation as a 4-dimensional sketching capacity could fit into sketching non-idiomatic technologies.

In [B1] I thus turned to one of the foundational ways of examining a digital system within the computer sciences - the system as a *simulator*, proposed by e.g. Mathiassen et al (2000) as the interplay between an *interface* (with input/output), a set of *functions* (the logics), and a *bounded dynamic model of reality* (a database). When designing a digital system, it is essentially these macro aspects we are designing. Traditional static sketches, essentially the 1D-3D capacity, enable what we label the *depiction* of a dynamic model of a reality, but they do not represent dynamics of the input/output - not a least without leveraging on established idioms filling in the temporal blanks in the represented. Thus, a static sketch is able to depict the bounded model of reality in single states - without the input and output, and neither the dynamics between the elements of the simulator. On the other hand, functional prototypes can provide a dynamic model of reality, together with the functionality mediated by interactive input and output, thus showing the complete simulation of the digital system, and is thus a simulator in the same regard as any other digital system.

Between *depiction* and *prototypical simulation*, we argued animation provides a third distinct mode of representation. Manipulating the position over time, of different graphical elements, can represent a dynamic model of reality, and through the generation of temporal information animation can also illustrate the dynamics of the interactive system. That is even though the input and output are not realised as a full simulation, but as a scripted sequence. This makes animation-based sketching an ontologically different thing than both static sketches, which depict, and prototypes, which simulate. When animating a scripted sequence of a proposed digital system, we simulate something which is already a simulation, and thus we are actually not simulating the digital system, but rather '*emulating*' the simulator.

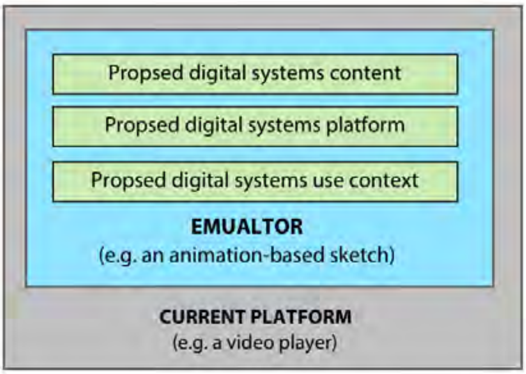


Figure 22: My proposal for viewing animation-based sketches as an emulator - being able to emulate the digital simulator as well as its context on another platform - like e.g. a video player.

In this manner, we see the fit between emulation and sketching. By emulating aspects of the full realised system, even if it is limited in it's fidelity of the expressed features and functionality, it generates information. This informs about different possibilities in the design space, rather than prototyping the viability of the a defined system.

Prototypes, static sketches and temporal sketches like animation-based sketches thus makes up a typology of representations of a digital system:

Figure 23: My distinction between simulating, depicting and emulating a digital technology

Thus, what we understand as animation-based sketching involves emulation of a sequence inside a proposed digital system, whereas non-temporal sketching enables depiction and prototypes enable full simulation.

3.4 ANIMATION APPROPRIATED FOR SKETCHING

Having established these two approximations to define sketching, and how sketching with animation can be seen as a way of emulating the digital system, the next step was to understand sketching in relation to animation, by examining my sub-question of:

How does animation fit with design sketching?

In [B1] I reviewed the concept of animation, building upon an ontological grounding made by Ward (2012), and further through a series of proposed definitions on animation from Furniss (1998), Wells (1998), Wells (2011), Johnston & Thomas (1995) , Frasca (2003), and McLaren (in Sifianos 1995). In doing so I criticise how many of the established definitions are rooted in the tradition of animated film, somewhat not being appropriate in describing animation outside this domain. Thus, I turned to one of the oldest and oft-quoted definitions of animation, made by Normal McLaren, in an revised version accounted in Sifianos (1995). I included a series of Brain Wells' characterisations of animation into McLaren's original definition, and defined animation as: *The process of deciding and manipulating the differences between a set of graphical positions, with enough difference to produce an sequential illusion of apparent motion or change.*

This is very broad way of understanding animation, but also one which can include the use of animation as an emulation in design sketching. I discuss what Wells (1998) calls the *'hyper-realism'* traditions of Walt Disney Studios' animation, and through reviewing the classic 12 principles of animation (Johnston & Thomas 1995), a few constraints are established. I argue, that animation-based sketches must sit in between the orthodox life-like animation, and the abstract art-based animation, in what Wells (1998) would call *'developmental animation'*. As such animation-based sketches must adhere to *'second order realism'* - that is, adhering to the ontological laws of reality to some extent, but not attending to too much detail in the orthodox physic's details.

3.4.1 ANIMATION AND FACILITATION

Following this, I turned to the issue of using animation outside entertainment, art and communication, towards a more functional use. I based this on the existing discourse on animation facilitated learning, presented by among others Tversky et al 2002) and Betrancourt (Mayer & Betrancourt 2005). Their studies and reviews, on the principles of *apprehension*, *congruence, attention* and *interactivity* stood out as possible factors in using animation in design sketching. Tversky et al (2002) critiqued animation for not being proven stronger than static imagery, if stripped away of the extra levels of graphic details in the animated sequences. I assessed, that this critique was somewhat artificial, given that animation by default generates more information than static imagery, due to its temporality. The pacing, rhythm and audience anticipation adds more to the whole an animation, than the sum of individual frames themselves. Even if every single frame of an animation was drawn out as static images, these elements would still not convey the same, as the temporal sequence.

Lowe (2003), on the other hand, showed that novice learners focused their attention on what was perceptually pleasing, and argued that animation used for facilitation should use the second order realism. Aesthetics and orthodox precision should only be utilised if it also supports the representation of the relevant features of the content. If done so, Mayer & Sims (1994) shows that the novices can actually learn more through animated facilitation, and mentally simulate the future implications of a system. However Mayer & Sims showed this was only the case for novices, and that domain experts showed little improvement in learning from animation. I inferred, that this shows promise about the scope of animation-based sketches as means of supporting the design process of non-idiomatic technologies. That domain experts may not gain the same level of information from a temporal sequence, serves to show, that animation-based sketching is not a swiss army knife of design. Rather, animation can facilitate and generate effective information when little or none domain expertise about the subject matter exist - that is, when the subject matter is non-idiomatic.

3.5 THE NON-IDIOMATIC

Based on different instances of the use of 'idioms' in the design discourse from especially Löwgren (1996, 2004, and 2012), Lindel (2012a & 2012b), and Cooper et al (2012), I sought to use this concept to frame the type of emerging technologies (Rotolo et al 2015), which replace the need of certain expressive capacities in a design sketch due to the experiential knowledge filled in by the designer. In doing so, I could turn to my sub-question of:

What is a non-idiomatic technology?

In [B1], with e.g. Löwgren (2004), Pine & Korn (2009), Cooper et al (2012), Svanæs (2000), and Fällman's (2003) characteristics of the multiple challenges with grasping the possibilities of new digital technologies, I attempt to approximate a tentative characteristic of the non-idiomatic. I argue, that when the design situation handles technologies or interactions with few or no conventions, the situation becomes non-idiomatic, and design idioms often become insufficient. This is in part derived from Löwgren's (2012) approxi-mations to the lack of idioms in new technologies from a public speak in 2012.

When trying to convey the dynamics and complexity in the interaction and user experience design of a non-idiomatic technology, Buxton (2010), among others, shows how static sketching in scenarios can take us only to an elaboration of individual states. This critique corresponds with the lessons learned from the studies of animation facilitated learning, given that a lot of the experiential information is in the transition between the states of the static sketches. Thus, non-idiomatic technologies are challenging due to the lack of temporal and dynamic information in static sketching. Approaches for exploring the interaction and user experience design of such technologies must differ from conventional static sketching, since they have to generate temporal information about the dynamics of both the system, and the user experience to reduce the uncertainty.

3.6 GENERATING TEMPORAL INFORMATION

From the insights about the challenges of non-idiomatic technologies, I turned my eye onto the existing discourse on temporal sketching capacities in [B1]. I have already discussed how this discourse seem to mix the notions of 'sketching' and 'prototyping', when using video (e.g. Buxton 2010, MacKay & Fayard 1999, Mackay et al 2000, Bardram et al 2002, Zimmerman 2005, Vertelney 1989, Ylirisky & Buur 2007). From having a more formal definition on sketching, and framing it onto exploring non-idiomatic designs, I examined the use of video as temporal sketching in part II of [B1], to approximate the sub-question of:

How is animation different from live action video in design sketching?

Based upon mainly Ylirisky & Buur (2007) and Buxton's (2010) work it is evident, how animation has previously been used in design visions in large organisations, such as Apple's pioneering use of video and animation with the Apple Knowledge navigator concept in 1987:

Figure 24: Images of the vision video, depicting the Apple Knowledge Navigator concept from 1987 - envisioning many of the uses of tablets, AI assistants and collaboration, partially in use now by 2016.

Such concept videos are argued, by the authors, to have production qualities beyond what is viable in most design processes, and also show to be more didactic than we would expect sketching to be. However, I also argue that it is evident in most video-based prototypes, visions and sketches, that without animation, the temporal information generated is quite limited. Video can be utilised throughout the design process - but without using animation, representing not yet existing technological designs are limited to props and enactments without the dynamic model of reality represented.

Inspiring approximations of using animation as a sketching capacity in design were afterwards identified from e.g. Moschovich & Hughes (2003), Davis et al (2008), Sohn & Choy (2012), Quevedo-Fernandez & Martens (2012), Löwgren (2004), Bonanni & Ushii (2009), Zarin et al (2012), Fallman & Mousette (2011), and Fallman et al (2012). While being important contributions, the existing discourse mainly focused on one specific animation technique or material. Thus, these contributions said more about a specific production environments utility towards animation-based sketching, than on the nature of animation-based sketching as a whole. As such, I proposed that animation-based sketching should be seen in a broader scope as a tool agnostic approach. That is, using a set of principles for creating temporal sketches, through a variety of tools, techniques and enabling technologies.

3.7 DEFINING ANIMATION-BASED SKETCHING

Having established animation-based sketching as a broad concept, which is tool-agnostic, left me with the obvious question of what animation-based sketching actually was? That is, a definition of animation-based sketching.

From the initial discourses from the Animation Hub Network, led by Thorning's (2014) concept of *'functional animation'*, it was initially proposed that animation-based sketching should be seen as a sub-category of functional animation. When putting the concept of functional animation under scrutiny, I however argue in [B1], that there exist multiple different uses of the term ‘functional animation’, and that animation used as a design approach is rather ill-placed within them.

Based on a review of contributions from e.g. Baecker & Small (1990), Chang & Ungar (1993), Elliott & Hudak (1997), Arya (1986), and Daliot (2015) I proposed the following distinguishing of animation types:

> ***Traditional entertainment & art***
> *Using animation to portray a fictional reality - aimed at creating an experience.*
>
> ***Functional animation - Factual information***
> *Using animation to portray facts about reality - with a high or low degree of objectivity.*
>
> ***Functional animation - Design Component***
> *To use animation as a design component to support interface design through motion inspired by both reality and fiction.*

The question remained, wether animation-based sketching could be defined as being either of above. While trying to convey a proposal, for how a design idea could become real, sketching cannot be described within the traditional animation category of entertainment and art. Still since the animation-based sketch proposes an idea about the abductive ‘what if?’, it does not really portray facts about reality, and is thus not factual information either. As a functional design component, animation-based sketches might portray e.g. interface elements, but since they are not components in the design, but ultimate particular designs themselves, this category does not work either.

Instead, I argue animation-based sketching exist somewhere in between. It uses the traditional components of animation to portray a fictional reality. However this is a reality, which is framed as could be possible. Furthermore, the animation-based sketch is not aimed at creating an entertaining or art experience, but aims at exploring or arguing for the viability of the proposal to become a fact - to be realised.

Thus, I define animation-based sketching as:

Using animation to portray a fictional reality - aimed at becoming fact

Though mostly a matter of semantics, I argue that a definition of using animation in design sketching is important in order to focus the discourse, and differentiate between the value of live action video and animation. Both are in my assessment important, since we rarely see live video sketches without animation at some level, but also often see live video used as foundation in animation-based sketches.

Furthermore, defining animation-based sketching also became a substantial approximation to answer the final sub-question of the project:

What are the archetypical features of using animation in design sketching?

To elaborate on the defining features of animation-based sketching, I sought to accumulate the findings from study B-E in [B1] to propose a framework of the archetypical forms of animation-based sketches. In doing so, I examined the content of more than 500 sketches (Appendix 1.2), which were made through the workshops I facilitated. From these I identified five design perspectives the sketches commonly used. Furthermore, through Genette's (1983) concept of narrative discourse, and Greimas' (1983) structural narratology I identified five auxiliary narrative discourses commonly used in the sketches.

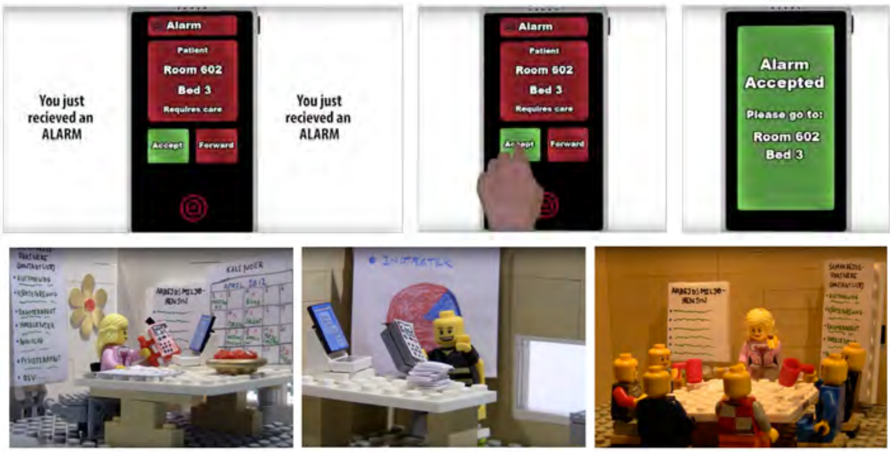


Figure 25: Two different visual and temporal fidelities used to represent two different perspectives and discourses. The first uses an isoloated interface and artifact interaction perspective, in a instructional discourse, to explain the interaction procedure of a new health care application, using a keyframe animated interface. The second one uses stop motion to animate LEGO figures to portray the service touch points in an existing user scenario, to investigate which touch points to focus on in the further design process.

Finally I assessed how the animation-based sketches used various *visual fidelities* - referring to the rendering quality discussion by e.g. Walker et al (2002), Sefelin et al (2003) and Buxton (2010), but added the notion of varying *temporal fidelity*. Some sketches used e.g. simple and crude stop motion, while others used a combination of orthodox realistic animation principles, to portray more sophisticated dynamics in e.g. an interface.

In total, combined with the four sketching functions I appropriated from Olofsson & Sjölen (2007) I presented the following framework in [B1]:

PERSPECTIVE	DISCOURSE	INTENT	FIDELITY
Isolated interface & artifact interaction	Natural	Investigative	High Visual
Use scenario - present	Documentary	Explorative	Low visual
Use scenario - positive	Instructional	Explanatory	
Use scenario - negative	Comedic	Persuasive	High Temporal
Systemic view	Dramatic		Low Temporal

Figure 26: The framework of archetypical sketching features, categorised between ‘perspective’, ‘discourse’, ‘intent’ and ‘fidelity’. The schematic is meant to be read vertically, and not as horisontal relationships.

Through this framework I argue that the sub-questions of the research project has been answered to the extent that I have expanded upon the discourse on animation-based sketching, removing some of the unanswered questions.

3.8 THE PRIMARY RESEARCH QUESTION

Through the optic of these theoretical findings, the remainder of the contributions regard findings in relation to the primary research question of:

> ***How can animation-based sketching support the concept design of non-idiomatic digital technologies?***

Thus, the remainder of this chapter focus on the findings from the three experiment-based papers [P3-5], and he practice-oriented part III of [B1].

3.8.1 THE ENABLING PRODUCTION ENVIRONMENT

From my own experience with using animation-based sketching, as reported in [P5] and [B1], and my facilitation of other designers and design students using the approach in [P3], [P4] and [B1], I found a series of criteria for the digital production environments enabling animation-based sketching. These criteria are grounded in the attempts to design specialised production environments for to sketch with animation from Davis et al (2008), Sohn & Choy (2010) and Quevedo-Fernández & Martens (2012).

The criteria for the production environments are summed up in [B1] as:

Interactive timeline or control mechanism akin to timeline controls to enable an iterative back and forth exploration in the designers use of animation-based sketching

Live Preview of the animation-based sketch in order to establish the reflective practice of sketching, where the designer constantly gets temporal feedback from his temporal sketching with animation.

Component library to either create or import graphical components to be used in the designed motion or change - to create the graphism of animation

Reusable components and animations which uses the component library to save configurations of both graphism and animation to be reused in other sketches. This establishes a more efficient pipeline for sketching, making the process more practical, and thus facilitates the generation of more information

Sketches in layers of other sketches in which entire animation-based sketches as output emulators are used in multilayer edits with a new animation-based sketch to again function in a pipeline, not with graphical or animated components, but as entire sketched sequences

Figure 27: Criteria for the digital production environments for animation-based sketching

As I discuss in [B1], these criteria are highly tentative, since it is easy to imagine both hardware and software developments, which will either alter or make several of the criteria obsolete. Once such development is Lindel (2012), Forsén et al (2010), and Victor's (2012) inspiring efforts in using responsive code to explore the temporal dynamics of design proposals.

3.8.2 REPRESENTING CONCEPTS - FIDELITY VS. NARRATIVE

In [P3], my co-author, Søren Bolvig Poulsen, and I examines the use of animation-based sketches in study B, the U-CrAc workshop. Here, we mapped the 158 produced animation-based sketches, in accordance to the animation-techniques used, as well as which user experience aspects they explored, based on the concepts by Buchanan (2001), Jensen (2013) and Hassenzahl & Tractinsky 2006). Our initial hypothesis was, that we would see a clear pattern in favour for the sketches using complex animation, and their expression of the potential user experience of the proposed design. However we were unable to see any such pattern in the data (Appendix 2.4). Instead, we saw a clear correspondence in how the inclusion of some sort of narrative in the sketches seemed to heighten the user experience articulation. When represented in a temporal (and linear) narrative, the design proposal is contextualised, and the possible effects of the design's dynamics are represented as having an impact in e.g resolving a problem, changing a behaviour, or creating an emotional impact. The non-idiomatic technology gains temporal feedback through animation - information which could not be generated without having the dynamics expressed as a temporally. The role of animation is to tie the dynamic temporal information into the narrative context, while still being a sketch in terms of being one proposal, framed in a certain way, showing something, leaving other things out.

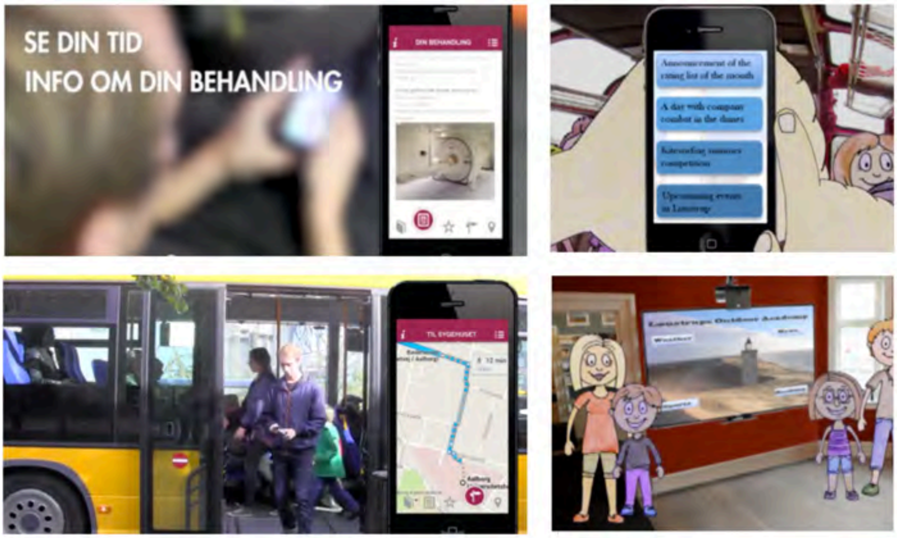


Figure 28: Wether high visual and temporal fidelity (left) or lower fidelities (right) we saw no clear correspondence between the applied visual or temporal fidelity, and expression of user experience aspects.

In this way the full potential of animation-based sketching is not only in it's ability to represent a product in itself, with high visual and temporal fidelity, but rather to support the creation of an easy perceived narrative, in which the proposed design stars as a main component. What matters is how the animated graphism is used to make an idea understandable, contextualised, and relatable in terms of making both the designer, and other stakeholders reflect upon the potential user experiences.

Simplistic fidelity adds to the conceptual value

From further examining the results of study B, I saw a pattern of how the design students, who initiated their design process through very simplistic animation techniques, actually often ended up with a more refined and articulated design proposal, than the ones starting with higher visual and temporal fidelities. I argue in [B1], that the simplistic approach actually supports the understanding of the important non-idiomatic aspects in the sketch, by emphasising what to question, and what to take for granted. That is, they support the animation being perceived as a sketch. Along this, I agree with Buxton (2010) in the observation that too complex visual and temporal fidelity run the risk of creating too narrow an interpretative space for understanding the interactions and user experience of the technology in the animation-based sketches.

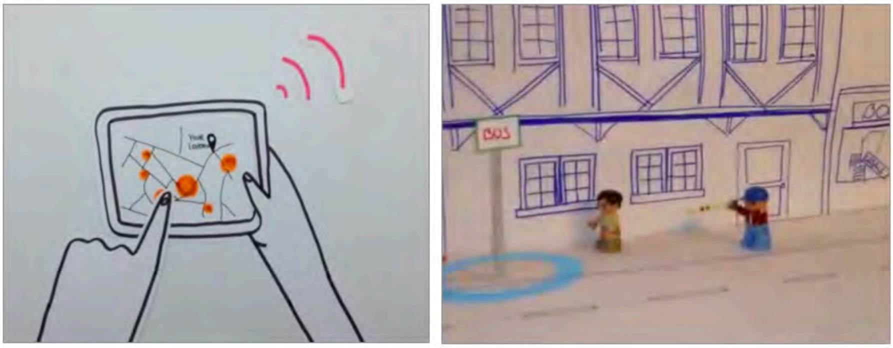


Figure 29: The simple animation techniques, such as stop motion (left) or LEGO's (right) provide a surprisingly high feedback on the user experience of a concept, without taking up much production time.

An auxiliary explanation to the observed pattern is, that when using simplistic animation approaches, the sketching time is reduced, and thus frees up resources for the design students too explore more branches of ideas. It essentially enables a more divergent sketching process.

This explanation is further supported by my findings from study C, the Service Systems Design Workshop, described in [B1]. Here, I observe how even simplistic animatics, which only adds limited temporal information to static sketches, proved to have value in exploring the early design ideas. The students used animatics to investigate the problem setting, and explore a lot of rough future scenarios within a half days work. They identified the most promising proposals, which they further explored with finer grained visual and temporal fidelity later. Given that the students in study C only had three days to create the sketches, and arrive at a tentative design proposal, this indicated, that when appropriated as continuum between low and high fidelity of useable animation capacities, animation-based sketching is also applicable in constrained design processes. That is, as long as the animation-based sketch is utilised to contextualise the design problem, and make the design proposal relatable.

Finally, based on the insights about animations role as anchoring the non-idiomatic technology into a contextualised narrative, I turned my attention back to Disney's 12 principles of orthodox animation. I further added what Johnston & Thomas (1995) described as the *'pre-Disney principles'* - principles much less realistic and crude in their physics and production value. I examined and compared these principles in [B1], and related these to the sketches from both study B and C. As I had just seen in the two studies, animating orthodox physics often became counter productive in terms of actually sketching - starting in a too high fidelity led to less articulated design proposals in the end. This led me to assess, that if the temporal fidelity needed to inform the design needs to include complex orthodox physics, the designer is properly not sketching anymore, but have actually transcended into reducing complexity via prototyping. However, since the vast majority of animation-based sketches uses some form of narrative structure (e.g. Harms-Larsen 2003), some elements of orthodox animation is still in place, but only through second-order realism.

Thus, I further elaborate on the placement of animation-based sketching, as a developmental genre of animation, in Wells' (1998) framing. In sketching, animation leverages principles of both pre-orthodox, orthodox, and artistic animation, with which simplification and eclectic selection af styles and techniques are the common thread towards creating relatable, and contextualised narratives.

3.8.3 ANIMATING NARRATIVES TO EXPLORE USER DISPOSITIONS

Following the findings regarding the narrative anchor of animation, me and my co-authors in [P4], Søren Bolvig Poulsen and Thessa Jensen, sought to analyse the results from study B, in regard to how animation-based sketching enables exploration of possible user dispositions behind a design proposal. Here, the point of venture was an ethical framework previously developed in collaboration with Thessa Jensen (Vistisen & Jensen 2013). In the framework we use the *ontological ethics* of Løgstrup (1997) to distinguish between three ethical user stances in user experience design: *Apathy* as the strict adherence to a system or procedure, *sympathy,* as the reaction to an effect, and *empathy,* as the reaction to a cause (Vistisen & Jensen 2013, 5).

We examined a series of animation-based sketches from the U-CrAc workshop, and analysed how the life world of the users would be taken into account in the animation-based sketches. Furthermore, we sought to assess wether the design students moved between multiple user dispositions in their sketching process. From our analyses, we found that the students often initiated by portraying an apathetic design proposal, solving the problem with little consideration for the end-user. From their reflections on these initial proposals, we see a movement towards designing proposal, which more clearly wants to help the user in the context represented. However, these mid-workshop sketches showed to often undertake a 'give the users what they want' mentality, and thus reflected a sympathetic stance towards the users. In the end, the final animation-based sketches in our analysis showed to take into consideration not just what the user wanted, but also an ethical responsibility, taken by the design students, to 'translate' their previous learnings into a proposal which actually sought to address the cause of the problem setting.

In [P5], the findings are put into a simplified communication model of animation-based sketches, in which the concept of *personas* (Cooper et al 2012) act as stand-ins for real users, and Caroll's (2000) concept of *scenarios* form the plot about the possible user experience with a proposed non-idiomatic technology.

Figure 30: Our model from [P4], illustrating the portrayal of an interactive technology in a linear narrative, in which the personas, and scenarios inform the gradual development of ethical reflections upon the end-user.

Through the plot in the animated narrative, there is a ethical reference back towards the persona, indicating the user disposition inherent in the design proposal, and aimed toward creating a response of further reflection from the viewers of the sketch.

The components in the model seeks to illustrate what the viewer actually sees in the animation-based sketch. Wether it is the designer(s) having an investigative or explorative intent, or other stakeholders when having a explanatory or persuasive intent. The components are of course shaped by the previously introduced archetypical features, such as design perspective and discourse, but are perceived as a narrative structure involving personas, plot and technology. In a narrative animated context, focus is taken away from the design proposal itself. The context, plot, and characters become more present - open for interpretation, enabling a discussion which surpasses mere functionality, but focus on the accumulated user experience with the technology. With this, we argued in [P4] that engagement in the represented narrative is facilitated, which forms the basis for further reflections about the possible user experiences with the technology.

The communicative intent of a linear sketch

A closing remark on the findings regarding the narratives created via animation-based sketching, is one which came from my discussions with Jonas Löwgren in the autumn of 2015 (Löwgren 2015). Given that the structure of animation-based sketches are linear narratives, portraying a non-idiomatic technology, which is seldom non-linear, due to its interactivity, the choices of what to *include*, and what to *exclude* in the sketch becomes an important issue.

In [B1], I discuss how the emulation of the digital simulator, through animation, can be seen as a scripted overlap of horizontal and vertical features of the digital system in regard to Nielsen's (1993) model of prototyping digital systems. As such, in an animation-based sketch, we focus on only a few elements of a proposed idea, which is potentially much broader in scope than the scenario represented in the individual sketch. Of course, multiple or more extensive sketches might portray the entirety of the proposed system, but again, the complexity of different potential use-cases, and contexts makes it almost impossible to represent everything in a scripted linear scenario. It is thus a constant process of choice about the communicative intent - what the designer actually intents to do with the animation-based sketch. The designer might intent to only explore the non-idiomatic aspects of the proposed idea, thus leaving out e.g. interface elements and interactions which use established idioms and design patterns.

This was the case with my own animation-based sketching process in [P5], when designing an augmented reality app. The interface menu elements was rarely represented in the sketches, since little uncertainty reigned about this specific element in the idea we explored. The question however is, whether the designer can ever be truly neutral and objective in the communicative intent, behind what to include and exclude in the sketch? If the designer has taken a liking to a certain idea, and is about to present it to other peers, will the represented animation-based sketch (or any type of sketch for that matter) not be inclined to represent the proposal from where its interaction and user experience is most elegant, and leave out the less desireable parts?

I argue in [B1] that these are important questions in regard to sketching capacities in general, and especially in regard to animation-based sketching, which uses narratives in their representation in such a wide extent. Following the notions of e.g. Kolko (2010) and Buxton (2010), one of the principal activities of design is *choice*. Before arriving at the final design solution, all the '*designs to produce another design*' are essentially all a series of contingent choices, which could have been made differently. As such, even when not intending to have a persuasive intent, I argue that design sketches can never fully escape being persuasive at some level - either trying to convince others about an idea, or maybe even persuade ourselves through the visual thinking of sketching.

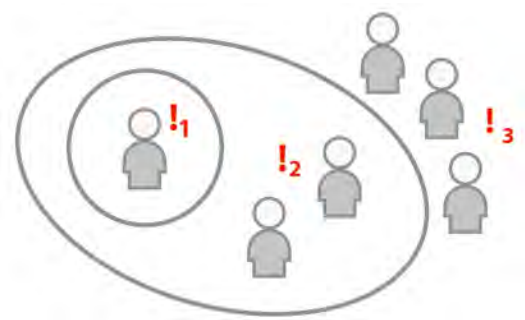


Figure 31: Persuasion at play in some extent at all levels of design. From the designer's own process of investigative thinking (1), to exploration in the design team (2), and to the explanatory and fully persuasive intent towards outside stakeholders (3)

If we agree that design can never be objective, persuasion is not something separate, but simply a natural aspect of design. This would help explain why animation-based sketches succeed by portraying narratives of 'what could be', since Wells' (1998) already suggested that animated narratives are also never neutral, but always portrays a second order perspective on reality. Thus, I assessed that exploring the potential of a non-idiomatic technology, and having some at least some level of persuasive intent, is not contradictory. Rather it is a condition we have to accept when doing design, embracing that we are constantly choosing, and our responsibility is to be open to reflections and critique, to explore more branches of ideas.

3.8.4 THE ROLE OF ANIMATION THROUGHOUT A DESIGN PROCESS

From the experiments with applying animation-based sketching in a lab context described above, I also contribute with a series of findings from the experiments carried out in a field context.

In [P5], based on study D, conducted with the North Sea Oceanarium, we described the use of animation-based sketching to facilitate consensus between the multidisciplinary stakeholders in the design of the mobile augmented reality app 'North Sea Movie Maker' (Huge Lawn 2013). In this project, we used various applications of animation-based sketching throughout the entire design process, well beyond the early conceptual design. We initially used animation to explore both the features, and content of the augmented reality ideas, and later explored the entire design of the new context in the aqua zoo through more detailed sketches. The animation-based sketches were used whenever the stakeholders where unable to reach consensus, about which direction the design concept should go, in terms of e.g. the interaction between the users and the digital content, and how the context of the zoo needed to be altered to accommodate the design.

Figure 32: Stills from one of the animation-based sketches in study D, representing a proposal for how a mobile app would register and enable the augmented reality effects.

We observed how the animation-based scenarios acted as a facilitative material in the discussions, making different opposing proposals concrete at an early enough stage for alterations to be made, based on the reflections of the different stakeholders involved in the design team. The sketches did this, by emulating the temporal, material, and interactive aspects of the design proposal, without writing code. While it also took time to create the animations, the time used on each animation-based sketch in our case where considerately shorter than the system development time in the later phases of the project.

This was especially true due to the reuse of previous animated components in new animation-based sketches - setting up a pipeline of animation assets to be reused throughout the iterations. Thus, we found that the time and care used to create animation-based sketches in the early phases of design, can actually be saved in designing the equal graphical and temporal aspects in the later development. In [B1] I describe a similar pattern observed from both my involvement in study E, with designers at an external bureau, and in study C with service design students. The participants in both studies, benefitted from setting up a pipeline of reusable animation-based sketching components.

Setting up pipelines of reusable sketching components further illustrates the finding I describe in both [P5] and [B1], about how animation-based sketching proved useful through a longer period in the design process than I had initially thought. An example from the North Sea Movie Maker case illustrates how we late into the development of functional prototypes needed to make a critical decision, of wether to scale down the app's functions in order to support the Android smartphone platform. Having to develop a coded prototype to test the viability of this would have spent resources, which would have required us to leave features out of the already working iOS platform. Here, I created a small animation-based sketch, which emulated the behaviour of the proposed Android version of the app, exploring the potential user experience, when having to wait one full minute for the augmented reality effects to render. This facilitated the consensus between the ones in favour for support of both platforms, and those in favour for focusing on creating one version with more content. The single platform support was chosen, and the resources saved were spent on purchasing as series of iOS devices to rent out to the visitors with Android smartphones.

As such, these findings illustrate how animation-based sketching is not necessarily an isolated approach for the early design phases. Rather it is an approach to reduce uncertainty about temporal dynamics of the user experience, hard to grasp by other means. What my studies indicate is, that generating such temporal information can be beneficial, even if it is at late stage well into development. On the other hand, the finding also extents upon the assessments of using animation from e.g. Buxton (2010) and Ylirisku & Buur (2007) in showing that simplistic animation can be utilised successfully to support the design process in practice settings, with more constrained setups, than the big-budget vision videos of large companies.

3.8.5 EASY TO ADOPT, BUT TAKES TIME TO INTEGRATE

The finding that animation-based sketching is applicable in practice does also come with a cautionary note, based on my involvement in study E with the external agency 'Tankegang'. Here, I supported the agency's designers in adopting animation-based sketching, used to explore a new game concept. The designers used animatics to quickly sketch a series of ideas, about how the player-generated avatars in the game would be affected by various effects.

Figure 33: Stills from one of the first animatics made by the agency's designers in study E.

However, the specific game elements were only added to the sketches as an afterthought - a secondary question posed in the sketch. From watching the sketch with the rest of the agency, it became evident how the two questions posed by the same sketch, gave rise to an unfocused discussion. The primary question, the appeal of manipulating the user avatar, was in many parts overshadowed by the unclear game elements.

In [B1], I assessed this via Lawson's (2006) point of not suggesting answers in sketches, which are not being posed yet in the design process. In the Tankegang example, the first uses of animation-based sketches clearly sought to answer to many questions at once. I argue this might be a special challenge for 4-D sketching capacities, such as animation-based sketching. When examining static sketches or individual states in a static scenario, we are free to focus our perception at certain elements for as long time as we need to reflect. When represented as a temporal sequence, the represented images is gone by the instance the animation or video has been played, with the need to actively rewind or repeat to focus on specific parts.

The finding is, that temporal information is necessary in order to inform the dynamics of non-idiomatic aspects, but that it also runs the risk of posing too many questions to be comprehended at once. That is, the information generated raises the complexity faster than the uncertainty of the design possibilities has been reduced. This is an important aspect, when adopting animation-based sketching in practice. While I assess the approach as a powerful way of generating temporal information, it does require a learning period to be able to assess what to include, and what to exclude from the sketch.

3.8.6 GUIDING PRINCIPLES OF ANIMATION-BASED SKETCHING

As a design approach animation-based sketching cannot stand alone, but is best viewed as an addition to the designers toolkit – suitable for situations when in need of reducing uncertainty about temporal aspects of interaction design and user experience design. From my findings about the possible challenges of integrating the approach in design practices with no experience in temporal sketching, I sought to accumulate the experiences into a series of shorter lessons learned. In [P5], we further derived three guiding principles, for when to emulate the digital simulator, through animation-based sketching, over traditional static sketching, or developing a functional prototype.

> **1. Emulation over depiction.** *The choice of animation-based sketching over traditional static sketching means that the creation time increases, but so too does the quality of the information generated. Is viable to reduce uncertainty, when there is a need for temporal information about the dynamics of the interaction & user experience design.*
>
> **2. Emulation over simulation.** *As a result of the choice of animation-based sketching over coded functional versions of the design, the information generated can be of sufficiently high quality for the questions being asked at the time, and the information can be generated more rapidly. Is viable to reduce the time to get information about temporal uncertainty issues, which can be emulated; but does not require actual interaction with the design.*
>
> **3. Emulation is not 'the product'.** *Regardless of the situation for which animation is chosen as a sketching tool, it must be used in a different way than traditional animated film; it should be kept fast, rough, and abstract enough to be a process tool for reflection upon the design problem and to support the decision-making process.*

The first two principles emphasise the distinction between the quality of needed information, and the time spent generating information. The third principle is of special importance to my contribution to understanding animation-based sketching since it illustrates why the two first principles are valid, and further why the distinction is not a trivial matter. When choosing to apply animation-based sketching as a design approach, we must reflect both on which methods we choose between, and upon the mindset behind the method. This is to avoid spending too much time on refining the animation, and instead engage in the reflective practice of visual thinking and visual communication, facilitated by the animation-based sketch.

3.9 SUMMING UP - EXPANDED AREAS

This chapter has provided an extended summary of the majority of findings from [P1-P5] and [B1], abstracted from study A-E. As the scope of this chapter indicates, there is a rather broad range of findings, some related and others with more disparate relation to each other. I have argued that these contribute to expanding the body of knowledge about applying animation as a sketching capacity. I have categorised the findings in accordance to the seven theoretical sub-questions, as well as the primary research question of the project.

In summary, I my findings have expanded the field with the following:

1. A literature review of the current sketching discourse, showing that abduction is the epistemological logic of sketching, and categorising sketching in 1D-4D sketching capacities, and the matrix model of investigative, explorative, explanatory, and persuasive functions of sketching.
2. Defining animation-based sketching, the archetypical features, as well as the differences between sketches, prototypes and animation-based sketches, in terms of which information they generate, and which parts of the digital simulator they represent.
3. Finding no clear link between visual and temporal fidelity, and the representation of UX aspects. It indicates that the decisive factor is the narrative, and that animation ties the non-idiomatic technology to a narrative by providing temporal information, which makes the proposed idea contextualised and relatable.
4. Provided a framework, showing how animation enables reflection on not just technology, but also the ethical impact on technology, by emulating user dispositions via temporal information.
5. Case study on facilitating decision making, throughout the design process at The North Sea Oceanarium - showing how animation created project relevant information about a non-idiomatic design situations.
6. Showing the approach can be introduced into design settings with resource constraints, and to designers with little or none competencies in temporal sketching.
7. Providing a set of guiding principles and lessons learned for when and how animation-based sketching can be viable to apply in non-idiomatic design processes.

This is, of course, a very condensed summary of three years of research , and I recommend diving into the specific contributions in the papers and the book for the full arguments, observations, and lesson learned about exploring how animation-based sketching can support the concept design of non-idiomatic technologies.

CHAPTER 4: CONCLUSIONS

The research project behind this thesis began three years ago with an hypothesis about how:

> ***Animation can be a useful sketching capacity in design processes concerning the dynamics of non-idiomatic technologies, due to the ability to obtain temporal information, without having to develop a functional version***

As I began to dive into this area of interest, I was greatly inspired by interaction design researcher, and Apple R&D alumni, Bret Victor's demo's and public speaks on creating *'mediums to think with'* (Victor 2012). The point of venture for me was the notion of, that we cannot invent, what we cannot see. That is, our ability as designers to explore the abductive 'what if?' questions is enabled by our representational mediums to think, and communicate with. This is the challenge I saw in working with design sketching, in cases in which the interaction and user experience design made use of technologies with little or no established idioms. As an educated interaction designer, I was curious to further explore ways of generating the temporal information needed to explore such design cases. As an inspiring design researcher, I was intrigued by the opportunity to explore a research area, which had only seen few previous contributions.

Most of all, I looked forward to experiment with, and seek new ways of supporting the practice of interaction design. As such, grounded in pragmatism my design research project was aimed at examining the following research question:

> ***How can animation-based sketching support the concept design of non-idiomatic digital technologies?***

The practice-inclined research question was supported by seven auxiliary sub-questions about the theoretical discourse:

- *What is a non-idiomatic technology?*
- *How do we categorise sketching capacities?*
- *What is the relation between thinking and communication in sketching?*
- *What is the difference between sketching and prototyping?*
- *How does animation fit with design sketching?*
- *What are the archetypical features of using animation in design sketching?*
- *How is animation different from live action video in design sketching?*

In the thesis, I have shown how designers, who deal with non-idiomatic digital technologies, can utilise animation-based sketching as a temporal sketching approach. I have proposed animation-based sketching as an extension to previous efforts into using video in sketching, with specifically defining and addressing the qualities animation adds to representation of interaction and user experience design.

One of the main contributions in the project is the theoretical clarification of the concept of animation in sketching itself. Animation has been used in conceptual design videos since the 1980's, but a dedicated description, and analysis of what the specify of animation adds to temporal sketching had not been clearly addressed. I have sought to add this to the previous contributions, and argue to have expanded the body of knowledge, of how animation can be seen as a 4-dimensional temporal sketching capacity, in the intertwined relationship between thinking and communicating visually through sketching. Furthermore, I have shown how animation can be described as a way of emulating the digital simulator, by representing a dynamic model of reality, while not enabling the input and output of functional prototypes.

Through my experiments, with applying animation-based sketching in both practice-oriented lab and field context, another main contribution is the pragmatic inquiry, into how animation-based sketching works as a design approach in actual design processes. Through my own designs, and the designs I facilitated, I have shown how animation-based sketching can be done through many different visual and temporal fidelities, enabled by a variety of techniques, materials, and in different software and hardware environments. These appliances show how the temporal dynamics of non-idiomatic technologies can be explored from the very earliest idea, to later issues about interaction, context implantation, and potential technical contraints and pitfalls. I thus conclude, that the indeterminate situation, of the potential of animation as a sketching capacity, has been moved towards a more stable determinant state. In other words, my studies have given examples of the scope of this specific design approach - from supporting design students, exploring their design ideas, to be the driving force in facilitating consensus in multidisciplinary design processes in the industry.

The most significant contribution I assess to be the range of different annotated portfolios, of animation-based sketches, this research project have generated. From purely animated sketches, to live video being augmented with animated overlays, done in both high and low visual and temporal fidelity. I argue these portfolios of sketches augment the theoretical claims about the viability, and feasibility of using animation to represent, and explore the potential of a proposed interaction and user experience design.

In the annotated portfolios there is both examples of when animation-based sketches worked well, using the identified archetypical discourses and perspectives to support the design process, and examples of when the approach proved less viable. These examples of less viable appliances show a pattern of having focused too much on making animations, which either elaborated too many aspects of the idea, or sought too high a visual and temporal fidelity too early on in the design process. I argue this contributes with an important lesson in regard to the expressive capacities of design approaches in general. That is, how the tools, which we employ in our process, both extends, but also at the same time limits our ability to explore a design problem. If all aspects of the design problem is approached through animation-based sketching, it will be at the risk of missing other crucial aspects of the proposed design. Thus, my contributions, towards assessing when and where animation-based sketching has proven useful, serve as lessons learned and examples to guide design practices' use of animation as a sketching capacity. These are the primary contributions, of the annotated portfolios as ultimate particulars, where I have abstracted lessons in my research-*for*-design process, which I argue can be extended into the general practice of applying animation-based sketching in practice.

In the end, it is obvious to ask, to which extent this research project has answered the primary research question of the supportive qualities of animation-based sketching. The examples from the experiments, and the accumulation of annotated portfolios serve to at least give exemplary evidence towards claiming that the hypothesis is in part confirmed, and answer the research question through its examples. Furthermore, I have sought to condense my contributions into theoretical frameworks, and practice-oriented guidelines, which are grounded in my design experiments.

Altogether, this thesis has expanded the body of knowledge of an area, which I cannot claim to have discovered, but in which vast territories are still unmapped. But in the wise words of Korzybski; "*the map is not the territory*" (Korzybski 1958), and the value of my research is thus to be found in the vast amounts of new examples, both good and less so, of animation-based sketches, produced in the various annotated portfolios of this research project.

With the focus on animation, as a sketching approach, it is easy to lose sight of the fact that it represents only part of a much bigger ecology of rendering types. In this regard, data and insights, made during my studies, cannot conclude animation-based sketching as being superior to other sketching capacities in design. And as I briefly concluded above, this should perhaps neither be the ambition. Every sketching capacity can, in theory, say something about any design problem. The real challenge is to qualify which sketching capacities are better suited for what. My project has sought to identify, exemplify, and argue for the viability of using animation-based sketching in design cases of technologies with little or none established conventions and idioms. I argue, that I leave this effort as a pragmatically more stable and determinate situation, than it was three years ago. The research has drifted and changed character throughout the three years, leaving this field open for more research to be done.

Thus, I allow myself to finally conclude this research have expanded, but not concluded this area of research, and I assess that further studies could provide value, by focusing on some of the areas not included in my research design. In the next chapter, I will point to what I see as obvious extensions of my research - some which may challenge my findings, and others may expand on new areas.

CHAPTER 5: FURTHER PERSPECTIVES

When nearing the finishing line, it is evident that some areas have been covered and expanded upon in the thesis, while some are still lurking in the distance. Writing the last sentences of the thesis, I will now briefly introduce and propose a range of research topics, which I argue as the obvious next steps in further researching animation-based sketching.

A re-focus from sketch to sketching

As I described in the research design (section 2.4.1), I initially set up an observational study in 2013, which I abandoned to focus on collecting a wider range of animation-based sketches, to be able to contribute with a broad view on the approach, together with clarifying the theoretical discourse. Now, with a more clear discourse, and with a broad range of annotated portfolio examples, I argue it would be feasable to again revisit the observational setup. With the lessons learned from my study's focus on the output sketches, and the reflection-on-action, a new observational setup would seek to observe the reflection-in-action while sketching. To overcome the methodological problems, with capturing the appliance of animation-based sketching through the natural unfolding of the design process, I do however propose a more constrained setup. This could be composed by small more or less defined design problems, or design ideas, to explore via animation-based sketching, while recording both the designers interaction with the production environment, and screen capturing the design moves. The challenge would be to create such constrained framings, if the subject matter should still be non-idiomatic technologies, since they are hard to grasp in a precise upfront problem setting. However, I argue it would be possible to choose a specific emerging technology - e.g. wearables sensors - and have the design students explore a series of user scenarios in such constrained setup. The design process captured would be more convergent, but I assess this would be compensated by the in-depth interaction analysis made possible. The results, from a study like this, could potentially be compared to existing observational and protocol studies of static sketching (e.g. Bilda & Demirkan 2003, Wu et al 2013, Suwa et al 1999).

Formal comparison of different sketching capacities

An observational study of the reflection-in-action of animation-based sketching could very well be integrated into a comparative study of the relationship between expressive capacity, and the complexity in using a given sketching approach. A comparative study like this would potentially be carried out through all four dimensions of sketching capacities, proposed in the thesis. A proposed question to examine in such a study would be, wether the expressive capacity in interaction and user experience design rise in correspondence with the use complexity when moving up in expressive dimensions:

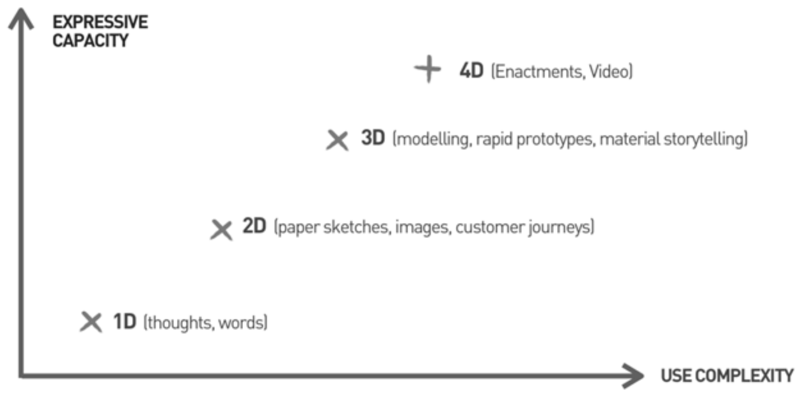


Figure 34: Proposal for exploring the expressive capacity and use complexity of sketching capacities.

It is properly unlikely that the results will follow a straight progression as the diagram above, and it will be an interesting contribution to the further qualification of the potential for both animation, and other sketching capacities, to gain more formal knowledge about each in comparison to each other.

The role of sound in animation-based sketches

One obvious omission in my analyses' are the role of sound in the animation-based sketches. I did not include sound in my studies as a way of constraining my focus to the visual and temporal fidelity of sketches. As an addition to my framework of the archetypical features of animation-based sketches, the role of sound should however be studied, and included into the framework. Furthermore, to the best of my knowledge, no studies have really analysed the role of sound in temporal sketches in-depth - besides Löwgren (2004) who evaluated on his sound design, but only in a single case.

A study of role of sound would include developing an experimental setup, guided by the existing discourse on sound in computing (e.g. Rocchesso et al 2015, Robare & Forlizzi 2009, Pauletto 2014). The aim would be to isolate, what the sound in animation-based sketches does in terms of exploring the interaction and user experience design of a proposed idea. I will propose two different setups in this regard. The first would be a continuation of my project's analysis of the annotated portfolios of animation-based sketches, but analysing them in regard to the sound design. These results could be accumulated in the same extent as my mapping of animation techniques, discourses and perspectives. A second setup, would be a comparative research-*through*-design perspective, in which the same animation-based sketch was given widely different sound designs. This would add further knowledge, about sound as yet another contingent factor of animation-based sketching.

Follow ups and further follow throughs of the practice effort

In my research project, I was able to observe the effects of using animation-based sketching in practice in study D and E, seeing how temporal information supported the design process of two mobile apps. However, more follow through studies like these would further add to the reliability of my conclusion, about the practical feasibility, and viability of animation-based sketching.

Furthermore, it would a relevant extension of the workshop experiments in study B and C, to make a follow-up study, with the company stakeholders involved in the workshop, to assess wether the animation-based sketches have had an impact on the companies product or service development. Follow up studies could be conducted through qualitative interviews (Brinkmann & Kvale 2014) with the stakeholders, optimally re-watching the produced sketches from the workshop together, and have the stakeholders reflect upon wether the proposed ideas and/or the sketches themselves have been used. This would further help qualify the role of animation-based sketching, not just as tool for designers in the design process, but wether the sketches themselves can be valuable deliverables.

Changing subject matter - organisational and strategic change

A further involvement of the company stakeholders involved in design processes applying animation-based sketching, also led me to wonder, if animation-based sketching could actually also be utilised as a strategic and organisational change agent? In my research, I have constrained the subject matter to the interaction and user experience design of non-idiomatic technologies. Through this I have analysed uses of animation, to emulate the functionality and interface interaction of a proposed design, to further investigate the user experience in context. In [P4], we further analysed the represented user experience, in regard to how the sketches explored different ethical user dispositions. This can be seen as gradual raise in scope of animation-based sketches, where strategic and organisational change could be seen as further expanding the scope.

RAISING COMPLEXITY OF SCOPE

SUBJECT MATTER OF SKETCHING	INTERFACE & FUNCTIONAL	USER EXPERIENCE	ETHICS	STRATEGIC & ORGANIZATIONAL
RESEARCHED	X	X	X	?

Figure 35: Raising scope of different subject matters investigated by animation-based sketching, with strategic & organisational change as yet to be explored in detail

In a study expanding the scope to organisational and strategic change, the temporal information generated, through animation-based sketching, would not be aimed at exploring the dynamics of an interactive technology. Rather, it would be used to break down complex structures or processes, to make it more easily comprehensible and more operational. However, this use of animation would also become closely related to the identified category of functional animation as a way of factual communicating (described in part II of [B1]). The difference would be the focus of using animation-based sketching to facilitate a process of change, rather than communicating about the present. Here the study would be similar to the involvements in study D and E, where as the analytical foundation would be grounded in business strategy (Porter 2008), business foresight (Ruff 2006), and strategic design thinking (Brown 2009).

Co-designing animation-based sketches

Changing the subject matter of animation-based sketching also opens for a study of appropriating the approach, from something designers utilise in a rather designer-driven perspective (Verganti 2009), into a more participatory approach (Sanders & Stappers 2008). Since I started this project three years ago, a lot of technological maturation has happened in regard to animation software and hardware. New easy to use tools for making e.g. stop motion, and simple keyframe animations has been realised to smartphone and tablet platforms - some of which we have experimented with in study B, C, and D. It is my hypothesis, that the insights from my studies, about how fast we can teach animation to novices, also open for further expanding this to non-designers. In this manner, stakeholders in a design process, e.g. representatives from companies or end-users, would be engaged in the sketching process, and not just reflecting upon the sketched output. This study would potentially open up an entirely new arena of animation-based sketching, as co-creation tool for supporting the representation of ideas, concepts, and problems between stakeholders in design projects

The persuasive function of animation-based sketches

Finally, despite my finding that persuasion is to some extent at play at all levels of sketching (section 3.8.3), my studies have primarily focused upon the investigative, explorative, and explanatory function sketching. In further studies I thus argue it would be beneficial, to examine the persuasive function in situations, that are primarily persuasive in their rhetorics. This could be examined, by looking into the use of animation-based sketches on online crowdfunding platforms such as Kickstarter (2016) and IndiGoGo (2016). Here, many of the companies, seeking backing for their concepts, utilise animation heavily in their introduction videos, which are aimed towards getting potential backers to support them financially. This use of animation often substitutes showing the real product in use - possibly due to the products often still being in the conceptual stage, when entering a crowdsourcing campaign. Thus I argue it would provide a valuable insight, into the role of persuasive animation-based sketches, by examining introduction videos using animation from both companies which have succeeded and those who have failed. It could then be assess, wether there are significant differences in the design of their introduction videos, and their use of animation.

FINISHED, BUT NOT DONE...

As above perspectives serves to show, the last word has not been written about using animation as a temporal sketching capacity in design, and I look forward to further explore the domain in the future. For now, it is my hope that the lessons learned, principles, and guidelines from my study can add a small drop in the pool of insights into methods, and practices for supporting and facilitating the design of new inspiring uses of technology.

Thank for sticking with me to the end of this thesis.

Peter Vistisen, 2016

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APPENDIX OVERVIEW

All appendix material in the thesis has been appended digitally. To the assessment committee a digital storage medium is provided, and for other readers, the accumulated appendix can be downloaded from http://www.petervistisen.dk/phdappendix.zip. Playback of the animation-based sketches appended can be done via the VLC media player http://www.videolan.org/vlc/.

Below is an overview of the appended material with appendix number used in the references in the thesis, and in [B1].

APPENDIX 1 - GENERAL
1.1 - Animation Hub Strategy
1.2 - Counting all sketches in the thesis

APPENDIX 2 - STUDY B - THE U-CRAC WORKSHOP
2.1 - Picture Portfolio
2.2 - 2014 Online Questionnaire
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APPENDIX 3 - STUDY C - SERVICE SYSTEM DESIGN IN COPENHAGEN
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APPENDIX 5 - STUDY E - COLLABORATION WITH EXTERNAL AGENCY
5.1 - Picture Portfolio
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APPENDIX 6 - DECLARATIONS OF CO-AUTHORSHIP
6.1 - Declarations of Co-authorship

APPENDED CONTRIBUTIONS

[B1] **Book 1:** Vistisen, P. (submitted) Sketching with Animation, submitted to Aalborg University Press

[P1] **Paper 1**: Vistisen, P. (2014) Abductive Sensemaking Through Sketching. Academic Quarter Vol 9, Aalborg University Press.

[P2] **Paper 2:** Vistisen, P. (2015) The Roles of Sketching in Design: Mapping the Foundational functions of design sketches. Proceedings of the Nordic Design Conference 2015, Stockholm, Sweden, June 2015.

[P3] **Paper 3:** Vistisen, P. & Poulsen, S.B. (2015) Investigating User Experiences through Animation-based Sketching. Proceedings of the 2nd Motion Design Conference (MODE), Dublin, Ireland, June 2015.

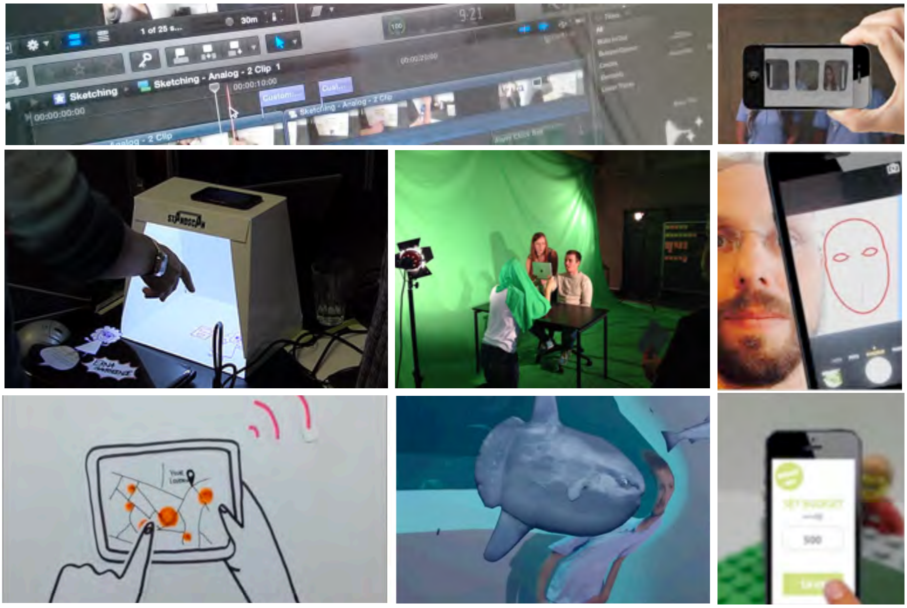
[P4] **Paper 4:** Vistisen, P., Jensen, T. & Poulsen, S.B (2015) Animating the Ethical Demand in Industry Innovation Cases. Computers & Society (online edition), vol 45, no. 3, s. 318-326, ACM

[P5] **Paper 5:** Vistisen, P. & Rosenstand, C.A.F (submitted) Facilitating Consensus in Cooperative Design Processes using Animation-based Sketching, submitted to International Journal of CoCreation in Design & the Arts (CoDesign), Taylor & Francis

SKETCHING WITH ANIMATION

Using animation to portray fictional realities - aimed at becoming fact

PETER VISTISEN, AALBORG UNVERSITY



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INDEX

INTRODUCTION

This book offers a contribution to the theory, method and techniques involved in the use of animation as a tool for temporal design sketching. Lifted from its traditional role as a genre of entertainment and art and reframed in the design domain, animation offers support during the early phases of exploring and assessing the potential of new and emerging digital technologies. This approach is relatively new and has been touched upon by few academic contributions in the past. Thus, the aim of the text is not to promote a claim that sketching with animation is an inherently new phenomenon. Instead, the aim is to present a range of analytical arguments and experimental results that indicate the need for a systematic approach to realising the potential of animation within design sketching. This will establish the foundation for what we label **animation-based sketching**.

The research project that inspired the writing of this book began with a request by the Danish innovation network ‘Animation Hub’, sponsored by the Danish Agency for Science Technology and Innovation. Animation Hub is managed and administered by a consortium consisting of the universities of Aalborg, Aarhus, and Copenhagen, as well as the Animation Workshop in Viborg. The initial ambition of the network was to further the use of what they labeled ‘functional animation’ - that is *“animation aimed at specific purposes outside the domain of entertainment*” (en.animationhub.dk). This definition was inspired by oral presentations delivered by the head of school of the Animation Workshop College in Viborg, Morten Thorning. Thorning provided an overview of various ways in which animation could be valuable beyond the realms of entertainment and art. These new applications included visualising science, news, health care information, data visualisation and graphical facilitation (Thorning 2014). It was evident that functional animation was a very broad concept, embracing everything from animation used to create documentary style communication to animations used as components in the user interface of computers.

Into this arena came an ambition to explore how animation could be utilised to facilitate the early phases of innovation projects. As with any relatively uncharted territory, many questions have arisen about definitions, practices, viability, and technical issues . This book aims to address some of these questions.

RESEARCHING ANIMATION-BASED SKETCHING

Researchers have published many studies on methods to handle the uncertainty and complexity of the early phases of innovation projects that draw on new technologies (Suwa et al 1998, Lindell 2012, Herrera-Viedma et al 2007). However, few of these studies examine the use of animation as an innovation method, and those that do have not systematised and arranged the broad palette of available techniques and approaches in all their complexity.

This is somewhat strange since animation and, to some degree, traditional video have a range of qualities which make them ideal for exploring interactions, services, and user experience designs which occur through time, and with new (imagined) technologies. Animation researcher Ralph Stephenson has distinguished between mimetic film and animation in a rather more precise manner:

> *"The key difference between animations and classic film is that animation offers the producer the ability to have near full control of the material matter, and is not constrained from the context of the physical world which the video media is limited to."*
>
> Stephenson 1973

Stephenson suggest that the illusion of life potentially involves much more than making an animated figure come to life and telling a story or creating an artistic impression. Instead, animation offers us the ability to free ourselves from the contraints of the physical world *as it is* and to imagine contexts, situations, and designed products that do not yet exist in reality. In addition, it allows us to explore their dynamics and temporal features.

AN EXPANDED VIEW ON AN EXISTING PHENOMENON

This book did not discover animation as design material. As we will show, many previous contributions have paved the way by indicating both the potential and the pitfalls of using animation in the early design process. Not all of these are strict academic research contributions: some are intriguing examples of companies and organisation experimenting with animation in their own design processes. Examples of the use of animation in exploring the design of new technologies is not new. In1987,Apple's Knowledge Navigator videos made use of animation to portray the future use of technologies then only in the R&D stage of their development (Buxton 2010). Other examples are provided by Tognazzini (1995) and Nokia (Ylirisky & Buur 2007), and a programme of using animation in big budget visions has existed for at least 30 years. In recent years, companies as diverse as Jaguar, Google, and IKEA have utilised animation to communicate concepts. The rise of social media such as Facebook, Youtube and Vimeo has given rise to a steadily increasing amount of industry animation-based sketching reaching the public. Using short videos which often employ animation to represent an idea for the future use of given technology or a novel interaction between existing technologies, companies generate buzz and gain attention before the product has even been developed into a technical prototype.

For example, prior to the International Auto Show in April 2014, Jaguar teased their new R&D project 'Discovery Vision Concept' for Land Rover SUV cars. The concept used cameras located in the grille of the SUV to project an image of the terrain ahead on the Head-Up Display of the vehicle, making the hood virtually transparent to make it much easier to navigate up-close obstacles such as large rocks and narrow tracks. All the technology did exist, but no functional road-ready car prototype existed at the time. To overcome this obstacle, on April 8th Jaguar launched a Youtube video which was labeled a 'Virtual Prototype in Testing' (Land Rover, 2014). In essence however, what was presented was not a prototype but an edited video which used animation to emulate the behaviour of the digital transparency technology in a scenario employing a natural discourse to showthe technology in use.

Figure 1: Stills from the Jaguar 'Discovery Vision' concept video, showing the live footage of a car approaching a hill. Suddenly the front panel of the car is made transparent through animation, further animating how parts of the car would remain visible, while other parts become fully transparent to let the driver assess the obstacles below the car.

Jaguar disclosed little about the intent behind this video, but their launch on Youtube prior to the International Auto Show may provide some indications. In its first day on Youtube, the video was viewed 272.574 times, and several media outlets picked up the story about the concept (Ireson 2014, George 2014). Thus, the sketch undoubtedly served as an effective hype generator for the Auto Show and as a piece of viral marketing for Jaguar. But there was more to it than mere marketing. What the video also accomplished was to explain and show the natural potential of having an SUV with a transparent front shield, thus suspending disbelief about this new type of technology. In this regard, the video might have been made as a piece of marketing, but it also accomplished the important function of gathering feedback from the potential users of the future technology. This feedback was useable in further development of the concept. In the year since its first release on Youtube, the video has been viewed more than 1 million times.

What this short example shows us is that there is an incentive in the industry to use animation to represent the dynamic and temporal features of new interaction and user experience designs through animation. While most of the existing examples are used primarily as viral marketing, we hypothesise that the potential is bigger than this. Building upon prior research on video sketching and video prototyping, this book asks whether the use of animation might also be viable in the earlier conceptual phases of the design process. In other words, *can animation actually be appropriated to become a sketching approach in design?*

THE STRUCTURE OF THE BOOK

This book is divided into three parts. Part one begins by defining the foundational concepts needed to understand the animation-based sketching of interactive digital systems. We review the state of the art in design sketching, in studies of emerging technologies, and in the field of animation, as well as their potential fit with design sketching. Building upon this foundation, the second part of the book presents an attempt to define animation-based sketching as a broad tool-agnostic approach that uses animation to portray fictional realities - but with the aim of realising them as facts. We use this definition to distinguish animation-based sketching from other branches of animation studies, such as the functional use of animation outside the field of entertainment and art. We suggest that animation-based sketching enables the designer to represent a digital system that does not yet exist and to generate temporal information about non-idiomatic aspects of the interaction design and user experience of the technology. The third part then turns to the practical side of animation-based sketching. This section draws on examples from praxis and small constructed experiments designed to showcase specifics techniques as well as the design knowledge we might extract from using animation in design sketching. Finally, we seek to assess the role of animation-based sketching as a tool that can inform decisions early on in the design process before more costly resources have to be devoted to development or implementation.

ANIMATION - A FUZZY FIELD OF STUDY

The study of animation is a broad domain, with much ambiguity (Ward 2003). Much of the ambiguity derives from the common insistence on a direct parallel between 'animation' and 'animated film' (Wells 1998, Furniss 1998, Wells 2002, Israel 2007). This is not strange, and, as Furniss (1998) argues, it is probably safe to say that most people think of animation in this way, in terms of a variety of techniques such as cel animation, clay animation, and stop-motion because they have seen the production techniques used in animated films. While much can be gained by analysing animation in light of of a film industry which evolved in tandem with modern animation praxis, the definition of the nature of animation is unnecessarily complicated by the indirect inclusion of animated film

This is also why we do not refer to *'animated sketches'* but to *'animation-based sketches*': we see animation as an approach which can be used in tandem with other expressive tools to convey ideas, and not as a specific genre or medium per se.

The most difficult task facing animation studies is to map the perceived relationship between animation and cognate areas of knowledge and the ways in which practitioners in any of these fields respond to this relationship. Thus, addressing how knowledge increases, develops, and 'fits together' within the research domain of animation is arguably the first step towards describing the convergence between animation and design sketching. Animation scholar Paul Ward argues for the positioning of animation as a 'conjunctional' discipline (Ward 2003). The relationship of animation with fields such as film, media, and art &

design makes it what it is. Ward pinpoints the importance of stressing the distinctiveness of animation as an object of study; it is actually not a completely coherent field or discipline, but a multi-sited field. It is a diffuse but epistemologically important set of ideas, theories, and methods. Ward proposes a conceptual map that allows us to contemplate where animation lies in relation to the cognate subject areas that have studied animation.

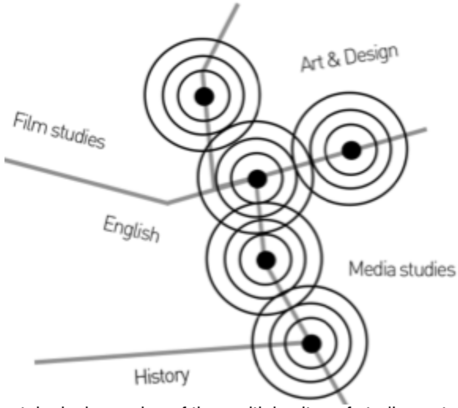


Figure 2: Paul Ward's ontological mapping of the multiple sites of studies onto animation, with rippling overlaps and fault lines between the different domains of knowledge.

The model depicts Ward's mapping of lines as the borders between different disciplines and multiple sites of animation-related inquiries. This creates ripple effects and fault lines overlapping other fields of study. Ward's ontological mapping serves to show the complexity of addressing the fundamental question of 'what it is'. For example, the close historical relationship of animation with the development of live action film has tended to mean that the theoretical and historical assumptions of cinema are either simply taken on board as if application to animation were unproblematic, or these assumptions are rejected out of hand solely because they originate from live action film.

Our goal of establishing animation-based sketching as a distinctive approach also adds a new site to this ontological mapping. Accordingly, the first step in this book is to establishment of the foundations for such an ontological mapping of animation-based sketching as a distinctive approach to using animation for design sketching.

PART I - THE FOUNDATIONS

Before embarking on the definition of animation-based sketching, we must first address the theoretical foundations of the various concepts that merge in this book. It is tempting to jump straight into the description of animation-based sketching in action and to present findings from various examples and experiments. However, building theory and method requires an understanding of the preconditions for the claim that animation-based sketching is a feasible technique for exploring new technologies. In the words of the pragmatic philosopher John Dewey:

> *"It is quite possible to enjoy flowers in their coloured form and delicate fragrance without knowing anything about plants theoretically. But if one sets out to understand the flowering of plants, he is committed to finding out something about the interactions of soil, air, water and sunlight that condition growth of plants."*
>
> Dewey, 2005

Consequently, this section undertakes a journey that starts with the fundamentals of design sketching and their function in the design process. A review of the limitations of traditional static sketching and the identification of a series of unexplored questions in the domain of temporal sketching lead us to propose the combination of sketching and animation. By analysing and categorising the relationship between these seemingly disparate fields, we seek to establish a foundation for providing a clearer distinctive definition of *the nature of animation-based sketching.*

CHAPTER 1: WHAT IS SKETCHING?

If the ambition is to describe animation-based sketching as a specific approach to design, we need to address 'design sketching' as an isolated concept before combining it with the concept of animation. This chapter examines the argument for a view of design sketching as one of the principal activities of design thinking, and it argues that we should view sketching as more than traditional pen and paper sketching.

We see sketching in terms of an intertwined relationship between the traditions of visual thinking and of visual communication. This relationship is not fixed: during the design process, it can change between the investigative, explorative, explanatory and persuasive functions of sketching.

Finally, we propose a new way of distinguishing between the concepts of sketching and prototyping on the basis of information theory. Sketching is the generation of new information, reducing uncertainty but increasing complexity. Prototyping then reduces complexity by testing the information generated through sketching.

DESIGNERLY WAYS OF FINDING OUT ABOUT THE WORLD

In discussing the study of design, legendary design philosopher Nigel Cross famously stated that *"there are things to know, ways of knowing them, and ways of finding out about them that are specific to the area of design"* (Cross 2006). Cross was one of the first to frame *design thinking* as its own epistemology. This was supported by Herbert Simon's proposal for fixating design in the artificial 'built environment' (Simon 1996). Richard Buchanan later adapted the concept of 'wicked problems' as specific characteristic for the type of problems designers face (Buchanan 1992). He proposed that designers approach ill-defined, contradictory, and constantly changing problems by respecting how the subject matter of design does not exist before being framed by the designer. The performative nature of this epistemology shows us that design bears an 'ontological politic' concerning what is being made (Gaver 2012), and that this amounts to a responsibility for creating possible future states of the world.

With the contributions of Cross and Buchanan and of a growing community of scholars, design thinking is now a recognised field with its own discourse of creative and solution-focused ways of exploring what Simon called 'preferred future states' (Simon 1996). Kolko (2010) emphasises abductive reasoning as how designers a balance the dialectics of problem setting and problem solving. Kolko relates abduction *sensemaking* as a natural human process, in which experiences are integrated into a more and more articulated understanding of the world (Klein et al's 2006). Via abductive sensemaking the designers add seemingly disparate information to the parameters of a problem setting. This changes the conditions, and through this kind af 'experimentation', the designer qualifies how a proposed 'might be' a viable and desireable solution. Unlike the logics of either deduction or induction, abduction does not look for logic inherent in the premises, but allows for creatively hypothesise new meanings through qualified guesses. These guesses, or hypothesis' are not necessarily included in the original premises but added through using the designers experiences with familiar situations, and by experimentation via trail and error.

As an epistemological part of design thinking, abduction represents the designer's sensemaking process as an approach to asking 'what if?' questions. Kolko describes the experiential conditions behind these questions as the unique signs the designers leave in everything designed - the evidence of how the abductively added their own lived experiences into the sensemaking behind the design (Kolko 2010). To enable abductive sensemaking in design mostly requires some kind of interaction with conditions of the problem - expressing a 'what if' question, which adds new information to the existing conditions of the problem setting.

This exploration of a framed part of the world is related to Cross's claim that designers have a 'specific way of finding out about' phenomena by generating knowledge through externalisations. This is essentially why Löwgren & Stolterman (2004) argue that the main output of the thoughtful design process is not the artifact but the *knowledge construct.* Design knowledge is primarily intended for other members of the knowledge construction culture of design, including not only designers, but also critics, stakeholders, and users. They can then share, debate, challenge, extend, reject, and reflect upon this knowledge, but this requires articulation in forms that can be appropriated and assessed (Löwgren & Stolterman 2004).

Externalising an idea makes 'visible' what was previously only a thought and makes the idea accessible for both the designer and others to expand, criticise, and further develop. In other words, it is through their external representation that ideas become 'real' and move the design process forward in figuring the preferred state of the world. It is often difficult for a design team to share and develop an operative image, since the members tend to understand ideas in widely different ways. Potts and Catledge (1996) studied this in a large software project for almost a year, describing the creation of a shared vision and its evolution into a final specification where the end result was ambiguous and contradictory. Thus, in order to cope with the complexity of the design process, the designer needs to externalise his or hers design thinking through external representations.

Cross himself used the notion of 'a drawing' or 'sets of drawings' as his example of these external representations (Cross 2006), and he argued that the drawing was the end point of the design process, which would then transcend into engineering phases on the basis of the drawings. While it is clear that this division is based on his emphasis on the design practice of architects and industrial designers, Cross's notion of 'the drawing' is still the basis for the way in which the majority of design thinking discourses talk about external representations - as sketching.

SKETCHING AS THE PRINCIPAL DESIGN ACTIVITY

The term ‘sketch’ usually denotes a rough or unfinished drawing, and to sketch is to give a brief account or general outline of something (Goldschmidt 2003, Goel 1995). The wording of the English term originates from the Italian *schizzo*, which in turn is based on the classic Greek term *skhedios,* signifying ‘done extempore - spoken or done without preparation’ (Dictionary.com).

Figure 3: Design sketches are often a mess of fidelities, styles and concepts explored visually.

Sketching is recognised as the archetypical activity in nearly all disciplines associated with design (Buxton, 2010, Jones 1992, Krippendorf 2005, Schön & Wiggins 1992). However, various groups of researchers have examined the role of sketching in design from different perspectives, and there is an ongoing debate between them. Two key questions have been the primary focus of these debates; *what constitutes sketching* and *what is the function of sketching?* The first question is wether sketching is a stage in the design process (e.g. Simon 1996) or if it is specific set of techniques used throughout the process - mostly represented by pen and paper sketching (e.g. Jones 1992). The second question relates to what Löwgren & Stolterman (2004) call ‘the knowledge construct’ of design. In this approach, design is not seen as primarily concerned with making artifacts but with the construction of knowledge, which forms the basis for all designed artifacts. Sketching is considered the principal activity in this form of knowledge construct.

One dominant perspective on sketching sees it as the ability to mediate between the designer and the design problem in the sensemaking process. Here, sketching is primarily thought of as a tool for ‘visual thinking’ (Goldschmidt 1991 & 1993, Goel 1995, Arnheim 2004). The resulting research into how visual thinking enables the designer to ‘have a conversation with the drawing’ is quite extensive (Suwa et al 1998, Suwa & Tversky 1997, Verstijnen et al 1998, Bilda & Demirkan 2003, Schön 1983, Buxton 2010) and is broadly recognised as the primary value of sketching. This notion of sketching also answers the first question regarding ‘what sketching is’: it is a way of helping limited human mental processing to conduct a problem analysis in a reflective conversation with the design situation (Schön 1983). The designer sees what is 'there' in the representation of an idea, creates sketches in relation to it, and then examines what has been represented. This process informs further design moves.

A second perspective emphasises the inclusive value of sketching in the design process. This perspective argues that the main value of sketching is its inclusive way of using visual spatial expressions in the design process (Lugt 2005, Schütze et al. 2003, Buxton 2010). The proponents of this view hold that since the design process is strongly influenced by feedback and critique from peers, the expressive function of sketching is of great importance; it allows a broad community of stakeholders to observe, comment on, and revise ideas through new reflections upon what is represented in the sketches (Frankenberger & Badke-Schaub 1998, Löwgren & Stolterman 2004). To the best of our knowledge, relatively few academic studies have focused on sketching as what we label 'visual communication'. The result is that sketching studies have developed a processual focus on 'sketching' and paid less attention to 'the sketch' as the outcome of this process.

AN INTERTWINED RELATIONSHIP

Questions regarding the nature of sketches and the value of sketching and sketches are not necessarily as clearly separate as the main theoretical contributions often lead us to believe. Nearly all of the most frequently cited sources actually do acknowledge that sketching is a specific integral step in the design process, that sketching is a specific set of techniques, and, even more importantly, that sketching has value both as an internal and external mode of exploring designs. The main difference is in their emphasis; researchers interested in the reflective practice of design (Suwa & Tversky 1997, Schön & Wiggins 1992, Goel 1995, Goldschmidt 1991) are primarily interested in the design process. Other sketching contributions such as those of Buxton (2010), Löwgren & Stolterman (2004), Lugt (2005) and Hutchins (1995) also show an interest in the design process, but they also prioritise the role of sketches as external communication and as a way of "...putting the ideas out there" for debate, critique, and new interpretations (Hutchins 1995). Thus, from a visual thinking and visual communication perspective, the function of sketching seems to encompass two aspects: it aids the construction of knowledge in the design process by generating new and more sophisticated information, and it allows assessment of the sketch.

Eugene Ferguson (1994) identified this intertwined relationship when he proposed a distinction between three types of sketch: *the thinking sketch*, *the talking sketch*, and the *prescriptive sketch*. The thinking sketch refers to the classic notion of visual thinking, where sketching is used to "…focus and guide thinking". Talking sketches, on the other hand, create shared points of reference in external visual communication to facilitate peer-feedback. Finally, the prescriptive sketch is a more formal rendering of the talking sketch that the designer can use to increase effectiveness in conveying the idea of a design to stakeholders who are disconnected from the design process. Ferguson's categorisation is a very concrete way to differentiate between the different values sketching can have, though it also implies that we have to determine which of the three types a sketch actually is. Even though the three types encompass both visual thinking and visual communication, Ferguson's categorisation assumes that the specific sketch has a rather finite nature. This leads to the obvious question of whether the designer needs to reflect upon the purpose of the sketch prior to the sketching process, or whether the category of the sketch is first determined after its creation. When sketching is seen in Schön's terms as a 'reflective conversation with the material', it certainly creates a paradox if the classification of a sketch is to be established prior to the generation of the sketch.

THE MULTIPLE FUNCTIONS OF SKETCHES

One way of coping with this paradox is to regard the intertwined relationship between visual thinking and the visual communication of sketches as a dynamic relationship which may change over the course of time. This was the case in an earlier analysis of the functions of sketching (Vistisen 2015). Here the point of departure was Olofsson & Sjöflen's work (2007) and their indexation of sketches, elaborating Ferguson's work into four genres of sketching: *investigative*, *explorative*, *explanatory* and *persuasive*. The *investigative* function of sketching is related to examination of the problem space during the early phase of unfolding a design problem, and it belongs to the visual thinking perspective on sketching. *Explorative* sketching is used to express design solutions for evaluation and when those solutions may not make much sense to others than the people directly involved in the design process. This function is located somewhere between visual thinking and visual communication. The *explanatory* function, on the other hand, involves communicating a clear concept to stakeholders outside the design situation. These sketches describe and illustrate proposed concepts in a neutral and straightforward manner to invite feedback from users, clients and external experts. In this sense, they are like the talking sketch. Finally, the *persuasive* function uses sketches for rhetorical purposes, with less ambiguity and more details. The focus here is on 'selling' the proposed design concept to influential stakeholders, removing the focus from reflection and emphasising something more akin to marketing. This is a more radical concept than Ferguson's prescriptive sketch.

In Olofsson and Sjöflen's book, the four genres of sketching were little more than an indexation feature - a way to separate the chapters. The underlying assumptions and consequences of categorising sketches in this manner were not discussed. Combined with Ferguson's deeper reflections on the topic of categorising sketches, we proposed a new model in which the four categories of sketches might constitute a continuum, rather than strictly separate categories. The model is a continuum between the investigative and explorative function on one axis and the explanatory and persuasive functions on the other.

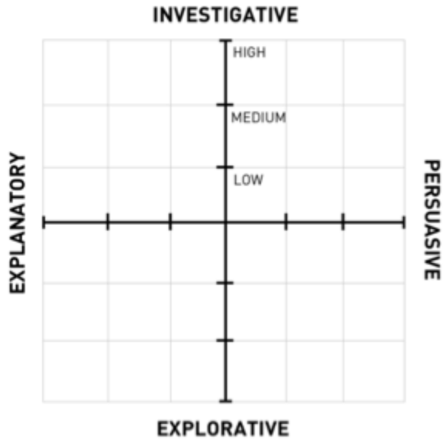


Figure 4: The sketching matrix, composed by appropriating Olofsson & Sjölen's (2006) four categories, into a continuum of functions sketching can take during the design process.

We have added 'high', 'medium' and 'low' to the vertical axis to indicate that a sketch might be assessed as combining qualities from more than one sketching function, although some qualities might be more important than others at a specific time. In the new model, time becomes an important aspect in explaining the different roles of sketches. The model indicates that different sketching activities and techniques might be used in the same way but with different values, depending on the time and context of use. Thus, as an alternative to seeing the various types and functions of sketching as representing fixed qualities, the same sketch might be seen as taking on different qualities depending, for instance, on whether it is being used to reflect about a choice of different design alternatives or is being shown to an external stakeholder in a project:

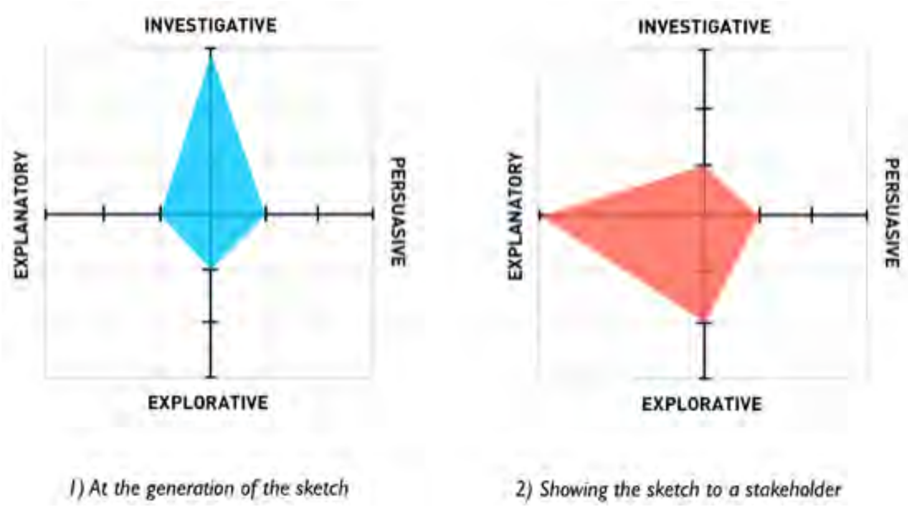


Figure 5: Two setups in the sketching matrix, depicting how the same sketch takes on different functions over the course of time in the design process.

This takes the intertwined relationship between visual thinking and visual communication to its logical conclusion - sketching is both visual thinking and visual communication, and its primary quality is entirely dependent on when the sketch is used and for what kind of knowledge construct. Consequently, we do not assess the function of a sketch epistemologically in terms of its inherent qualities but in terms of the specific constellation of context and time of use.

LESSON LEARNED
In design, sketching is concerned with visual thinking and the output sketch with visual communication. These two exist in an intertwined relationship which changes functions over the course of time in the design process.

We might argue that even when no external audience is present, all sketching involves communicative intent and thus always involves the persuasive function to some extent. The sketch is framed, and this selects what is included and what is excluded. Even when using sketching to investigate the problem as a means of visual thinking, designers cannot avoid a measure of self-persuasion; they sketch certain aspects because of personal taste, domain expertise or external demands. In fact, this is true for all kinds of expressive capacity: they all involve leaving something in and leaving something out. Before the finished product has been realised, everything else is a matter of contingent selection. Thus, design is never objective. Instead, it involves a balance between showing the potential and elegance of a proposed future vision and leaving out enough details out for it to avoid being regarded as finite.

The new challenge for sketching is to assess how different approaches work in the continuum between investigation and exploration, between explanation and persuasion, and in the possible combinations between the four of them. This can lead to a revision of 'what a sketch actually can be'. Does a sketch necessarily resemble Cross's notion of a 'drawing', or might sketching and sketches involve other materials and techniques?

I have discussed this issue in detail in an earlier publication (Vistisen 2014), where I described sketching in terms of Bill Buxton's seminal work on the role of sketching within the domain of human-computer interaction and user experience design (Buxton 2010). Buxton broadened the scope of sketching by suggesting eight criteria for determining when something is a sketch: *evocative, suggestive, explorative, questioning, proposing, provoking, tentative* and *non-committal.* Drawing on Buxton's criteria, we proposed that sketching should be seen as a specific mindset rather than as a definite set of constrained techniques. Sketching enables the abductive sensemaking central to design; in sketching, we do not explore *what is*, but instead seek to speculate about the conditions for *what might be*, then pruning and experimenting with them.

Buxton's criteria also mean that sketching should be regarded as way of acting upon the world in a more broad scope. We suggested framing these different expressive sketching capacities through a categorisation based on both the material context and the technological praxis enabling the sketching. Inspiration was drawn from the domain of interaction design, by using Gillian Smith's description of interaction according to its 'dimensions': 1-D, 2-D, 3-D and 4D (Smith in Moggridge 2006). Smith's categorisation was directed as a means of deconstruction the part of interactive products. However, we found the categories suitable for a broader use of the dimensions in which we practice design sketching. Consequently, I proposed a typology for the mindset of sketching applied in both 1-dimensional sketching (e.g. thought experiments), 2-dimensional sketching (e.g. pen & paper sketches), 3-dimensional sketching (e.g. models and mock-ups) and 4-dimensional temporal sketches (e.g. enactments, video and animation).

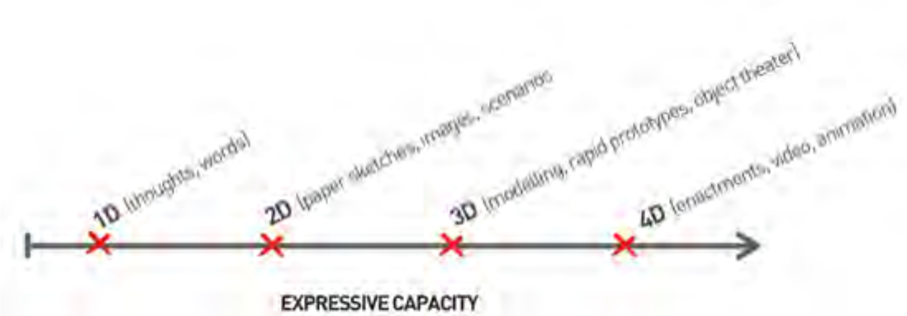


Figure 6: Scale of expressive capacities in sketching, from 1-dimensional thoughts and words to 4-dimensional temporal capacities like video and animation.

This typology of the expressive dimensions in which the sketching mindset can be applied involves the hypothesis that expressive capacity increases when further dimensions are added to sketching capacities. For instance, when sketching with materials and techniques that accommodate temporal aspects, we are able to generate richer design knowledge about things that unfold over time than we would if the sketch was produced through pen & paper. Whether this richer temporal design knowledge is necessary to move the design process forward is highly dependent on the design problem and its subject matter. We limit this notion of higher expressive capacity to the domains of interaction design and user experience design, which, to a higher degree than most other design domains, have the dynamics of time as their subject matter (Kolko 2011). In this regard, the typology in general does not specify which sketching capacity is preferable, instead proposing that designers have a broad range of expressive capacities from which they can choose when they are exploring a design problem.

SKETCHES VS. PROTOTYPES

A review of past academic publications and contributions based on design practitioners' reflection-on-action reveals how the term 'sketch' is often used either as a synonym for so-called 'prototypes' or as a 'low-fi' reference to prototypes (Snyder 2003, Svanaes & Seland 2004, Rudd et al 1996). This confusion is unfortunate since it raises an obvious ontological question: if the two terms are interchangeable, why do both terms exist? Some would argue that the confusion arises from differences between the fields of origin: sketching originated in the design discourse of architecture and industrial design (Schön 1992), and prototypes originated in the computer sciences and engineering (Ferguson 1994). However, the history of the two terms still does not clarify 'what they are' and 'how they differ'. Some scholars have illustrated the difference indirectly by proposing various principles and techniques for creating different types of design sketches (Ferguson 1994, Olofsson & Sjölen 2007, Buxton 2010), and other principles and techniques for variations of prototypes (Wirklund et al 1992, Sears & Jacko 2009, Hill & Houde in Helander et al 1997). While such principles are helpful when it comes to applying a specific technique, they still lack the formality of a definition and may be criticised for still being interchangeable.

In his seminal writings about using a multitude of media as sketching capacities in user experience design (Buxton 2010), HCI scholar Bill Buxton moved a step beyond principles of sketching and prototypes. Rather than setting up specific principles, Buxton attempted to create a set of characteristics defining what makes a sketch a sketch, and a prototype a prototype:

Sketches are...	Prototypes are...
evocative	didactic
suggestive	descriptive
explorative	refining
questioning	answering
proposal	testing
provoking	resolving
tentative	specific
non-committal	depictive

Figure 7: Buxton's (2010) characterisation of the difference between between sketches and prototypes.

Buxton's list of defining characteristics constitutes a point of reference that is arguably stronger than most other attempts at clearly articulating the difference between sketching and prototyping. He also approximates a definition in his notion that sketching in design is concerned with *'getting the right design'* and that prototyping within usability engineering is concerned with *'getting the design right'* (Buxton 2010). In other words, we might say that sketching asks *'what is the problem and how might we solve it?',* whereas prototyping asks *'which solutions are most feasible?'* This distinction works well in discussion of the *aim* of sketching and prototypes, but it hardly addresses the formal difference regarding *what* they are. While they are defining, such characteristics are hardly precise, and since they seem to exist in a continuum, Buxton also acknowledges that the characteristics sometimes seem to overlap when one is attempting to determine whether a given material, process or technique is more suitable for sketching or for prototyping on the basis of his framework:

> *"The real value in drawing a marked distinction between sketching and prototyping lies not in the end points, but in recognising that there is a continuum between them. An awareness of it, its properties, and its implications, may help guide us in how and when we use different tools and techniques.*
>
> *[...] how a technique is used is the ultimate determinant of whether one is sketching or prototyping."*
>
> Buxton 2010, 248

The last part is especially important, since Buxton acknowledge that what specifies the label of a given technique in his continuum of characteristics is not defined by anything inherent in the technique itself, but by what it is used for. This begs the question of whether it is possible to formalise what sketching and prototyping are used for and thus create a more formal definition of the two terms.

Uncertainty vs. complexity

In Vistisen & Rosenstand (2016), we suggested that we should draw on the domain of information theory to create a more general formal definition of the division between sketching and prototyping. On the basis of Herbert Simon's theory of bounded rationality (Simon 1973) and of the development of ways to describe bounded rationality in regard to the information society (Newell & Simon 1972, Mathiassen & Stage 1990), we argue that sketching and prototyping can be differentiated in terms of how they deal with uncertainty or complexity. Uncertainty is a negative measure of available information – the lack of information. This is opposed to complexity, which is a positive measure of available information, or information at hand. On this basis, sketches and prototypes can be differentiated in terms of the information they add to the design process.

We position sketching as the explorative generation of new information. Sketching adds knowledge by filling out gaps in the information about which possible design alternatives might be viable, desirable, and feasible, and thus it reduces uncertainty. This fits Buxton's characteristics of sketches as 'proposing' and 'explorative' while emphasising 'what sketches do'. While generating information, however, sketching thus also increases the complexity of the design situation, and the designers now have to choose between and evaluate a series of alternatives as the best fit for further development. In this regard, prototyping is a process which reduces complexity by putting the most promising information to the test. This aligns with Buxton's characteristics of prototypes as 'testing' and 'refining'.

We argue that this information-based distinction makes description of the fundamental qualities of sketching and prototyping both easier and more precise, and it clearly articulates the difference between the two activities. The definitions supports an understanding of typical design process models (e.g. Boehm 2000, ISO 9241-210:2010), in which sketching is typically dominant in the front-end phase due to the lack information at the beginning of the project - an uncertain situation. This uncertainty creates the need to use a fitting technique to sketch design alternatives that can inform further decisions. Once design alternatives have been created, we now have more information than needed in the form of multiple design concepts. This creates the need to choose between the different alternatives. In other words, complexity has to be reduced through prototyping.

LESSON LEARNED

Sketching is concerned with the reduction of uncertainty by generating information
Prototyping is concerned with the reduction of complexity by testing information

In relation to the previous division of sketching mediums into 1D-4D capacities, the distinction between uncertainty and complexity further illustrates how the same medium might be used for both sketching and prototyping. When the aim is to reduce uncertainty about what is to be produced, the action is sketching, and when the aim is to reduce the complexity surrounding the question of which of the possible ways to realise the design is the most viable, the action is prototyping.

A GENERAL SKETCHING MINDSET TO BUILD UPON

This way of approaching sketching as a specific mindset that is applicable in a multitude of dimension means that a range of materials may now be considered applicable for sketching. These materials provide an increase in expressive capacity that can overcome some of the natural limitations of the traditional 'drawing' genre of sketching with pen and paper. In the next chapter, we will review these limitations in relation to the challenges of exploring early design ideas regarding non-idiomatic technologies.

CHAPTER 2: THE LIMITATION OF DESIGN SKETCHING

While design sketching can be identified as one of the principal activities of design thinking, and while the process itself is a crucial reflective part of gaining design knowledge, sketching is sometimes inadequate to express dynamic and interactive aspects of a proposed design. This is especially true when the proposed design involves aspects which lack established conventions or best practices.

This chapter examines the limitations of sketching in its traditional static sense. We analyse these limitations to provide a better framing of the concept of new emerging technologies, which we describe as 'non-idiomatic'.

THE IDIOMATIC STRUCTURE OF STATIC SKETCHES

As we have discussed, sketches has the capacity to represent and externalise ideas; that is, sketches make internal thoughts public. Sketches do this in another way than e.g. written language, by making it possible to convey visuospatial concepts directly, using a language of visual forms (Tversky 2002). This makes sketches public, and thus allows for other than the individual design thinker to observe, critique and propose revisions on the idea - maybe even enacting new sketches in the process. Together with the reflective practice of the sketching process itself, this externalisation enables the reflective practice of sketching.

Sketching as visual vocabularies

When sketching in traditional static pen and pencil, the designer usually starts with a blank canvas which is potentially open for the expression of any kind of concept. However, existing studies have shown that when designers sketch, their sketching can be categorised into segmented elements (Tversky 2002), composed by shapes, figures, signs, and diagrams (Zacks et al 2000). Goodman has noted that these segments even have language like properties, combining in different ways to produce different meanings and thus constituting the syntax of the semantics of the concepts (Goodman 1968). Tversky's study shows the extent to which semantics can map onto the meaning of linguistic elements, for instance idioms for certain expressions and annotations (Tversky 2002, 4). Drawing on a survey of sketches produced across ages and cultures, Tversky demonstrates how sketches can include depiction not found in realty, but rather annotates reality - such as boundary lines, arrows and exclamation marks.

As such, sketches consist of a repertoire of stylised elements which can be combined, mixed and matched. As an example, architectural sketches can be deconstructed into a rather small set of elements, which combined can create the most creative and vivid structures (Do and Gross, 1997). Even outside the design domain, children throughout the world draw human heads and bodies as circular blobs and add sticks for arms and legs (Kellogg, 1970).

This corresponds to what Löwgren labels *visual formalisms* (Löwgren 1996), a term which refers to elements in which their relations and semantics are established by convention. Nardi and Zarmer (1993) suggest that they are based on simple visual objects such as maps, tables, graphs, plots and panels. Greenberg et al (2012) apply this to sketching, summarising a number of common visual formalism to create a 'visual vocabulary' of the sketching language.

Figure 8: A small cut of the visual vocabularies of sketching, as presented by Greenberg et al (2012), showing of idiomatic patterns of objects, and actions.

In essence, visual vocabulary and visual formalism are a set of learnable idiomatic elements which speak in a strong simplified voice. Sketching vocabularies and their semantic combinations cannot convey the exact configuration of the world, but they suffice to create the reflective conversation with the material needed to explore the design problem. In fact, the way in which sketches distort the configuration of the world might even be one of the drivers of abductive sensemaking (Kolko 2009); they loosen the framing of extant reality to allow exploration of a preferred state of affairs. Thus the vital characteristic of design sketching is its ability to leave 'gaps' in its expression that are big enough to facilitate reflection while still using known idioms and patterns to create broad recognition.

Pattern languages of design

The whole notion of a visual vocabulary in design owes a lot to early work on visual formalisms by Christopher Alexander (1964). Alexander recognised the combinatoric nature of architectural designs and analysed the relationships between different applications and combinations as well as the idiomatic relations between architectural designs; the resulting reusable segments were what he came to label *'pattern languages'*.

A pattern is an abstract collection of relationships within a small system of interacting and connecting elements and is independent of all other elements. The idea is that it is possible to create such abstract relationships one at a time and fuse the resulting relationships into whole designs (Alexander 1964). Because the patterns are independent of one another, we can study them and manipulate them one at a time so that their evolution can be gradual and cumulative. Moreover, because patterns are abstract and independent, they can be used to create an infinite variety of designs, all of which are combinations of the same set of patterns in the evolving language. The language metaphor creates the basis for seeing design patterns as *networks of truths* (Alexander et al 1977, 18) and as endless sequences of semantic combinations. The sequence of patterns is both a summary of the language and an index of the patterns. Thus, if the combinations were read together, an overview of the pattern language would emerge. This is how Alexander's concept of patterns helped to form what designers now label 'best practices' (Bogan 1994), which constitute a way of connecting the multiple sequences of semantic patterns within a specific design domain to reveal the current state of its pattern language as the current best practice or state of the art.

Later on, object-oriented computer scientists began to adopt the pattern language concept (e.g. Gamma et al 1994). Like Alexander et al's (1977) pattern language, design patterns of software described reusable insights about software design, which was concrete enough to be used immediately, but still abstract enough to be applied and mixed in situations.

HCI researchers such as Jenifer Tidwell (2005) have used the pattern approach to systemise reusable forms and styles for combination in the user interface of digital products and to solve re-occurring usability problems. These design patterns document different models of interface actions and interaction behaviour, which are proven useful in enabling a given systems user to complete their tasks.

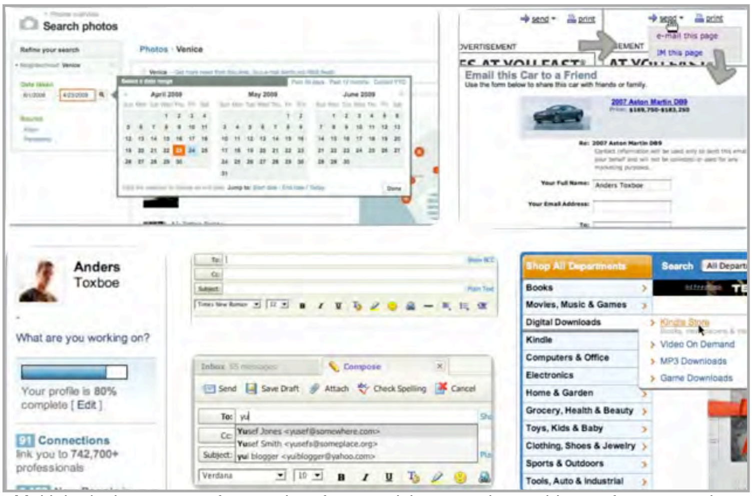


Figure 9: Multiple design patterns for user interfaces, solving recurring problems of user experience design.

When designers are working on a digital product presented through rather standardised design patterns, traditional representation techniques work well (Greenberg et al 2012). Examples include pen & paper sketches, storyboards and multimodal combinations When designing a web-site, the designer often knows the context of use and the requirements of the web-site, and she may investigate the business and user goals of similar sites or services. The designer can draw on years of knowledge acquired from the web-design domain to experiment with established design patterns, combining them in new variations. Likewise, when sketching the initial ideas, the designer can use an array of established idioms from the domain to express ideas and can leave out details, relying on the ability of the community to fill in the gaps. We design against the backdrop of the collective experience and practices of our specific design domains. When a design problem has a known context, a known problem and familiar patterns and idioms for possible solutions, we label it a *normative design problem*. Normative design problems draw on idiomatic interactions, enabling the designer to fill in the blanks of how an interaction would take shape - even in a static medium such as a sketch.

LESSON LEARNED
Design idioms replace the need of certain expressive capacities in a design sketch due to the experiential knowledge filled in by the designer.

However, complications occur when the design depends on highly interactive and complex behaviour that is costly or difficult to represent using conventional techniques (Arvola & Artman 2006). In such design settings, the static patterns of sketching can only take the designer so far in the attempt to describe the multiple states of the dynamic system. In such cases, static sketching may never really generate all the information needed to explore the idea fully. Furthermore, with the emergence of new digital technologies and their integration into more and more aspects of society, the classical segmented elements of design idioms and design patterns fall short in terms of expressiveness. The designer must now sketch outside the established idioms of known conventions and practices.

NON-IDIOMATIC TECHNOLOGIES - SKETCHING OUTSIDE 'THE KNOWN'

We argue that one of the domains that lack established design patterns or conventions is the emerging landscape of dynamic digital devices. Such devices offer features such as multi touch screens, accelerometers, gyros, compasses, barometers, and cameras, all of which are embedded in a rapidly changing eco system of services, platforms and devices. Warwick's work (1997) indicates that areas such as artificial intelligence, robotics, virtual reality and persuasive computing all belong to the umbrella concept of 'emerging technologies'. Emerging technologies can be understood in terms of their technical nature, but their impact on socio-economic structure is just as important:

> *"radically novel and relatively fast growing technology characterised by a certain degree of coherence persisting over time and with the potential to exert a considerable impact on the socio-economic domain(s) which is observed in terms of the composition of actors, institutions and patterns of interactions among those, along with the associated knowledge production processes. Its most prominent impact, however, lies in the future and so in the emergence phase is still somewhat uncertain and ambiguous"*
>
> Rotolo et al 2015, 1827

This description portrays emerging technologies as a growth factor, which indicates how far the technology has moved from invention and refinement to reach the tipping point of actually gaining public traction. Bill Buxton labels this 'the long nose of innovation' (Buxton 2008). Furthermore, the definition offered by Rotolo et al emphasises an interesting relation between the potential impact of emerging technologies, and the ongoing ambiguity and uncertainty about their actual innovative potential - it is due to a lack of information about what is viable, feasible and desirable.

This mixture of promise and uncertainty makes it more challenging than ever for designers to rely on the known idioms of design patterns when they are exploring and assessing potential use cases in emerging technology. What is lacking is the visual vocabulary - the well-defined semantics for expressing relations (Nardi and Zarmer 1993). Such formalisms draw on simple visual objects such as maps, tables, graphs, plots and panels, and they contain their own semantics instead of metaphorically recreating the semantics of some other domain. A number of research contributions have shown that this lack of design patterns makes it difficult to sketch using the idioms and best practices usually applied in design - the conventions that are *learnt*, not analogically or metaphorically transferred (Cooper et al 2012). Consequently, these emerging technologies might be characterised as 'non-idiomatic' (Lindel 2012, Löwgren 1996, Lowgren & Stolterman 2004).

Löwgren (2004) explains that the dynamics of interactive systems means that most non-idiomatic technologies are hard to grasp in static expressions and that this constitutes a challenge:

> *"We are increasingly facing design situations where the intended use takes place on the move, using various mobile and embedded technologies"*
>
> Löwgren 2004

Non-idiomatic technologies merge into and transform the foundation of our way of being in the world; they change more and more aspects of our reality. Joseph Pine & Kim Korn have framed this development in their concept of the 'multiverse' (Pine & Korn 2009), which encompasses the multiplicity of when experiences happen[Time↔No-Time], where they occur [Space↔No-Space], and what they act on [Matter↔No-Matter]:

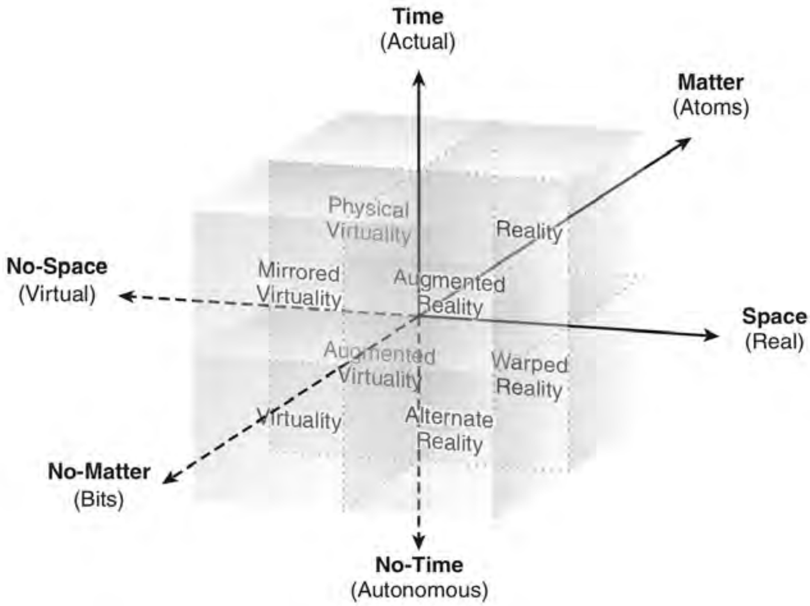


Figure 10: Pine & Korn's (2009) model of the multiverse, depicting eight quadrants of technological genres - some with a broad range of established idioms and conventions, while others have significantly fewer.

The model and the underlying analysis are of popular scientific origin, but what is inspiring is the overall metaphor and, in particular, the way in which it categorises the multitude of digital technologies. In the eight quadrants of the multiverse, a framework of technological genres emerges. This framework describes the multitude of ways in which digital technologies can merge into and affect both the real world and the virtual world. Although nothing specific is stated about the idiomatic nature of each quadrant, the framework serves as an example of areas beyond the established digital design domains of web-sites, apps and games, and it provides an ontological simplification of *how* they differ. Furthermore, the model also indicates that more or less all the digital genres involve a highly dynamic relationship between space, matter and time. The non-idiomatic aspects of a technology arise from the lack of established conventions about such dynamics. The framework helps to clarify *which* information exists in terms of patterns, idioms, and best practices, and what does not exist in these familiar forms. These gaps in information challenge the designer who is exploring the potential use cases for a new technology. In turn, they also limit the extent to which the designer's toolbox can provide sufficient information. Until generally accepted idioms or design patterns are culturally established, the design process involving a new emerging technology will deal with what we label *non-idiomatic design problems.* This entails a process of great uncertainty in the front-end of the design process, which means that the initial setting will be 'fuzzy' (Reid et al 2004).

LESSON LEARNED

When the design situation handles technologies or interactions with few or no conventions the design situation becomes non-idiomatic, and design idioms often become insufficient.

The challenge of statically sketching non-idiomatic dynamics

When dealing with fuzzy non-idiomatic design situation, designers must rely on their experience from other technological idioms, using methods, tools and techniques which might at best be a 'force to fit'. This challenges the capacity of sketching to reduce uncertainty by creating new information, since the designer has few idioms to use when sketching in this non-idiomatic domain - or perhaps none at all. Furthermore, from pen & paper to more sophisticated mock ups and widget tools, the static nature of conventional sketching methods means that they lack the expressive capacity to generate temporal information about the dynamics of use situations where technologies are embedded in various devices, touch points and contexts, and where patterns of interaction are untraditional. The main issue in exploring the finer grain of interaction involves the experiential qualities of the interplay between user and product over time - the temporal information. Consider the range of expressive dimensions we touched upon in the last chapter:

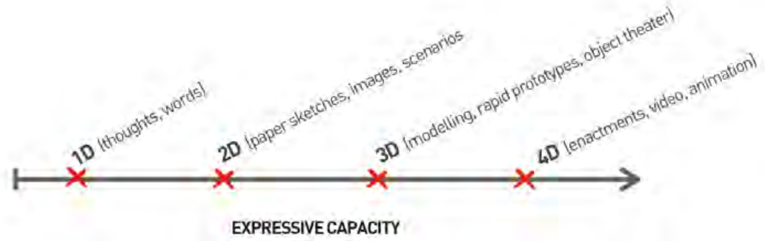


Figure 11: Remember me?

Idioms replace the need for fine-grained temporal information about the dynamics of the system and make it viable to sketch in lower expressive dimensions. Whereas some things are established and conventional enough to be understood through words, other issues require visual thinking in pen and paper. This is a central reason why a designer can sense more feedback from a sketch than it makes explicit: it speaks to the idiomatic knowledge of the designer. The problem occurs when the temporal information needed is based on dynamics of which the designer has little idiomatic experiential knowledge – or none at all. The idiomatic point of reference is no longer available, and the designer can no longer foresee the consequences of the dynamic and temporal aspects of the possible uses of the technology. The situation becomes non-idiomatic.

From this perspective, we can frame the limits of traditional 'static sketching' in terms of its expressive capacity to explore the interaction design of technologies beyond established patterns, idioms and best practices.

According to Cooper et al, *"...interaction design is first and foremost the design of behaviour that occurs over time"* (Cooper et al 2012). We might thus frame the challenge of traditional sketching as primarily a 'temporal limitation'. Buxton has noted this temporal limitation in a critique of the often-applied method of 'scenarios' (Carrol 2000) when it comes to exploring the interaction design of a new technological application (Buxton 2010).

Figure 12: Multiple sketches forming a scenario of the scanning of a product with a phone app (Buxton 2010). The designer has attempted to capture temporal dynamics through the use of arrows and colour annotations.

Buxton points out that scenarios and other storyboard-oriented ways of portraying temporal information tell the designer a lot about individual 'states', but almost nothing about 'transitions'. They capture the static display of interfaces and product forms, for example, but the temporality of interactions themselves are only implied by the space between states or by crude annotations. From Buxton's perspective, the user experience of something is shaped more by what happens between each state than by the states themselves; it is important not to leave out too much temporal detail out for designers to fill in by themselves. When we lack known idioms to sketch from, it becomes harder to fill in the gaps regarding the temporal aspects of the interaction because experiential knowledge of the technology in a given context is inadequate. Accordingly, such sketching in interaction and user experience design is quite different from sketching in other design domains. Interaction and user experience design has focus on expressing the dynamics of interactivity, multimodality, tangible, haptic, audible and immersive experiences (Cooper et al 2012, Svanæs 2000, Fällman 2003). These are all characteristics that could also fit the notion of emergent non-idiomatic technologies.

Thus, non-idiomatic technologies are challenging due to the lack of temporal and dynamic information in traditional static sketching approaches. Approaches for exploring the experience and interaction design of such technologies must differ from conventional static sketching since they have to generate temporal information about the dynamics of both the system and the user experience to reduce the uncertainty of the design process. The issues involved in generating and facilitating reflections about the temporal and dynamic aspects of non-idiomatic design problems are the topics of the next chapter.

CHAPTER 3: TEMPORAL SKETCHING

This chapter presents a review of how non-idiomatic design projects have attempted to meet the need for temporal and dynamic information by using what we label *'temporal sketching approaches'*. We describe cases involving the application of video-sketching in non-idiomatic design cases, and we also include examples where animation is used to augment the video sketches but where the designers have scarcely reflected upon the animated aspect.

From this overview, we identify a range of preconceptions for the use of animation in sketching. Animation has previously been used in design visions, but with production qualities that exceed the possibilities offered by design sketching. Video can be employed throughout the design process, but without animation, the portrayal of interactive designs that do not yet exist is limited to props and enactments without formal design elements. Thus, we argue the need for further examination of whether animation is viable for sketching if aligned with the uncertainty reduction of sketching.

SKETCHING TEMPORAL AND DYNAMIC INFORMATION

We have established that design sketching is the generation of information to reduce uncertainty about design possibilities. Traditional static sketching approaches are challenged when they are used to explore the dynamics of interaction and user experience with new technology which has non-idiomatic aspects. Consequently, the need arises for the 4D sketching capacity introduced in Chapter 1 - what might be termed temporal sketching. In meeting the challenge of sketching non-idiomatic technologies, temporal sketching should specifically enable the generation of temporal information.

Video - the precursor for animation in design sketching

The 4-dimensional forms of expression have previously been explored as sketching mediums (Buxton 2010, MacKay & Fayard 1999, Mackay et al 2000, Bardram et al 2002, Zimmerman 2005, Vertelney 1989). In particular, experiments have been conducted using live-action video as a sketching medium, building on the suggesting that techniques of film are ideal for conveying temporal aspects such as timing, movement, and dynamic relations (Ylirisku & Buur 2007, Vertelney 1989, Bardram et al 2002). Passman (2012) points out that with its ability to capture the richness of life as it unfolds, video is a feasible medium to register the world *as it is now* and to visualise the world *as it could be*. Raijmakers (2009) notes the ability of the medium to showcase experiences through time and in context: *"Film is definitely the most powerful tool to an emotional understanding of the user"*. Empathy for the user is a central goal of any user-centered design process, and video can be perceived as an intermediate artefact during design and as a means of persuasion that can engage people in the design process (Veland & Andresen, 2007). Finally, video can be applied as a change agent, functioning *"...as persuasion to present complex ideas in a concentrated and exciting way for influencing research directions and* *decisions,"* (Chow 1989). In this connection, Ylirisky & Buur even noted how video scenarios in design could *"...in a way replace the need for functional prototypes that provide people with the overall experience of the system in fluid action"* (Ylirisky & Buur 2007, 33). Botin & Bolvig (2015) have added that video scenarios can present the emotional, social and cultural aspects of concepts before they are created. This is supported by Veland & Andresen's (2010) notes on the technical feasibility of video; recording hardware, editing software, and distribution platforms are now both cheap and easy to access.

These approaches are commonly labelled in terms of the common concepts of 'video prototypes' (Vertelney 1989, MacKay & Fayard 1999, Young & Greenlee 1992) or 'video sketches' (Zimmerman 2005, Bardram 2002, Tikkanen et al 2008). However, no real justification is offered for the use of the terms 'sketch' and 'prototype', other than the interchangeability that we identified earlier. Many of the contributions also seem to use live action video and animation as interchangeable parts of the 'video' label, leaving reflections upon the specificity of animation more or less out of their analysis.

Ylirisky & Buur's book 'Designing with Video' (Ylirisky & Buur 2007) is particularly noteworthy. It covers the broad potential for applying video in design processes, but, as we will argue, it also distorts the potential of animation by linking its role solely to that of augmenting live action video prototyping. Ylirisky & Buur argue that video plays a role either as the designer's 'clay', enabling the expression of concepts, or as 'social glue', where video supports the social process of collaboration and the development of an operative image of the design problem and possibilities. The authors provide an impressive review of techniques and processes for the application of video in design processes, and they also dedicate a section to exploring a topic aligned with what we have described as the sketching mindset: 'generating information which envisions the future'. Whether the aim is to improvise in an investigative manner, doing future ethnography from an explorative and communicative perspective, or to persuasively argue for a certain view of the future, Ylirisky & Buur argue that *"concrete images of possible futures enable the making of judgements about what would be preferable" (*Ylirisky & Buur 2007, 181*)*. For Ylirisky & Buur, video prototypes are illustrations of how reality could or would if what the temporal sequence proposes is resolved. They argue such sequences should 'provoke' as well as 'propose' in order to overcome status quo perceptions. Thus, video does not *tell* us about the future. Rather, it invites us to have a conversation about it, establishing a shared point of reference for communicating about the desirability, feasibility and viability of proposed design ideas.

Animation - an expensive high fidelity tool?

As well as discussing the creation of video prototypes to provoke change, Ylirisky & Buur also discuss the question, "What scale would be appropriate with the resources we have?" Their analysis emphasises the "Starfire" video prototype described by Bruce Tognazzini (1994) and the Apple Knowledge Navigator (Buxton 2010), which applies professional looking video, acting, animation and special effects to portray an idea of the future.

Figure 13: Images the vision videos, depicting the Apple Knowledge Navigator concept from 1987 - envisioning the uses of tablets, AI assistants and networked collaboration as we see in use now by 2016.

This process is described as similar to the creation of a live action movie, as outlined by film scholars (Rosenthal 2007, 12), and it involves *(1) script development, (2) pre-production, (3) filming, (4) editing, and (5) final lab work.* Ylirisky & Buur also briefly cover the use of animation, but mostly in the creation of 'special effects' in video prototypes. Here, animation to create motion graphical elements is practically synonymous with the notion of 'high fidelity special effects'. This is one of the critical elements of the use of animation that is covered by Bill Buxton's critique of the Apple Knowledge Navigator concept (Buxton 2010). The Knowledge Navigator was an environment video showcasing the potential of R&D technologies of the time, such as touch screens, hypermedia collaboration and artificial intelligence assistants, where all digital elements were animated to portray the device as 'real' in a range of short storylines. With reference to the budget, the production quality and the rhetorical aim of persuading people about the technological ambition, Buxton's main argument was that this use of animation was not a sketch; it was only a vision (basically intended as a sketch of the future), but it ran out of control and was perceived as a promise regarding how a specific product would be launched and would function. Removed from the context of the presentation of the video, the visual vocabulary and production values were too persuasive: people started to believe that Apple was actively working on the system (Buxton 2010, 365).

Buxton argues that even if The Knowledge Navigator had been quick, timely, inexpensive and disposable, it would still not have worked, since it involved telling a story about the future instead of asking whether this would be the preferred story. In terms of our matrix of sketching functions, Buxton's critique is that the Knowledge Navigator became almost purely persuasive; its explanatory and explorative purpose were overshadowed.

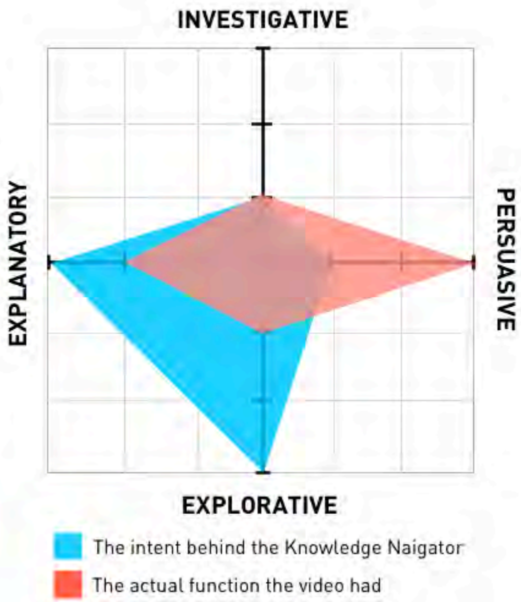


Figure 14: The sketching matrix, mapping how the Apple Knowledge Navigator vision videos took on a more persuasive function, than the intent described by its creators.

Buxton points out that this issue is a result of one of the main strengths of high fidelity renderings: they are the attractive results of craftsmanship, and are thus seductive. This relates back to Chapter 1 and our discussion of the omnipresence of a degree of persuasiveness in design sketches. In a sense, the higher the fidelity, the higher the persuasiveness of the sketch, and this entails an increased risk of the sketch not being perceived in the right way as something tentative and not finite.

Ylirisky & Buur elaborate on this issue in examining a design case from Nokia which envisions the future of context-aware mobile phones and pervasive computing environments, Substantial resources planning, filming and editing of the finished video scenario resulted in a high-fidelity rendering of their proposed design vision. Ylirisky & Buur note how the created video:

> *"...had an impact on numerous projects. It has been presented in various situations at Nokia and also at numerous seminars and conferences."*
>
> *[...]*
>
> *"With the cost required for realising virtual 3d-models and animations, it is clear that this is only appropriate for long-term visions at corporate level. For visualising short-term research ideas, e.g. of less than five years, one would need cheaper and faster production and to focus on the business benefits."*
>
> Yilirisky & Buur 2007, 215

Ylirisky & Buur conclude that without big budgets of the scale devoted to the future vision video at Nokia, few techniques are available for the small-scale representations of designs that explores the 'what if' of the not-so-distant future. Without animation and its ability to create apparent motion in graphic positions not fixed in reality, video as a sketching medium is limited to capturing the world of 'what is' and is only able to *illustrate* the world as it might be. Thus, in light of Ylirisky & Buur's critique of the cost and time required to use animation in video prototyping, the potential of animation for portraying patternless non-idiomatic technologies would seem limited.

Bill Buxton arrives at much the same conclusions as Ylirisky & Buur regarding the fidelity danger of being "*...sucked in by this fascinating craft, and in the process, losing sight of why you are using it. We are sketching interaction, not Toy Story*" (Buxton 2010, 299). Like Ylirisky & Buur, however, Buxton does not discard animation all together, but proposes the adaption of rough animation techniques, such as Terry Gilliam's cut-out techniques in 'Monty Python' and the stop-motion style of 'South Park'.

Figure 15: Still images from 'Monty Python and the Quest for the Holy Grail' and 'South Park: Bigger Longer, Uncut' - both examples of simplistic and cruder animation fidelities than that of Disney studios.

In the end, Buxton does not present a clear proposal for a sketching approach for animation but acknowledges that early on in the design design process, the focus is typically to explore different alternative proposals, rather than refining one single design in program code. Following this, as long as animation can be appropriated to be cheaper and faster to get feedback from, than implementation in code, it is potentially a valuable tool in design.

Approaches for improvising artifacts and services include the use of props (Brandt et al 2012) or the body (Oulasvitra et al 2003, Arvola & Artman 2006). For instance, Binder's (1999) improvised scenarios were shot in context with a consumer grade camera and props in cardboard and foam. Mackay et al (2000) deployed a technique called "video brainstorming", which lets designers present proposals in a more vivid and memorable way writing design briefs. However, without the layer of artificially created motion and effects provided by animation, the ability to explore emergent non-technologies is somewhat limited due to the limited simulative ability of the video medium per se. This also constitutes a limitation of its sketching capacities.

LESSON LEARNED

Video can be utilised throughout the design process - but without animation, the portrayal of not yet existing interactive designs are limited to props and enactments without formal design elements.

Animation has previously been used in design visions - but with production qualities beyond what is viable in design sketching.

These insights present us with two interesting unanswered questions: ***Is animation at all suitable for use outside big budget future visions?*** Further, if it is suitable, ***how can we appropriate animation to explore future scenarios with non-idiomatic technologies without spending more resources than it would take to build a functional prototype?***

We need to address these two questions, establishing animation-based sketching as a distinctive way of reducing uncertainty in the design process and as something that is qualitatively different from video sketching and video prototyping (but which might be combined with them). In order to so, we must take a step back and reflect upon the specific qualities of animation. The contributions we have reviewed so far have not touched upon how animation differs from video, other than its ability to create ‘special effects‘. This is too limited if we are to understand the role of animation in design sketching. Consequently, in our attempt to develop a more sophisticated understanding of animation-based sketching, the next chapter details the history of animation as a concept and grounds the various definitions of animation.

CHAPTER 4: ANIMATION - THE ILLUSION OF LIFE

In this chapter, we discuss what animation is and what it is not. This discussion includes a basic ontological description of studies of animation. The chapter presents previous arguments and debates about the nature of animation and attempts to free these arguments from the common preconception that associates animation with animated storytelling and film-making. This association has resulted in a blurring of definitions. The goal is therefore to identify a concept of animation that is ontologically precise yet still sufficiently open to include broader applications of animation such as design sketching.

We draw on the review to define animation as the process of deciding and manipulating the differences between a set of graphical positions with enough difference between them to produce a sequential illusion of apparent motion or change.

We further investigate how animation-based sketches must adhere to 'second order realism', adhering to the ontological laws of reality to some extent but not attending to too much detail in orthodox physics. Animation-based sketching will be categorised as a 'developmental' genre of animation placed between the orthodox and experimental genres of animation.

We conclude the chapter by reviewing experiments in facilitating formal learning by using animation. On the basis of these studies, we argue that animation generates more information than static imagery due to its temporality: pacing, rhythm and audience anticipation add more to the sum of the animation than the sum of the individual frames per se. Furthermore, animation can provide novices with the means to mentally simulate the future implications of a system. This is the scope of animation-based sketches as a means of visually communicating proposed concepts.

THE SEARCH FOR TEMPORAL EXPRESSIONS

The term 'animation' originates from the Latin word 'animatio', meaning *'Action of imparting life'*, or *'A bestowing of life'* (Wells 1998). The word *'anima'* is also familiar from Latin: it is a noun meaning *'soul, spirit or life'* from the verb '*animare*' meaning '*vitality*'. Most people today understand animation in terms of cinematographic animation, which stems from 1912 and describes a specific technical process (Wells 1998). The derivatives of the verb *'to animate'* are *'animates, animated, animator, animating and animation'*. Wells noticed that the verb is currently used in a variety of situations apart from the action of creating a cartoon. For instance, the term 'animatic' is frequently used by practitioners to describe a visually presented *'timed storyboard'*, but animation can also include static layout drawings or animated 'key poses' in a static sequence. At the other end of the spectrum, the term 'animatronic' is used to describe 'puppets' that are controlled electrically, electronically, mechanically or pneumatically to emulate life-like movements (Wells 1998). The uses of animation vary greatly and indicate that the concept of creating change or motion in the inanimate covers a range of actions that is much broader than merely making drawings into cartoons.

From cave paintings to mechanical creating of apparent motion

The ability to give life to the inanimate and to grasp the temporal nature of reality has been valued throughout the ages of human civilisation, thus considerably predating the live action film. In fact, some early palaeolithic cave paintings from the last ice age apparently attempt to capture the phenomenon of motion in still drawings, where the limbs of the depicted humans and animals are portrayed in multiple sequences of superimposed positions, suggesting an attempt to convey the perception of motion (Curtis 2006).

Figure 16: Early cave paintings (Curtis 2006), depicting hunts of bisons. The multiple drawn legs in different positions has been interpreted as early attempts to portray motion.

A famous example of early attempts to convey motion is the Ibex goblet, which dates more than 5.000 years back (Bendazzi 2015). The goblet has five images depicting a Persian Desert Ibex eating leaves from a tree, by jumping and down.

Figure 17: The artwork from the Ibex goblet drawn out in a cartoon like strip to show the clear expression of the ibex's action taking place over time.

While this series of images and similar examples from other ancient cultures are not animated motion, they indicate a clear early ambition among human cultures to be able to portray the temporal aspects of phenomena.

In the late 19th century, renewed interest in creating motion in the inanimate was spurred by the development of photographic film and the ensuing optical experiments with light and human visual perception (Bendazzi 2015). Devices such as the phenakistoscope, zoetrope, praxinoscope, and the common flip book became experimental audience spectacles by creating the illusion of movement from a sequential drawings. In 1892, Charles-Émile Reynaud's 'Théâtre Optique' allowed him to present his animated short 'Pauvre Pierrot' in Paris (Reynaud 1892). It was the first time animated motion had been projected onto a screen, not trapped inside the illusory device itself.

Figure 18: The Théâtre Optique by Reynaud (left), the playback device used to render the animated cartoon 'Pauvre Pierrot' (right) in 1892.

In the following years, the development of the first real motion picture projectors, the art of film recorded animation, and the principles for creating animations developed in tandem with the new movie industry, sharing many of the same storytelling and visual language techniques (Wells 1998).

The gestalt foundation of apparent motion

In 1912, Max Wertheimer's seminal work provided the foundation for creating the perception of motion - making the inanimate come to life. Wertheimer uncovered two different aspects of motion perception: *Beta movement*, and the *Phi phenomenon* (Wertheimer 1912). Beta movement occurs when images are shown in quick succession and the brain registers a difference in the images as movement. Wertheimer showed that the optical illusion due how the eye's optic nerves responds light 10 times per second, and that changes twice this speed are perceived as being in motion, and not as separate images. The phi phenomenon is related to beta movement, but it only exists at higher speeds of changing lights in which we perceive constant movement instead of a sequence. If images are shown changing at a fast enough rate, the brain supplies information that is not there and produces the perception of constant flowing motion. This is what gestalt psychology labels 'apparent movement' (Wertheimer 1912), and is a product of these two illusory forms of visual perception, and together they are the fundamental mechanisms behind animation and projected movie film. Whenever we refer to animation in the remainder of the book, we are talking about the application of beta movement and the phi phenomenon in creating the illusion of movement over time. Taken alone, however, this gestalt psychological explanation of how animation works has proved inadequate as a definition of 'what animation is' in the discourse of studies of animation.

LESSON LEARNED

Animation is the ambition to artificially create apparent motion and change - enabled by the gestalt phenomenons of beta movement and and phi phenomenon

The remainder of this chapter therefore explores various attempts to describe animation and discusses them in relation to a definition of animation that is applicable across multiple sites of study. First, we will examine the identification of a 'medium that is specific for animation'.

MEDIUM (IN)SPECIFICITY OF ANIMATION

Much of the power of an idea is inherent in its representation (Victor 2012), since the representation enables us to think the idea - and to think with it. Representations require a medium to carry them, and the production of powerful representations and powerful mediums for representations is among the main drivers of the intellectual development of humanity, allowing us to 'think bigger thoughts' (ibid). If we follow the notion of the 'illusion of life' or even just 'apparent motion over time' as the ambition for the representational capacity of animation, the next challenge involves pinpointing a medium that is specific for animation.

The history of animation indicates that this art form can exist in almost any kind of medium. The illusion of apparent movement can be achieved using clay, paper drawings, cut-outs, puppets, pixelated humans, or digital 2D and 3D. In this regard, Walt Disney's notion of animation as the conceiver of everything we could possibly imagine seems reasonable – the only restriction on animation is the capacity of the mind that is creating it.

Figure 19: Multiple techniques used for animation. Claymation (top left), Motion capture (top right), Stop motion (bottom left) and pixelation with the human body (bottom right)

As a consequence of the breadth of enabling mediums, it makes little sense to claim one medium as being specific to animation. That is, unless we follow the popular notion of animation being seen as equivalent to animated film. In that case, the computer would today be the medium of animation. Almost all animated films today are created using computer animation in some instance. But before the development of digital animation, animation used to drawn, and then transferred to film perforation. Thus, even the recording medium cannot be defined as the specific medium of animation. Thus, history teaches us that it might also be unwise to claim the computer as the specific medium of animation, since it too might be rendered obsolete by new enabling technologies for animation.

The attempt to define the medium of animation seems to be dead end. Animation can be done with both digital, as well as analogue means, from advanced software to flipping pages of paper. If the beta movement or the phi phenomenon can be created, animation can be realised in an moving piece of material.

It may be more fitting to address animation by leaning on Brian Wells' (2011) principle that animation is always a visual form of communication; that is to say, we cannot imagine animation without some sort of visual expression being manifest. From this point of view, animation encompasses all types of visual expression and does not involve a sense of been rooted in one specific medium. This should properly be considered one of the strengths of animation if the ambition is to harness it to explore the potential of technologies and user experiences which do not yet exist. As a collection of possible visual expressions, animation is a way to represent the previously unrepresentable by manipulating time and motion via the visual medium best suited for communicating the specific idea.

ANIMATION IS NOT MOVIE GENRE

An often-repeated preconception in many animation studies is the suggestion that animation is a movie genre (Wells 1998, Furniss 1998, Israel 2007). A genre exists within a certain form of expression. For example, several genres exist in literature: crime drama, adventure, romance, science fiction, etc. Painting includes portraits, landscapes, still life, etc. Live action cinema comprises westerns, soap operas, war pictures, etc. "Genre" is a very broad concept, and we will not attempt to review the concept in all of its variety in this book. In very simple terms, however, a genre can be seen as a deal between the manufacturer and the user, that is, as the users' guarantee that a specific product will satisfy some of their specific requests (Devitt 2004). If the user wants space ships, aliens, and far-away exotic planets, the user selects a science fiction movie. If instead the user wants to be scared and thrilled, the product requested will be a horror or thriller movie. The familiar idioms of specific genres mean that genres are repetitive and therefore reassuring for the user. In that case, animation is not a genre of movies in itself, but a style of filmmaking that can encompass as many genres as live action.

Many genres exist within animation, and thus we will not treat animation as a genre or macro-genre but as a separate style of production that is related to live action production. To some extent, animation uses the visual language of live action cinema as novels use words. Animation conveys meaning and communicates abstract ideas such as emotion and experience, and it does so over the course of time by representing lines, shapes, colours and symbols - giving pace, rhythm and anticipation through apparent motion (Block 2007). Together with, or with absence of, sound, it can represents ideas an evoke emotions in the viewer, crafting an experience.

Live action cinema captures an image of reality that closely relates to what we see in our everyday lives, in a more or less extreme variant. In contrast to this relatedness to everyday life, animation can abstract concepts in a form that could not exist in the physical world. Through aesthetic and functional choices, the animator is able to condense, enhance, and even exaggerate meaning. For example, the use of a certain colour palette and rendering of iconographic characters can break the barriers of what we normally perceive as reality and open our minds to assimilate ideas in a different way. This is what animation inherits from the classic cartoon comics: 'amplification through simplification' (McCloud 1994). When we abstract the idea of a concept in a simpler animated representation, we are not so much *eliminating* details as focusing on *specific* details. Stripping down a representational style to its essence amplifies the meaning in a way which realistic live action cannot achieve. With the gestalt manipulation of time and motion, this amplification becomes even stronger, since it is not only the details of the multiple states of a concept which are amplified, but rather the entirety of the transitions between the states (Buxton 2010). Brian Wells sees this in terms of a principle of consistency in animation:

> *An animated performance must remain absolutely consistent, exactly as its creator committed to creating it, throughout all viewings and screenings. If the animated performance changes in any way, from how it was initially created, the artistic integrity of the animated performance is lost, and the animation has the potential to be interpreted very differently than how its creator(s) intended.*
>
> Wells 2011

While clearly aiming to characterise the artistry behind animated film, Wells actually communicates an important point about the *communicative intent* that is present in all animation. If animation is *always* apparent motion created with a specific intention, this indicates that while animation may not be a specific genre, it cannot escape the communicative intent of the author.

Since the viewer can focus upon more specific representations, animation helps the viewer to process the depicted without being closely attached to 'real' world. This relates to a point made in our introduction: Stephenson's (1973) key difference between animations and classic film is that animation offers the producer the ability to exercise near full control of the material matter. As well as being a strong representational style, animation also involves multiple mediums.

We argue that this is what places animation in a strong position to eliminate the prejudices which people lodge in reality and the present state of world, thereby enabling the representation of different perspectives on the future. However, we still do not have a clear basic definition of 'what animation is', which continues to challenge our ability to precisely articulate the expressive capacity of animation.

ANIMATION IS NOT JUST ANIMATED FILMS

One of the first attempts to subject animation to systematic academic scrutiny was Donald Crafton's book *Before Mickey* (Crafton 1993). Crafton made the important claim that instead of looking at modern animation as a remediated cartoon strip, we should seek the 'modern' in the experimentation with special effects and trick photography of pioneers such as Georges Méliès. Furthermore, Crafton was one of the first authors to critically analyse the way in which many of the popular ways of understanding animation relate more to applied production techniques than to the inherent qualities of animation. That is to say, animation studies often analyse the specific aesthetics rendered possible by a given technique, but they rarely analyse the foundation underlying the use of apparent motion in the first place. Despite Crafton's work, this fallacy of relating description animation to its 'specific' technology or production method was carried over into some of the first academic attempts to define animation. For instance, Small & Levinson (1989) defined animation as simply 'frame-by-frame recording' or 'single-frame cinematography' (Small & Levinson 1989, 68). Charles Solomon formulated a contemporary definition, stating that animation is special due to 'the illusion of motions created (designed) rather than recorded as in live action film' (Solomon 1987). Besides focusing on the production technique, both of these definitions fall into the trap of defining animation by how it compares to live action film; in essence, this amounts to a definition which is based on what it is not. In line with both Small & Levinson and Solomon, the acclaimed animation researcher Paul Wells falls into the same trap in presenting his working definition of animation: *"it is film, made by hand, frame-by-frame, providing an illusion of movement which has not been directly recorded in the conventional photographic sense" (*Wells 1998*,* 1).

There are a problems with such definitions of animation as being the non-recorded illusion of motion and as frame-by-frame production. On the production technique side, these definitions are simply too limited in terms of modern animation techniques. For example, computer animations creating the illusion of motion are not animated frame-by-frame, but rather through a set of variables and keyframes which automate the creation of motion. We shall address the issues of computer animation later in examining the creation of digital animation-based sketches, but for now this critique should indicate how the previous definition fails to include computer animation in its scope.

Brian Wells gets around this problem by adding yet another principle to his descriptive analysis of animation. As Wells notes,

> *"Animation is comprised of a sequential set of still images, each recorded for a discrete unit of time, and these discrete units of time are displayed in relatively rapid succession in order to achieve the illusion of lifelike movement or change. "*
>
> Wells 2011

Wells modifies the limitation inherent in the definitions provided by Small & Levinson and Solomon by simply stating that while animation does indeed consist of a sequence of still images, they have not necessarily been recorded frame-by-frame, but rather in a *discrete unit of time.* This means that the production technique of animation can vary, as long as the output can be displayed in succession to achieve apparent motion. However, as Wells argues, this is also partly true of live film footage. This leads him to adopt the perceptual concept of ‘short and long range apparent motion’ from Anderson & Anderson (1993), in which ‘long range’ describes the fluent nature of ‘real’ motion, and ‘short range’ describes the way in which animation, no matter how detailed, will always appear somewhat disjointed compared to reality.

As already mentioned, there is a broad area in which live action and animation overlap, especially in terms of aesthetics - for instance, cuts, angles, and light setup. Rather than seeing the two as existing in separate categories, Maureen Furniss (1998) argued that it would be more accurate to think of them as placed in a continuum. This continuum would represent all possible types of images as ‘motion picture production’. At each pole, the continuum uses more neutral terms than ‘animation’ and ‘live action’, replacing them with ‘abstract’ and ‘mimesis’. Mimesis represents the desire to reproduce natural reality, and abstraction describes the use of proto-forms, thus suggesting a concept rather than an attempt to explicate it in real form. The placement on Furniss’ continuum is somewhat arbitrary - there is no one specific spot for a specific example to be, but rather a relation between different placements.

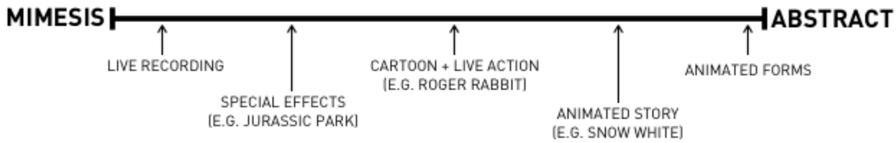


Figure 20: Furniss’ (1998) continuum of moving picture types, ranging from the purely mimetic, to the purely abstract artificially apparent motion of abstract forms.

The difference between a continuum and a hard definition is that the continuum uses similarities to position items in relation to one another, while a definition seeks differences to separate items from each other. Furniss’s goal is an aesthetic view of animation, which is why the continuum approach works. For instance, the continuum helps to show the relation between the use of animated special effects in a live action movie such as ‘Jurassic Park’ and the animation of a cartoon such as ‘Bugs Bunny’. While this is a great strength, and while the continuum will be revisited later in this book, Furniss still implicitly distinguishes between real live action and the artificially animated. Thus, the continuum still relies on the reader’s ability to understand when something is animated and when it presents live recorded events. We still need a fundamental definition of animation that can fit into Furniss’s continuum but is independent of the production techniques used, thus accommodating both classic frame-by-frame manipulation and modern computerised animation.

MOVEMENTS THAT ARE DRAWN - OR DESIGNED?

In the 1950s, animation veteran Norman McLaren offered what has become one of the most quoted insights into animation. He suggested three defining characteristics of animation:

> *"(1) Animation is not the art of drawings that move, but the art of movements that are drawn. (2) What happens between each frame is much more important than what exists on each frame. (3) Animation is therefore the art of manipulating the invisible interstices that lie between the frames."*
>
> Quoted in Sifianos 1995, 11 - my added numbering

There is a significant depth in McLaren's way of describing animation. First, while he points out that animation happens during the 1/24th of a second between the frames of film, he is also referring to the way in which human perception quickly integrates, evaluates and communicates the most subtle changes in time and space. The properties of animation that McLaren notices provide the animator (or designer) with the almost magical ability to simultaneously control both time and space and to use them as media for creative expression.

Furniss, Wells and Solomon quote McLaren's notion of animation, but they develop their definitions or categorisations in directions that diverge from McLaren's original statement, perhaps because the anecdotal nature of McLaren's statement remained outside any academic or even popular publication. However, on the basis of correspondence with McLaren in 1995, George Sifianos published an in-depth explanation of McLaren's characterisation (Sifianos 1995). First, Sifianos corrected the notion that 'a drawing' could be interchangeable with any kind of 'moveable medium', and the idea of drawing motion is even partially discarded as being yet another 'definition based on production technique'. The essential quality of the first characteristic, however, is that it frames motion as the essence of animation, independent of the drawing medium or technique. Motion or change as the essence of animation is further elaborated in McLaren's second and third characteristics of animation. The real essence, according to McLaren, is expressed in the second and third defining characteristics, which state that the most important characteristic of animation is the way in which the animator moves the figure between each frame. This is a slightly different definition from the type proposed by Solomon and Small & Levine, since, like Wells principle, it does not limit itself to frame-by-frame recording; instead, it addresses the decision making process regarding what needs to happen between a succession of frames. As such, it constitutes a definition not of the practice of animation, but of the essence of animation.

McLaren's characteristics encompass five basic categories of animated motion: (1) zero motion, (2) constant motion, (3) accelerating motion, (4) decelerating motion, and (5) erratic/chaotic motion (Sifianos 1995, 64). The animator has to decide how much to move between shooting one frame (or sequence of frames) and the next. In McLaren's words, that critical decision is 'the heart and soul of animation'. The difference between each successive frame is to the animator a more essential aspect, than the graphical expression (the graphism) on each individual frame. Animation, therefore, is *"the manipulation of the differences between successive frames' constituting the animator's operation"* (Sifianos, 1995, 66). This effectively provides a definition of animation which is not tied to the notion of animated film, which does not conflict with modern animation practices using digital computer animation, and which is strict enough to constitute a fundamental quality, while still being broad enough to fit Furniss's notion of the continuum between mimesis and abstraction. It also indicates that 'motion' and 'change' are both properties of animation. A thing can move according to McLaren's movement categories, but it may also erratically change; for instance, it might simply disappear. The succession between discrete units of time in animation is thus not just movement, but all kinds of change manipulated between the frames.

McLaren's final definition also makes an important ontological distinction between creating artificial motion or change and creating artificial expressions - what McLaren calls 'graphism'. This division effectively helps us to understand animation as the process of artificially producing motion or change, while, depending on the expressive material, it falls to other disciplines to construct the imagery that is to be 'moved'. That is to say, designing animation, and designing graphics, for example, are not the same thing. Consequently, the quality of the temporal sequence must be assessed independently from the quality of the visuals. Moreover, 'designing motion or change' is the essential design craft of animation. Animator Richard Taylor noted that *"It is possible to make a bad film with beautiful drawings or models - the art of animation is in the action"* (Taylor 2003, 7).

Drawing on Sifianos's published conversation with McLaren and the critique of medium-specific or genre-specific definitions, we suggest a broad definition of animation and the creation of apparent motion:

ANIMATION IS:
The process of deciding and manipulating the differences between a set of graphical positions, with enough difference to produce an sequential illusion of apparent motion or change.

This working definition of the fundamental essence of animation will be our point of reference as we move towards pairing animation with design sketching. To stay true to the sources from which we gather new perspectives in our further review, we continue to use the eclectic mix of the concepts of 'animation', 'animated film' and 'animation genre'. In doing so, however, we use a definition based on McLaren's, and we do not attempt further approximations to the concept of animation itself.

FEATURES FROM CLASSIC ANIMATION IN ANIMATION-BASED SKETCHING

The first step in defining animation-based sketching as a distinctive approach is a discussion of how the traditional studies of animation might inform a design sketching perspective. Thus, we start by expanding on our established definition of animation and examine which aspects of traditional animation are inherited by animation-based sketching.

Thompson & Johnson argue that the use of abstractions of reality in animation adheres to the aforementioned principles of 'amplification through simplification' (McCloud 1994) by tapping into the basic encoded visual language of human beings. They refer to this as the (potential) ability of animation to reach almost any audience, regardless of language barrier: communication through animation is based on the symbols that all human beings can understand because they go back before we developed speech.

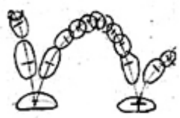
According to Thompson & Johnson, the universality of the visual language of animation is the basis for Walt Disney's famous note about the expressive capacity of animation:

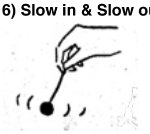
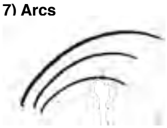
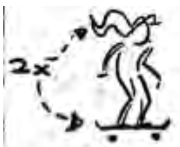
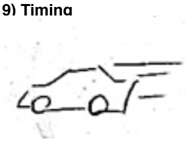
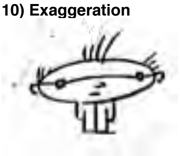
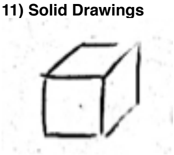
> *"Animation can explain whatever the mind of man can conceive"*
>
> Walt Disney in Thompson & Johnson 1981

Disney's notion reflects the ambition to position animation as the centerpiece of imaginative expression. This ambition helped transform animation into a significant industry. Unlike live action film, animation is more unrestricted, and draws from a raw material that is essentially entirely made up. It is the how animators imagine and combine ideas about the forms, movements and meaning of things constitute animated expression (Bendazzi 1994). Animated films create a narrative and visual space, that are potentially very different from what live action would portray. Whereas live action films seeks to present physical reality, the ambition of the early animation industry seemed to be to deal more with a meta reality. That is not, how reality looks, but what it means. The animated film here connotes escapism and unambiguous visual emotions (Wells 1998).

Unlike live action storytellers, however, the animator faces the challenge of capturing the subtlety and aliveness of an artificial reality via symbols that are culturally related to the emotions and actions depicted. Issues often arise which are difficult to formalise, such as the representation of the chemistry between actors. In live action, the canvas is never blank as it is for the animator. In the pioneering work of the Disney Studios, this 'abstraction gap' was overcome by leveraging what Disney labelled 'audience involvement' (Johnston & Thomas 1995). When telling a story, regardless of how abstract the story would end up being, the animator would start with something the audience knew, liked, and could relate to in using their experiences as human beings to fill out the gaps in the abstraction. Consequently, the animated product would seem to come 'alive' and appear 'real' through the indexical link between real world experiences and imagination. Early pioneering film-maker Sergei Eísenstein recognised Disney's achievements in animation as achieving a particular effect: *"...if it moves, then it is real - moved by an innate, independent, volitional impulse"* (Leyda 1988, 54). This aliveness gave animation its particular enigmatic quality of creating 'the illusion of life'.

The early contributions of Disney studios (founded in 1923) helped create the foundation for the entire animation industry, cemented by the first full length animated feature film, Snow White (Cottrell et al 1937). Even though Disney Studios had already experimented with the scope of animation, it soon became fixated on verisimilitude in its productions, conforming to a mode realism concordant with that of live- action film-making (Wells 1998). Johnston & Thomas (1995) recount the early history of Disney studio as Walt Disney's search for established principles or idioms of apparent movement to establish animation as an art form on a par with live action movies. This is what Paul Well's (1998) called the ambition of *hyper-realism*, which, due to the success of the Disney studio, defined the orthodox genre of animation. Through Disney Studio's accumulation of experience, the complex process of creating 'the illusion of life' was gradually condensed into specific principles. Johnston & Thomas (1995) elaborate them in their summary of the '12 principles of animation', which they describe as a reflection on the practice from Disney's animation process, developed from earlier prototypical and less life-like principles (Johnston & Thomas 1995, 48)

1) Squash & Stretch 	"Squash & Stretch" is often seen as the most important principle, it describes the illusion of weight and volume of an object, and defines how rigid an object it, by how its volume is affected by movement. Squash and stretch is especially useful animating dialogue and movements of the face. The extent of squash and stretch is affecting many of the other principles, since this foundational physic invokes much of the more emotional animated expressions.
2) Staging 	Staging is not in itself about movement. It involves presenting the animated scene so that is unmistakably clear to the audience where it should direct its attention. In animation, this principle has been essential to establishing correct perspectives, light, and field of views for the actions to be perceived as intended.
3) Anticipation 	Anticipation means preparing the viewer for actions about to happen, such as initiating a jump, speaking or waving. Once again, this principle is not related directly to the creation of apparent motion; it guides attention. Whereas staging is about the entirety, anticipation is about the specifics and finer details.
4) Straight Ahead & Pose to Pose 	This principles is actually two different approaches to the production of animated graphics, and thus not principles of movement themselves. With "Straight ahead action" the scene is drawn out from beginning to end, and in "pose to pose" so-called key frames are drawn to define positions, an the 'in-betweens are then filled in later.

5) Follow Through & Overlapping 	These two techniques address motion physics, especially motion inertia. "Follow through" describes how parts that are loose continue to move after the object stops moving. "Overlapping action" is describes parts of an object that move differently, depending on the center of gravity.
6) Slow in & Slow out 	Time is stretched to emphasise actions or to make actions adhere more realistically to the physical laws of acceleration and deceleration. As an action starts, more positions are drawn near the start, with few in the middle, and more positions right before the next pose. The amount of positions determine how fast or slow an action is.
7) Arcs 	Most motion in reality follows arched trajectories; this principle involves recreating such arcs artificially. This principles is another physics oriented principles, urging the animator to analyse the nature of the object animated in order to make the motion adhere to ‘implied’ arcs of motion, e.g. by joints or parabolic trajectories.
8) Secondary Action 	This principle involves showing the action of and object resulting from another action. This is linked to anticipation and staging as it involves linking different points of attention for the audience. Critically, secondary actions should emphasise the main action rather than take attention away from it.
9) Timing 	Timing has to levels in animation. Physically, timing is about how an object adheres to the laws of physic - e.g. how weight affects momentum. Dramatically, timing prepares and delivers actions by adjusting them in accordance to the ‘personality’ of the object represented.
10) Exaggeration 	This involves accentuating the essence of an idea by the animated action. It often exaggerates timing and the geometric deformation of objects. Since exaggeration can greatly affect the style of an animation for dramatic and comedic purposes, this is one of the most variable principles of animation.
11) Solid Drawings 	Solid drawing states that the 3-dimensional space representable through graphical forms must be taken into account. Thus, this principle concludes the physical principles by emphasising the role of perspective in the graphics of object appearance.
12) Appeal 	An actor can be said to have charisma. An animated character (or object) has appeal. Characters have appeal whether they are heroes, villains, comedic or sad. This principle essentially denotes that all animation will have some sort of appeal, and thus states that a certain view of that appeal should be enjoyable (Thompson & Johnson 1981, 68)

Evident in the 12 principles of animation is a clear division between principles which establish how to animate in a life-like manner (1, 4, 5, 6, 7, 9 and 11) and principles which emphasise the emotional design of likeable characters and the aesthetic appeal (2, 3, 8, 10, and 12). Thompson & Johnston recognise this division in their description of how the exploration of characters and objects essentially is *"...to make the audience feel the emotions of the characters, rather than appreciate them intellectually"*. In film and in any type of storytelling, realism is relative and subjective (Wells 1998, Bordwell & Thompson 2010). The film-maker shows so-called subjective realities more persuasively while grounding this representation in photographic realism as its clear indexical link to reality. To a great extent, Disney studios aligned animation with this realism and only partially considered the more abstract qualities of animation to create the artificial illusion of motion in all its possible forms.

Wells has related this characteristic to Umberto Eco's notion of '*hyper-realism'* (Eco 1986): it is fake due to the that it does record reality with a camera, but artificially creates its own. Viewing the 12 principles of animation as principles for hyper-realism has a range of consequences, evident in how Disney, and other studios who emulated the studio style informed their animation process. For example, the design, characters, contexts and actions had to be subject to the ontological laws of 'the real world' to some extent, and they therefore corresponded to the representation of reality in live action films. Further, the creation of movement itself had to correspond to the possibilities inherent in orthodox physical aspects of human beings and objects in reality. Wells also argues that despite these links to the ontology of reality, hyper-realism is neither a strictly accurate version of reality nor a radical abstraction of the animated form, but rather what he labels a 'second-order realism' (Wells 1998, 27). In this sense, it might be argued that despite Disney's hyper realistic ambition, animation always avoids and resists realism, and thus can more accurately be said to be 'about realism'.

As such, animation plays a rather metaphysical role in portraying ideas. Whereas the fundamental goal of live action films is to present physical reality in real or imagined forms, animation is concerned not with how things are or how they look, but with what thing could be and what they mean. Thus, the domain of animation-based sketching has inherited from Disney's hyperrealism the recognition that while we orientate the animation of our ideas towards the reality of our world, an animated sketch will, to a certain degree, always constitute a 'second-order realism'. This implies that while we need to address the ontological laws of reality, we need not necessarily prioritise strict adherence to the orthodox movements and physical aspects of objects.

On the basis of Wells' analysis, it may be argued that following the success and maturation of animation through Disney's work in the late 30's, hyper-realism became the dominant discourse of animation to the point where Disney's animation principles were nearly synonymous with animation. Wells labels the genre of hyper-realism in animation 'orthodox animation' and compares it to more art-based and abstract 'experimental animation' in his final framework of animation:

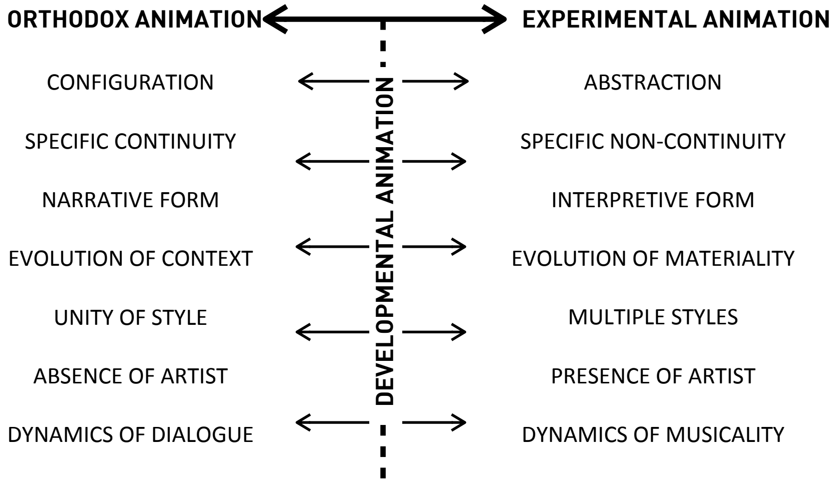


Figure 21: Well's division of animation genres set between orthodox and experimental animation, whereas the orthodox genre corresponds with the left half of Furniss' (1998) continuum, and the experimental with the right half of the continuum's abstract style. In the middle, Wells places developmental animation as a combinatory genre, which combine, and mix multiple styles of both orthodox and experimental - a fitting match for animation-based sketching?

Wells adds an interesting division between the two. He proposes a middle-ground which he labels 'developmental'. This middle ground leverages selected aspects of both domains in a flux that informs the evolution of principles for both orthodox and experimental animation. As stated by Wells, *"Developmental animation, by definition, harks back to traditional aspects of the animated film but also seeks to embellish or reform these traditions with contemporary approaches"* (Wells 1998 51). This category seems to be the obvious ontological space in animation studies to place animation-based sketching. Animation-based sketching as a 'developmental animation' approach illustrates, for example, how the approach might combine multiple styles and mix narrative and interpretative forms without the need to supply a specific genre label or to stipulate a specific medium.

However, we must not forget that Wells' framing is rooted in his definition of animation as something that is tied to 'film'; some aspects of the framework will be ill-suited for distinguishing animation in general. What the framework division does show us, however, is that throughout its evolution, 'traditional' animation used for entertainment or art has been influenced by both orthodox and experimental ways of addressing motion. This helps us draw a line connecting the earliest examples of developmental animation to the ambitions inherent in contemporary animation-based sketching.

Early developmental animation was used by the likes of Georges Méliès. Méliès used animation combined with live film to create ‘original effects’ (Wells 1998) which were outside the physical reality of our here and now but which to some extent still sought to conform to the basic ontology of reality. His now famous ‘Journey to the Moon’ (Méliès 1902) is a classic example, showing the potential of space travel on the basis of the technological and astronomical knowledge at the time, long before it become a reality. A similar example was one of the earliest uses of cartoon animation in Winsor McCay’s ‘Gertie the Dinosaur’ (McCay 1914), in which McCay appears to enter the film from the physical stage, thus providing an example of what would become a continuing discourse between animation and live-action film in the early years of the medium.

Figure 22: Stills from early pioneering films. Méliès ‘Journey to the Moon’ (left) using early stop motion cutting techniques, and Mckay’s ‘Gertie the Dinosaur’ simulating a mix of live acting and cartoon animation (right)

These early examples of animation showcase the fundamental developmental ambition of early animation to expose the limitations of representing ‘reality’ on film and to use animation to free itself from these limitations in portraying ‘the seemingly impossible’. This idea is backed by Holloway’s (1972) reference to the Zagreb school of animation and their idea of animation as “*a way of giving life and soul to a design, not through the copying of reality, but through the transformation of reality*”. The early developmental movements in animation thus emerged as a representational tool to think and reflect about artificial phenomena that we would be unable to understand without the temporal information from animation. With this in mind, we will argue that, since its earliest development, animation has actually been a movement that correlates with the ambition of design sketching: it creates information about the world which did not exist before so that we can explore it and reflect upon it. Animation adds a layer of temporality to artificially created graphics, and, as Fallman & Moussette (2011) point out, it creates vital information about crucial aspects of the interactions and dynamics of the design of digital technologies.

Thus, animation-based sketching takes its cue from animation history and becomes the driver behind imagining ‘seemingly impossible things’ by drawing upon experimental qualities, on the one hand, and, on the other, by drawing on its orthodox qualities as the mediator connecting it to reality. The question is whether this expressive capacity is also able to facilitate and inform new design knowledge. In other words, can animation facilitate?

LESSON LEARNED:
Animation-based sketches must adhere to 'second order realism' - adhering to the ontological laws of reality to some extent, but not attending too much detail in the orthodox physics details

Animation-based sketching is to be categorised as a 'developmental' genre of animation

ANIMATION-BASED SKETCHING - A LEARNING TOOL?

The majority of research done on the facilitative capabilities of animation has not been conducted within the domain of design studies, but in the study of facilitating learning. Consequently, we review the contributions in this field and examine the conclusions drawn in facilitating learning in light of the ambition of using animation to facilitate explorations within the design domain.

Pictorial languages as facilitators

As we learned previously in this chapter, history shows that mankind has long had the ambition to portray temporal information, starting with the use of static images to showcase motion and dynamic concepts. Understanding artificially created imagery, or 'graphism' as McLaren (Sifianos 1995) called it, is therefore a fundamental part of understanding animation. This is due to the ubiquity and naturalness of graphic representations used to represent abstract concepts across cultures (Tversky et al 2002). Such *pictorial languages* can be found across the world and throughout the course of human history (e.g. Gelb 1952, Dege et al 2001, Mallery 1972). The manner of schematising people, animals, and contexts shows striking similarities across cultures.

The research into the role of static graphical elements as facilitative tools for learning is rather comprehensive, and has indicated that only carefully designed material can actually be beneficial (e.g. Tversky 1997, Larkin & Simon 1987, Scaife & Rogers 1996). The major division is between the use of graphics to portray inherently visuospatial information (a building, living being or any other material object) and to present what is metaphorically visuospatial (for instance, graphs, flows, and organisational charts). The assessment of graphical representations is based on the natural cognitive correspondence between the real world and the depiction - the way in which the pictorial language enables us to see a given visuospatial expression as the sign for something in reality. This is expressed in what Tversky et al (2002) label the *Congruence Principle* for effective graphics: *the structure and content of the external representation should correspond to the desired structure and content of the internal representation.* This principle indicates that the driver of graphical depiction is not the creation of realism, but the creation of a *runnable mental model* of the depicted (Mayer 1989), in which the depicted phenomenon can be distorted if this helps us to understand its essence.

Can animation facilitate learning?

Tversky et al (2002) suggest that according to the congruence principle, animation might be expected to offer a compelling way to convey concepts of temporal change, just as static graphics are natural for conveying space. However, the authors argue that this is not necessarily the case, and they set out to investigate whether animation facilitates better learning than comparable static imagery. They review a large selection of research on the use of animation in learning situations, including teaching of the water circulation (Large et al 1996), of Newton's Laws (Rieber 1990), electronic circuits (Park & Gittelman 1992), and mathematics (Thompson & Riding 1990). All the reviewed research claims that the animated content created stronger comprehension than the static imagery.

Nevertheless, Tversky et al criticise these conclusion for being based on what they label *'incomparable content in static and animated graphics'* (Tversky et al 2002, 251). As they see it, more information has been created and integrated in the animated material than in the static imagery, which could possibly also have expressed the information through further graphical details in the static images. They argue, that a lack of equal information in static and animated material makes it difficult to conclude whether it was the illusion of apparent movement and change which alone facilitated the higher degree of learning, or whether it was simply due to the addition of more information.

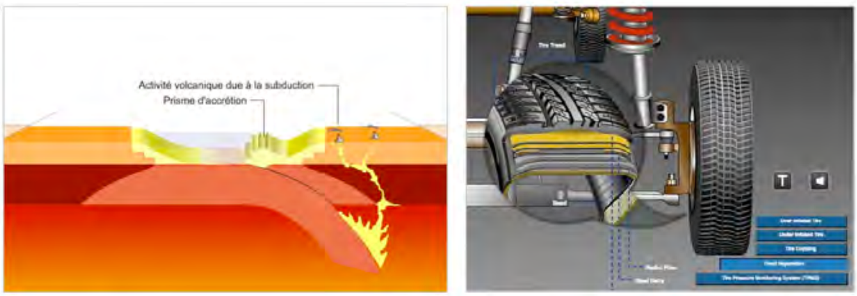


Figure 23: Examples of animations with the purpose of facilitating learning about dynamic phenomenons like plate tectonics (left) and tire mechanics in a car (right).

They add to their critique of the existing research by pointing out examples of how interactivity affects the role of animation when used to facilitate the learning of cistern systems (Hegarty et al 2002), algebra (Nathan et al 1990) and energy systems (Kieras 1992). They discuss how the studies confuse the effect of being able to manipulate variables and experiment with their predictions of how a given concept would work with the effect of animation. Rather than being attributable to animation, the improved learning outcomes of these studies might actually be a consequence of interactivity supporting superior study procedures, which is known to support learning independent of graphics (Schnotz et al 1999).

This leads Tversky et al to conclude that most of the reported successful application of animation in learning situations seems to be due either to extra information presented in animated content compared to the information presented in static forms, or to the addition of extra procedures. They therefore suggest that when the content and procedures are the same, animation might not prove any better than static imagery in facilitating learning.

They do not see this as a fault of the congruence principle, but as cognitive limitations in processing visual change. They label this the *apprehension principle: the structure and content of the external representation should be readily and accurately perceived and comprehended* (Tversky et al 2002). Animations are fleeting and not fixed in discrete steps as static images, and Tversky et al point out that when stripped of the extra information and interactive procedures, information conveyed in animated material disappears immediately after being presented, removing the ability to reinspect it.

Animation adds an extra layer of information per se

The analysis performed by Tversky et al paints a rather bleak picture of the potential scope of using animation for sketching purposes. Their critique indicates that animation might not provide any more relevant temporal information than we can already derive from static sketches. All is not lost however, since we will argue that while Tversky et al offer a comprehensive review, it might also be read from another perspective. The authors' primary point is that cases using animation in a learning environment often present better visualisation approaches than static imagery or that they employ superior study procedures such as interactivity. But does that not just state one of the obvious qualities of animation, and of temporal expressions as a whole? The superior extra detail of information in the animation can be related to McLaren's distinction between creating the artificial image and deciding *how much* it should move between each successive configuration. The artificial image itself is static, but combined with the (design) thinking regarding the extent to which it should be configured to portray the desired motion, it naturally conveys more information than could be portrayed in a single image. That is, to paraphrase Buxton (2010) and McLaren (Sifianos 1995), *the experience is in the transition between states.*

We therefore suggest that the argument that animation provides extra information is valid but obvious. Extra information exists in all animations, but this is simply an effect of the process of creating motion - it provides temporal information, which adds pacing and rhythm to the series of moving images. One might argue that such information could also be conveyed by adding more static images, that is more states, but it is not a natural part of the static sketching process as sketches involve key frames. By definition, however, animation integrates reflection about what happens between the states in the animation process, and this makes it more natural to express more information, which of course also increases the production time itself. But even if we drew all the frames of an animated sketch as static images, viewing the sketches would not provide the same temporal information as the animation. This is because browsing through static images cannot convey the pacing, rhythm and anticipation involved in watching something unfold over time. Of course, browsing between multiple states does have its own strengths, but it does not express the same temporal information as animation.

The second critique upon using interactivity, to overcome the apprehension challenge of animation, is viable to the extent that the digital system is based on interactive computing rather than on the animated content itself. However, a critique based on the apprehension principle is arguably too weak, since we can imagine animation being stripped of all unnecessary content to focus exclusively on the bare necessity of creating a running mental model. In fact, this has been a design principle of much animation since the work of Walt Disney himself:

> *"Walt Disney was basically a communicator, and in animated film he found an astounding potential for expressing his ideas. The cartoon drawing always had been a very simple and direct graphic form, and whether it was for social commentary or just amusement it had to present a unified, single ideas with nothing complicated, extraneous, or contradictory in its makeup. When cartoon was transferred to film these elements still applied, and nothing was drawn that was not part of the idea."*
>
> Johnston & Thomas 1995, 30

The apprehension principle of facilitative animated graphics stipulates that the content should follow the conventional graphic representation in the specific domain and should be stripped of all cosmetic features that are not directly useful for understanding. The critique of interactivity is also somewhat problematic when addressing a temporal expression which, as Brian Wells (2011) notes, is dependent on some type of playback medium. Playback mediums for analogue mechanisms, electronic appliances or digital software features always have the potential to give the viewer some control, with 'on' and 'off' as a minimum. However, features such as 'pause' and 'resume' frequently exist in playback mediums. Thus it seems artificial to require that this aspect should not be considered when evaluating animation in a facilitative setting.

LESSON LEARNED:

Animation generates more information than static imagery due to its temporality - the pacing, rhythm and audience anticipation adds more to the sum of the animation, than the sum of individual frames themselves.

In conclusion, it simply seems unreasonable to strip animation of these qualities: animation per se does generate more information, and does enable potential interactive features such as playback control. Such qualities could also be enabled in static imagery, but this is uncommon. Even with more images, static imagery would not be able to express pace, rhythm or sequentiality in the same way that animation does. Learning and instructional material might not always need this temporal information, since it makes use of established idioms instead of actually expressing the dynamics and temporality of the phenomenon. When exploring the interaction design and user experience of a non-idiomatic technology, however, we do not have this possibility; consequently we are in dire need of the temporal feedback offered by the animation-based sketch. Tversky et al, however, do end their paper with the caveat that other instances of animation might prove them wrong in their critique, and they add that, in theory at least, animation could be applied in accordance with both the congruence and apprehension principles.

Animated facilitation is best for novice learners

While we oppose Tversky et al's insistence on denying animation its extra layers of information and its ability to include interactivity by controlling playback, we do acknowledge the importance of their critical scrutiny of the way in which animation enables learning and their inclusion of experiments showing that animation might actually prohibit learning.

Mireille Betrancourt elaborates on this critique in presenting a set of principles for using animation in facilitative learning settings (Betrancourt in Mayer 2005). Like Tversky et al (2002), she is concerned that research into the effectiveness of animation in facilitating learning has given somewhat mixed results: the learning effects of animation ranged from highly beneficial to detrimental. Betrancourt adds an analysis of Catrambone & Say's (2002) study of the use of animation to facilitate the learning of computer science algorithms, in which animation is shown to have a positive impact on performance, but in which benefits disappear when the textual instructions were made more detailed. Drawing on further studies by Catrambone et al (1999) and Hegarty et al (2002), Betrancourt emphasises the role played by interactivity in cases where animation had a positive effect on the facilitation of learning. She expands on this notion by detailing how the benefits of using animation seem to be in correspondence with the learners ability to make predictions. In general, participants who studied using animation did not fare better than those who studied using text and image examples; however, when asked to predict system behaviour, the animation-based learners displayed a better understanding of the system. This indicates that the ability of animation to represent transitions between discrete states of a phenomenon is facilitative, in that it supports learners who might find it challenging to mentally simulate the future implications of a system from static imagery. This support is enabled by the combined effect of the temporal information generated by the animation and the interactive control mechanisms that enable learners to process the continuous flow of information, without being overloaded. That is, new temporal information about the dynamic system can be processed and integrated gradually into the mental model of the learner (Mayer & Chandler 2001).

However, as Betrancourt also notes, Tversky et al (2002) point out that these studies might not have monitored the control of the variables in their experiment thoroughly enough to isolate the specifics of animation very effectively. The conclusions drawn about the effectiveness of animated learning compared to static imagery are thus rather inconsistent. That is besides the effects interactivity can have on using animation to predict, and the fact that animations typically contain more information than static images. Betrancourt points to differences in learners' domain specific knowledge, and their visuo-spatial abilities as determinants which could be of high importance but which have scarcely been investigated (Betrancourt in Mayer 2005, 291).

Schnotz & Rasch's (2002) categorise on the basis of three functions which are attributed to animation in elaborating a mental model dynamic information: *enabling, facilitating* or *inhibiting*. Novice learners, or learners with low visua-spatial skill, are enabled in visualising dynamic systems mentally when supported by animation. Likewise, Mayers & Sims (1994) found that this benefit was mostly evident for novices, and less so for domain experts. For novices, the ability to mentally simulate and predict the behaviour of the dynamic system, the cognitive load is lower, and it is thus easier to form a 'running mental model' (Betrancourt in Mayer 2005). However, while animation supports the formation of said mental models, the cognitive efforts saved has been found to also potentially induce a more shallow understanding of the deeper content of the learning material - what Schnotz calls an *"illusion of understanding"* (Schnotz et al 1999; Lowe, 2003). In these cases, facilitation of the mental model is actually inhibited by animation. Furthermore, domain experts with well- informed mental models can rely on memory and experience to learn about new complex concepts within the domain, and thus benefits less than novices from added temporal information.

Lowe (2003) provides evidence on, how novices focus attention on what is perceptually dominant rather than on relevant domain features in the animated content. Betrancourt labels this the *attention-guiding principle;* animation is supported by clear visuals and interactive controls which guide the users' focus and enable individual pacing of the material. This relates back to the critical factor of the *apprehension principle* of effective graphics: the aesthetic features should all be conceived in relation to the domain and directed at the functional aspects of *what* the learner should gain from watching the graphics at any given moment. Betrancourt adopts this notion in a reinterpretation of the *congruence principle* for animation-based learning: *changes in animation should map changes in the conceptual model rather than changes in the behaviour of the phenomenon, even if this entails distorting the realism of the phenomenon* (Betrancourt in Mayer 2005, 292).

LESSON LEARNED:
Animation can provide novices the means to mentally simulate the future implications of a system, which is inferred as also being the scope of animation-based sketches as means of visual communication of a proposed concepts.

Effective facilitative animation is enabled by the attention-guiding, apprehension and congruence principles.

In the end, Betrancourt's perspective on the facilitative potential of animation in learning is more positive than in her work in Tversky et al (2002), even though her critique is inconclusive when it addresses the range of *when* animation can facilitate learning, and *for whom*. Nevertheless, her analysis indicates the clear potential of animation as a way of improving the understanding of dynamic phenomena involving temporal change. The principles of interactivity, apprehension, congruence and attention-guidance provide a guideline for avoiding the pitfalls that have been identified and may guide the establishment of running mental models via animation. However, while we have been able to learn much from these studies of the facilitation of learning by animation, the question remains - are these lessons transferrable to design?

Animation-based sketching is not animation-based learning - it is design!

The topic of discussion in this section has been limited to the role of animation in facilitating formal learning in complex learning systems, such as trajectories, transformations or relative motions. We suggest the term 'animation-based learning' for this type of animation, in which the facilitative aspect of animation is evaluated in terms of enabling learners to either remember, replicate or use the animated content to master a specific phenomenon.

This is rather different from how facilitation is predominantly understood within the domain of design. We follow Löwgren & Stolterman (2004) Nelson & Stolterman (2003), and Fällman (2003) in considering 'knowledge' the main 'product' of design. Design knowledge is primarily intended for other members of the knowledge construction culture to share, debate, challenge, extend, reject, and use. These members include designers, critics, clients, and users. The main purpose of facilitative tools and methods in design is thus to promote the construction of new knowledge rather than to assimilate or accommodate existing formal knowledge. Design as a practice never exists in the here and now. Whether the proposed state is a week or a year away, designers propose propositions what might come if following a proposed path. Thus, design is a contingent practice that operates on the boundaries of reality and, in the classical sense proposed by Simon (1996), attempts to explore its 'preferred state' version. Truth is not as crucial in design as in a formal learning paradigm. In design, an image of reality must be created to frame a foundation for the design process (Löwgren & Stolterman 2004). Since a design situation can be approached from many perspectives (ethical, functional, aesthetically, structural, material, experiential, and so on), a designer makes a contingent decision on what needs to be studied most carefully and on which dimensions of the situation should not be included in the framing. The main point here is that design intervention towards changing reality towards a proposed state. This type of agency is not objective: the designer includes some aspects and omits others from the frame.

We argue that this epistemological difference between animation-based learning and animation-based sketching should make us ask whether it is reasonable to transfer all insights from one field to the other. The principles of apprehension and congruence are transferable insofar as they determine how animation-based sketches should focus on only showing what is needed and allow distortion of the realism of the sketches if the distortion supports explorations of the underlying conceptual model. However they are not transferrable in the extend of the criticism of the divide between novice and expert learning, since the aim of animation-based sketching is not to reveal the inner complexities of *what a phenomenon is*, but rather to facilitate a vision of how the overall user experience of a future state *might be*.

Animation-based sketching is not concerned with reducing the complexity in the details of an idea, but rather with constructing new information to reduce the uncertainty about which ideas are viable in the first place. The divide between novices and experts is thus not as much a concern for sketching as it is for formal learning. The goal is not to make a solely intellectual inquiry into a domain by appealing to the intellectual qualities of the technological concept itself, but to create empathy for the potential users in the envisioned future. Thus, we might consider the positive effects of animation-based learning for novices as generally valid for animation-based sketching as a whole, since the situation in sketching is always similar to the learning situation of novices who need to explore and predict aspects of a future state of reality. The main benefit here is the notion of sketches not as *presentations* of reality, but as *representations* of reality (Tversky 2002). The sketch adds new information to the here and now, and maybe even distorts it.

The principle of interactivity is transferable to the extent that it fits the aim of exploratory design, which is to enable the designer to iterate back and forth by interacting with the animation tools. Likewise, the interactivity of simple control mechanisms, for example, allows stakeholders in the design project to pace their ‘reading’ of the design deliverables and design insights in feedback-loops, as proposed by Buxton (2010).

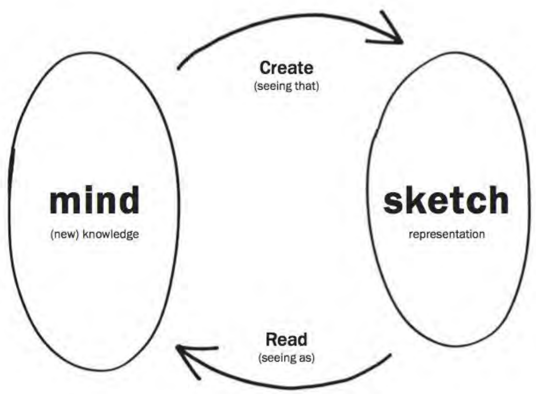


Figure 24: Buxton’s (2010) simplified dialectic between externalising thoughts through sketching, and reflecting back on the expressed in reflective loops inspired by the writings of Schön (1983).

The principle of interactivity is thus an integrated aspect not just of ‘reading’ an animation-based sketch, but also of the sketching processes of animating the sketch itself. Thus one of the main differentiators between the insights from animation-based learning and animation-based sketching is that in a formal learning context, only the animated output itself matters: the aim is to create an understanding of the complexities of a phenomenon. In design sketching, by way of contrast, the processes of sketching are just as important as the finished output – if not more so. The processes are crucial because they enable reflection-in-action in the designer's exploration of the design problem. In animation-based sketching, the learning aim is not expressed in a final sketch intended to facilitate further reflection, feedback and critique, but rather in the sketching processes itself, reflecting the investigative and explorative function of sketching and enabled by interactivity in the digital production environment of animation-based sketching. We therefore have an evaluative criterion to apply in examining production environments in part III of the book.

To summarise, previous studies of the use of animation as a facilitative tool have been restricted to very specific use cases of learning and instructional material. Even though the insights and contributions from these cases can be criticised for not providing definitive answers about the general value of animation, the result do provide us with some indications that prove useful for understanding the facilitative role of animation-based sketching. What we might call *big picture thinking* involves envisioning the overall state of a future state of the world and uses temporal information regarding the non-idiomatic aspects about which static imagery cannot inform us, and here the results from the novice learning use cases may provide inspiration. The principles of attention-guidance, apprehension, congruence, and interactivity may all be applicable to animation-based sketching to some extent, as long as we bear in mind the duality between 'sketching' and 'the sketch': it is not only the end 'product' that is important in the design domain. If nothing else, the literature reviewed in this section and its critical comments show that many authors have noted that animation has a tremendous potential to facilitate visuospatial reasoning via temporal information. While animation may not promote formal learning in all instances, we argue that it constitutes a promising perspective on generating information which reduces uncertainty rather than complexity.

MOVING ON FROM THE FOUNDATIONS

We now have a foundational understanding of the three core concepts needed to address the definition and potential of animation-based sketching. We have discussed design sketching as the subject matter and core activity of both design thinking and design communication. Furthermore, we have discussed the limitations of traditional static sketching when confronted with the temporal dynamics of new non-idiomatic technologies, and how temporal sketching capacities might offer a way to address these issues. Finally, to address the potential of animation in facilitating the knowledge generating process of design, we have sought to acquire a nuanced and deep understanding of what animation is and of how it is different from live action video.

This marks the transition from the first part of this book to part II. We now change the scope from reviewing the foundational core concepts behind animation-based sketching and go on to seek a definition and core characterisation of the approach itself.

PART II - DEFINING THE APPROACH

In this second part of the book, we will attempt to connect the foundational concepts to create an understanding of how animation, as apparent motion, can be used as a sketching approach to facilitate the reduction of uncertainty in non-idiomatic design situations. We start the section with a chapter reviewing previous attempts to understand animation within the domain of design sketching. These perspectives are used to propose animation-based sketching as a digital sketching approach with its own specific epistemological conditions for the generation of information. On this basis, animation-based sketching is defined as a way to emulate a digital system, by using animation to portray a proposed fictional future that is intended to become fact. This separates animation-based sketching from other approaches to animation outside the domain of entertainment and art, which we finally map into Ward's (2002) ontological map of animation studies as we introduced in the Introduction (p. 9).

Finally we extend our definition of animation-based sketching by exploring the archetypical features of animation-based sketches on the basis of a sampling of sketches.

CHAPTER 5: PRIOR APPROXIMATIONS

In this chapter we develop upon our review of animation, sketching, the challenge of non-idiomatic technologies, and the previous attempts in temporal sketching, by reviewing the previous approximations to apply animation techniques in design sketching. This lead us to establish how the role of animation has been experimented with in interaction design cases, but only to an extent of assessing individual techniques alone. The broader scope of animation, as an approach with multiple techniques, materials and genres is not addressed, and makes the existing cases intriguing, but with little reflection upon animation-based sketching as a way of doing design.

We end the chapter by arguing for the need to think of animation-based sketching in a broader scope as a tool agnostic approach - a set of principles for creating temporal sketches through a variety of tools, techniques and enabling technologies. Furthermore we propose that the unanswered questions from the previous approximations are in regard to the different ways animation can be utilised for sketching, the fidelity of animation required for sketching, as well as wether it is a viable approach for novices in animation to adopt in design.

EXPLORATIONS INTO ANIMATION IN THE DOMAIN OF SKETCHING

To some extent, as we have already stated , animation in sketching has previously been subjected to academic inquiry in a series of experiments that used animation techniques at different stages in the design process. The contributions touched upon in chapter 3 used animation interchangeably with video in 'video sketching' and 'video prototyping' (Mackay & Fayard 1999, Vertelney 1989, Bardram et al 2002, Tikkanen & Cabrera 2008). Augmenting traditional video with animated motion graphics is by far the most common way to include animation as part of sketching vocabulary, even though the animation techniques themselves are not examined or analysed in detail in the contributions but are discussed in the same terms as live action video. However, a few other contributions address the use of animation more directly, actually assessing the qualities that are unique to animation and their suitability for design processes.

An intriguing example is Jonas Löwgren's proposal to use motion graphic elements to create animated use cases that can gather feedback and explore the fuzzy front end of design ideas (Löwgren 2004). The created animated scenarios had a explanatory sketching intent a at late stage in the design process, when the stakeholders had to decide whether or not the idea to spend further resources. Löwgren's experiment sought to make the stakeholders reflect upon the sketch in a workshop, and avoid it being considered a persuasive sales pitch. Löwgren noted that the stakeholders' reception showed that the animated sketches were perceived as being clearly something else than animations made with marketing aims; they clearly communicated the technical details of the temporal interactions over time and between contexts.

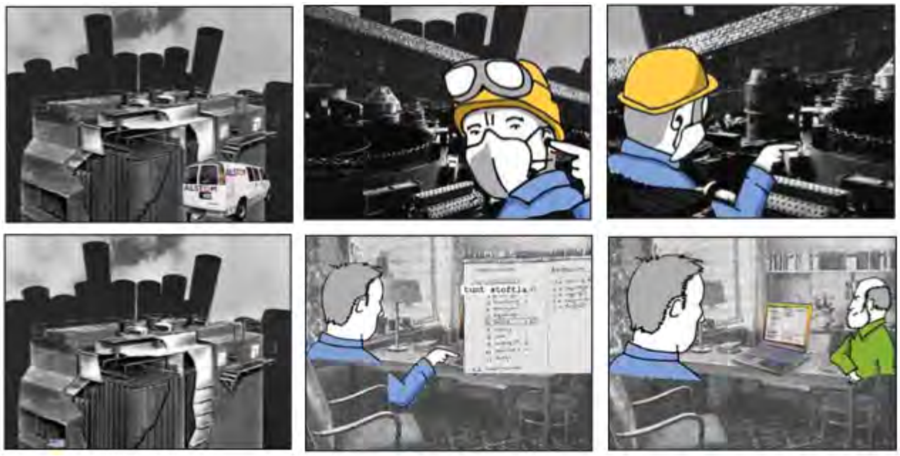


Figure 25: Stills from Löwgren's animated use sketch, expressing the use case of a voice controlled service system, enabling electricians to record and store their observations in the field. The sketch is made via keyframe animating various graphical figures on top of still photographies via Macromedia Director.

However, Löwgren does acknowledge that that the animated representations tended to communicate and persuade to a larger extent than neutrally illustrate. This indicates a risk that they might be interpreted as rhetorical and persuasive, rather than as explorative ideas inviting further reflection. The viewer might tend to "lean back" and see the sketch as a whole and respond to to sketch itself, and not the proposed underlying idea - much like the problem Buxton (2010) and Ylirisky & Buur (2007) pointed to with the challenges with getting the right feedback on the Apple Knowledge Navigator. Löwgren also noted that it took a total of 25 hours to create the moving-image representation, which makes the approach less than ideal for rapid reflection-in-action during "conversation" with design problems. Löwgren's results indicate that in order for animation-based sketching approaches to work, we must seek to use the techniques in a format which allows fast and cheap completion and which emphasises the investigative and explorative functions of sketches, rather than focusing on their explanatory and persuasive functions. Finally Löwgren's account also serves to remind us that sketching is both a process of reflection-in-action and an output format or visual style. What his animated-use sketch shows is that something can obtain the visual style of a sketch without necessarily being the product of a reflective sketching process. This echoes Buxton#s cautionary note that *"Just because something looks like a sketch, it does not mean it is a sketch"* (Buxton 2010, 338). The rendering style of a sketch is not a guarantee that the information it generates is suitable to reduce uncertainty about the design possibilities.

Attempts to adopt a more reflective digital sketching approach are offered in the workshop accounts of Bonanni & Ishii (2009), Zarin et al (2012) and Fallman & Moussette (2011). Here, stop motion animation is applied in early explorations of interaction design and architectural processes. Bonanni and Ishii (2009) suggested stop motion animation as an approach to low-fidelity concept prototyping of tangible interfaces. They made several remarks about the technique's potential which are aligned with our definition of sketching as the generation of new information. For instance, they can explore and reveal various impacts of technologies that do not yet exist by showing the interactivity. Their conclusion however, isnot unlike Löwgren's: stop motion animation in sketching mainly involves the communicative function of sketching rather than the 'visual thinking' traditions of Goldschmidt (1991) and Schön & Wiggins (1992). While they judge that animation can provide an relatively easy way to explore interaction design ideas, before investing in building functional systems, they also primarily frame the idea as an aid for presenting ideas that have already been shaped and represented in other formats.

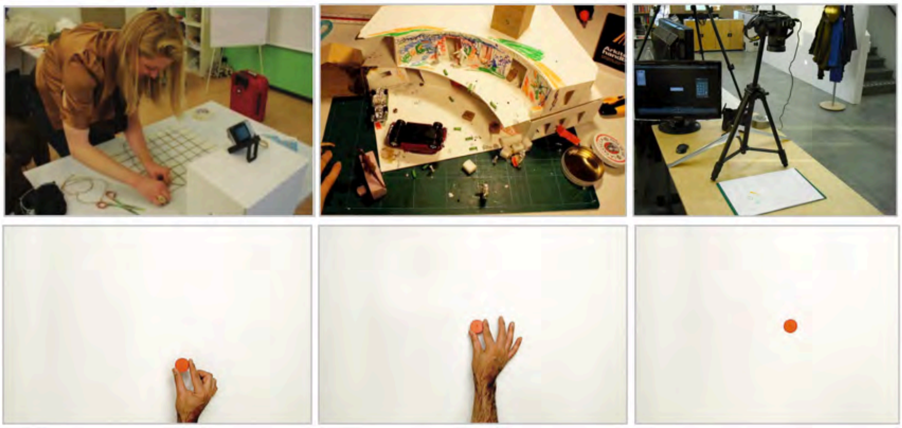


Figure 26: Stills from the studies by Bonanni & Ishii (top) and Fallmann & Mousette (bottom) showcasing how stop motion can be applied to explore early interaction design concepts.

Zarin et al (2012) and Fallman & Moussette (2011) oppose this view in their studies of the introduction of stop motion animation to interaction design students. They suggest that since stop motion animation are built frame by frame, it allows the designer to bypass the constraints of materials, physical properties and realities. The argue this makes it easier to think about ideas that change the conditions of space, time, and materiality, much as proposed by the eight digital genres of Pine & Korn's 'multiverse' (2009). This indicates that simplistic animation such as stop motion provides support for quite detailed explorations of dynamics aspect of interactive systems, which moves, flows, transitions and changes between different modes. The conclusion that can be drawn from their studies is that when it comes to working with and reflecting on processes, stop motion animation is useful for revealing and thinking about complex situations and consequences involving new technology, environments, and people. It does so in a way that requires less in terms of production environments and required competencies than more complex video prototyping. Fallman & Mousette (2011) even go so far as to ask whether we might regard stop motion as the pen & paper sketching of interaction design. In the later contribution, however, Zarin et al (2012) are less laudatory:they report that another set of students experienced more challenges and spent more time on successfully developing stop motion based sketches.

The results are interesting for the venture of extending upon animation-based sketching as a design approach, since it provided one of the first analytical perspectives on a specific way of using animation to generate information and thus reduce uncertainty in a design project. Furthermore, the conclusion that even the production of simple animation as stop motion might take a considerable amount of time to use for sketching, is also intriguing. It raises the question: is it possible to adapt stop motion and other animation approaches in a format in which the sketching time and sketching competencies have been sufficiently reduced to actually be 'the pen & paper of interaction design'?

LESSON LEARNED:

Animation can be used in design sketching to either make something look like a sketch or to explore simple concepts and interactions.

Three areas have not yet been addressed in-depth:

1) The fidelity of animation-based sketches
2) The competencies required to make them
3) The time it takes to produce them.

When it comes to building upon previous contributions, these three questions imply some considerations regarding *how* animation-based sketches are made. These involve addressing animation approaches and techniques themselves, such as the use of fully animated use cases in Löwgren's work, and the stop motion examples just covered. The *how* of animation-based sketching also involves production materials, especially the enabling technologies of animation. This includes an examination of the software that might be used to create and manipulate animation-based sketching. Here, a central question is whether we need dedicated software or off-the-shelf software tools.

Dedicated enabling technologies for using animation in explorative processes has been created previously. As early as 1969, Baecker presented Genesys (Baecker 1969), a system which could record changes in position, orientation and shape of virtual objects. In early 2000's Adobe's software packages popularised digital keyframing, in which two positions are designed manually, leaving it up to the system to interpolate between these two states (Wells 2006). Lately procedural approaches to animation has become popular ways of fusing the creation of apparent motion with algorithmic code, determining the animated behaviour over time (Martinez 2015).

In recent years, examples have been presented which adopt a sketching mindset. For instance, in the 'motion-by example technique' (Moscovich & Hughes 2003), where the user drags an object around the screen while it is being recorded by software. Similar approaches have been applied in a series of dedicated software demos such as 'K-Sketch' (Davis et al 2008), 'Sketch'n'Stretch' (Sohn & Choy 2012) and 'idAnimate' (Quevedo-Fernández & Martens 2012):

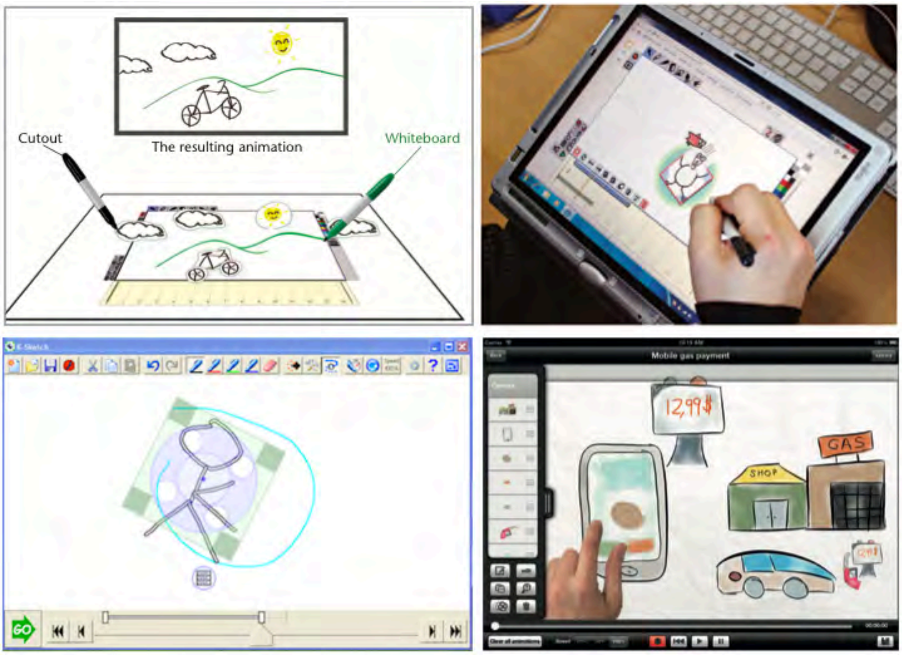


Figure 27: Stills from Stretch n' Sketch (top), K-Sketch (bottom left) and idAnimate (bottom right) - all special made production environments to the purpose of combining one specific animation technique with sketching.

In their studies, these authors develop different kinds of desktop or tablet software aimed at making it easier for designers to record motion in digital graphical productions, to convert cut out elements to digital animations, or to lower the threshold for creating 'keyframe'-based animation. All of these studies address the potential of temporal sketching compared to static design sketches. However, they do not address animation as a general approach; instead they concur with Ylirisky & Buur (2007) and Buxton (2010) that traditional animation and animation tools are not viable for sketching. Instead, their studies focus on the technical side of how animation is realised in their proposed software and on its potential to lower the participatory threshold when it comes to creating animations for design sketching. The three studies also criticise research in animation software for facilitating learning, communication and information visualization; they see it as too specific and as constraining the animator to a specific form. They propose that what sketching needs is a 'general purpose tool' (Sohn & Choy 2012, Quevedo-Fernández & Martens 2012).

All three studies are interesting and highly valuable contributions that attempt to address the *how* of applying animation within design sketching. They are particularly praiseworthy for they experimentation with lowering the threshold of competencies and withreducing the time demand on creating animation for sketching purposes. However, one might argue that they can all be subjected to the same 'specificity critique' they raise. One might also question whether they can really be characterised as 'general purpose' when each software demo only allows one type of animation technique (cut outs, keyframes or motion-by-example) and a pre-specified set of animation mediums (digitally drawn elements or pre-made graphical elements). Even though the purpose of the tools is non-specific and general, the tools themselves are also highly specific. Just not by topic, but by production. We would argue that to function as a general purpose sketching tool, an animation tool should be able to encompass different medium genres, production techniques and topics. Sometimes, an interaction design problem might require us to animate interface elements using the keyframe animation of graphics; at other times, we might need to show many interactions between humans, artifacts and environments by using stop motion via cut out elements. If the designer is limited to generating temporal information about the design problem without being able to explore different materials and techniques, the expressive capacity of the information will naturally be more limited. The point is that while limiting animation to a small set of techniques or materials might lower the participatory threshold and make it more time efficient, there is a risk that it might also limit the material conversations (Schön 1992) so that they become too pragmatic, addressing *what* the specific material can express, and not what animation in general can express. The ambition of creating dedicated software to handle issues of fidelity, competencies and time consumption in animation is interesting and valuable, but it is nonetheless just one specific way of approaching animation as a sketching tool for design processes.

LESSON LEARNED:

Animation-based sketching should be seen in a broader scope as a tool agnostic approach. Or more precisely, it should be seen as a set of principles for creating temporal sketches through a variety of tools, techniques and enabling technologies.

This brings us back to the fundamental question of *what* animation-based sketching is. To further develop our understanding of *how* animation can be applied in design sketching to reduce uncertainty about the design possibilities of non-idiomatic technologies, we need to build upon our now established foundational theories and establish a formal definition of animation-based sketching.

CHAPTER 6: ANIMATION AS DIGITAL SKETCHING

In this chapter, we discuss the basis for claiming that animation-based sketching is tool-agnostic and that it is also a digital sketching capacity. In doing so, we identify the links between digital animation and the epistemology it shares with that of digital programming. In software, the designer can determine in advance the behavioral rules of the system. The same is true for digital animation, where the designer controls the arrangement of graphics and sets the positions which forms the creation of apparent motion. In this sense, the difference between *animation* and *programming* is blurred: we might say that the programmer animates and the animator programs when creating apparent motion in digital software. We build upon this digital sketching notion in suggesting that animation-based sketching should be viewed as a digital emulator, digital software as simulators and static sketches as depiction.

This forms the basis for describing how animation-based sketching relates to and differs from both static sketches and the digital systems the animation emulates. Thus this chapter establishes the last piece of the puzzle needed to define animation-based sketching.

ANIMATION - A DIGITAL SKETCHING CAPACITY

The next step towards defining animation-based sketching is to address it from a technological perspective. The examples covered in the literature review of previous contributions regarding animation-based sketching seem to have one common denominator: all are based on the use of digital software as an enabling technology to animate the sketch. Even though we might create elements and record their movement in physical form, we edit and essentially arrange the graphical positions using some instance of digital software. In principle, one could sketch with animation without using digital software; however, the great strength of digital software is the flux between data and program to handle data (Finneman 2005, Löwgren & Stolterman 2004). This allows the user to quickly and constantly iterate within the digital animation software without having to redraw or re-record the material. This is crucial to the design process, allowing reflective conversation with the material (Schön 1983) to take place as a fluent process of move-see-move experimentation with ways to create a fitting representation for the interactions. Without the iterative cycles, animation-based sketching could be described as purely a communication device for reflection-on-practice expressing reflections that have already been made.

'Reflection-in-action' happens when designing the graphical positions (graphism) using either physical or digital artifacts and recording them in pictures or on film, together with live action elements. However, as soon as the designer begins to explore how to manipulate the different elements into combinations, how to create apparent motion, and how to use the mixture in a full exploration of the non-idiomatic design context, the designer undertakes a mixture of reflection-in-action and reflection-on-action. In using various digital tools and software to edit the bits and pieces together, designers temporally and visually express the reflections made previously in creating, deciding, recording and manipulating the elements. This creates a principle of *non-continuous production* in the animation-based sketching process, where in most cases the production of the image occurs in a different time from it's playback as apparent motion. In terms of Schön's modes of reflection, this means that animation-based sketching is epistemologically different from traditional static sketching since it breaks the sketching process into two stages - *capturing* and *editing*.

Static sketching adheres to the tradition that we previously labeled 'visual thinking' (p. 15), in which the designer's reflection-in-action enables the designer to see more in the created sketch than was put into making the sketch originally. This is also the case when capturing material for animation-based sketching; the designer decides upon what and how much to move an object in the animation process. This decision making happens in a dialogue with the situation (Schön & Wiggins 1992), and thus also creates a potentially different variant of the idea than might have been thought of before.. The designer reflects on the choices made in capturing materials in order to plan how to manipulate the materials in the given software to create the desired apparent motion, and this amounts to a reflection-on-action about a previous process. However, in manipulating the material in the software the designer also obtains temporal information which did not exist prior to the editing situation. Reflection-in-action begins again as the designer listens to what we might label *'the temporal backtalk'* of the animation(s) created in the software. This backtalk is what enables the designer (or animator for that matter) to obtain more information from creating the animated sketch than existed before the creation of the sketch.

It is in this overlap between reflection-in and reflection-on that animation-based sketching differs from the traditional hand-drawn sketching process, in which reflection-in-action happens during the capture of the sketch, and from reflection-on-action, which typically first occurs during communication of the sketch to others, for instance in a critique session (Buxton 2010, Schön & Wiggins 1992). The use of digital tools in creating, editing and manipulating materials to create animation enables this overlap between reflection-in-action and reflection-on-action. Thus, through its ability to iterate dynamically, the digital medium plays a crucial role in enabling temporal backtalk. This ties animation-based sketching to the digital realm, as was already implicit in the review of the previous research. Thus, digital materiality makes animation an approach to sketch with, and not just a way to create independent animated content. Consequently, a more precise way to talk about animation-based sketching would actually involve using the term *digital* animation-based sketches. The overlap between capturing and editing is thus also a transition concerned with *digitising* material into a format that is ready for digital editing, by first *sampling* and then *quantisation*:

> *"Digitisation consists of two steps: sampling and quantisation. First, data is sampled, most often at regular intervals, such as the grid of pixels used to represent a digital image. The frequency of sampling is referred to as resolution. Sampling turns continuous data into discrete data, that is, data occurring in distinct units ... Second, each sample is quantified, that is, it is assigned a numerical value drawn from a defined range (such as 0–255 in the case of an 8-bit greyscale image)."*
>
> (Manovich 2001 p. 28)

When capturing material in the real world and later editing and manipulating it, digital sampling shares the discontinuity discussed above. However Lev Manovich points out that because of quantisation and coding, digital samples can be programmed, unlike analogue data (Manovich 2001, 51). From this programmable character derives a paradox for our definition of animation: if the data we capture can be autonomously altered by programmed algorithms, does the designer/animator animate or is it the software? Omar Martines (2015) discusses this issue in his paper about the issues involved in describing digital animation, and among other things he touches upon the role of *agency* in digital animation software:

> *"Animation can be characterised according to its two general types of sources, where agency referees to the deliberate determination of illusory movement by a agent, while causality refers to cause and effect processes, whether accidental or systemic (from e.g. computer automatisation)"*
>
> Martinez 2015

The illusion of motion - or what we label apparent motion - is agential to the extent that the designer either arranges the material between a set of stages to create the motion or pre-determines the parameters which the digital software will use to simulate changing positions. In other words, the digital software is a simulator of motion. Martines refers to Gonzalo Frasca's notion of the designers of digital animation as 'simiauthors' (Frasca in Wolf & Perron 2003, 227), who set the rules that simulate motion or change in visual information presented by the system. Frasca explains that *"to simulate is to model a (source) system through a different system which maintains (for somebody) some of the behaviors of the original system"* (Frasca in Wolf & Perron 2003, 223), and thus simiauthors creates the rules of the simulated model of reality.

Thus, software allows the designer to determine in advance the rule of how positions of graphical components creates apparent motion over time.

LESSON LEARNED:

The difference between *animation* and *programming* is blurred in the creation of apparent motion in digital software: we might say that the programmer animates and the animator programs.

Thus, designers using digital software are also as animators to the extent that they may determine the creating of motion. They do so through the computer code or through the same logic by changing variables in the software. Whether or not the software has an interface as the front-end for manipulating these variables, using digital software to edit and create the animation-based sketch is based on an epistemology which has a lot in common with that of the programmer. However, the manipulation of variables, which in turn pre-determines the creation of apparent motion, actually continues what Norman McLaren initially described as the *'manipulation of the differences between* *successive frames'* which constitutes the animator's praxis (Sifianos, 1995: 66). As McLaren provides the basis for our definition of animation as ***the process of deciding and manipulating the differences between a set of graphical positions, with enough difference to produce a sequential illusion of apparent motion***, the programming-like epistemology of digital animation actually supports this broad view of animation rather than conflicting with it. Thus, animation-based sketching as a tool-agnostic but digitally enabled approach does not conflict with either analogue or digital means of defining animation. It does, however, raise an important ontological question. If digital animation is described in Frasca's terms as aligned with 'simulation', is that also the defining characteristic of animation-based sketching?

THE COMPUTER AS A SIMULATIVE MEDIUM

In 1984, computer scientist Alan Kay described digital technology as:

> *" A medium that can dynamically simulate the details of any other medium, including media that cannot exist physically. It is not a tool, although it can act like many tools. The computer is the first metamedium, and as such it has degrees of freedom for representation and expression never before encountered and as yet barely investigated."*
>
> Kay, 1984

Kay's description is related to the general architecture of computer systems, which are described (Rosenstand 2002, Rasmussen & Barret in Morán et al 1995) as 'simulators'. Like Frasca's notion of the concept, a simulator in computer science consists of a model of a bounded part of reality. This model can be influenced from the outside (input), and it will react (output) in a similar way the represented is expected to react in reality (Rosenstand, 2002). This means that the model is dynamic and can change on the basis of either external or internal dynamics. Rasmussen and Barret formally describe the simulator as the core aspect of any digital systems as

> *"a simulator is an emergence engine. It is a representational mechanism that is distinguished by its capacity to generate relations that are not explicitly encoded."*
>
> Rasmussen et al., 1995, 14

The formal description of the computer as a simulator works for any digital system, including systems with no direct user influence. With the advent of human-computer-interaction (HCI), researcher Brenda Laurel coined the metaphorical term *computers as theatres* to describe the way in which digital simulators created the human-computer experience (Laurel 1993). To Laurel, the bounded model of reality was a *'distorted model of reality'* and was

> *"about creating imaginary worlds that have a special relationship to reality—worlds in which we can extend, amplify, and enrich our own capacities to think, feel, and act."*
>
> Laurel 1993, 32

Laurel's description of the representational power of digital computing can be seen as a perspective on the multiverse model of digital genres proposed by Pine & Korn (2011). We can view these genres as possible simulative domains, which the computer can extend, amplify and enrich in interaction with the user. In HCI, the input and output to and from a simulator is the based on *interactivity*, where interactivity is defined as "... *a measure of a media's potential ability to let the user exert an influence on the content and/or the form of the mediated communication"* (Jensen, 2008). This is mediated through the interface, which connects the computer system to its surroundings through different interaction modalities.

The facilities that can be used by the surroundings through the interface to influence the dynamic model (input) and the facilities that the model can use to update the interface (output) correspond to what computer science typically labels *'functions'* (Mathiassen et al., 2000). From an output perspective, the interface represents the state of the model, and from an input perspective, the state of the model is a function of the interactions performed by the user. Thus, digital systems understood simulators consist of the synthesis between interface, functions, and model:

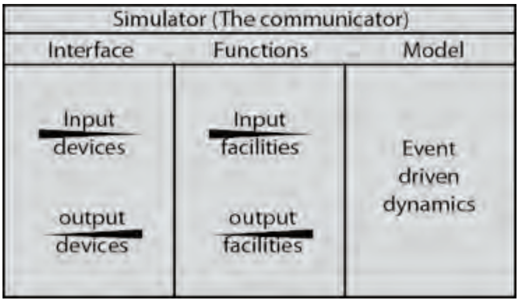


Figure 28: The simulator, as presented by Rosenstand (2002), consisting of a bounded model of reality, which is manipulated through a series of input and output functions, mediated by an interface.

This shows why the digital medium has often been described in terms of being *informational* and *able to represent all other mediums as content* (Finneman 2005), or more simply as *"...the material without qualities"* (Löwgren & Stolterman 2004). The bounded model of reality can be configured to model any given part of a factual or made up reality, with a given functionality mediated by a user interface.

This takes us back to the question of the role played by animation in exploring aspects of specific ways of simulating bounded models of reality in digital systems.

Between simulation and depiction lies emulation

Earlier, we introduced Gonzalo Frasca's notion of the designers of digital animation as 'simiauthors' (Frasca in Wolf & Perron 2003), who set the rules that simulate motion or change in the visual information presented by the system.

Frasca's notion of animation as the simulation of motion works well to describe what happens when we use a digital production environment to create apparent motion. However, the situation becomes more complex when we introduce the notion of the computer as a simulator itself, and when we aim to use animation as a way to sketch a future configuration of such simulators. The issue is that we use a digital simulator (the animation production environment) to simulate another simulator itself (a given digital system). However, we essentially do this by creating a temporal sequence of information which does not adhere to the same simulative qualities as the digital simulator - the animation does not maintain all the qualities of the modelled system. This is most obvious in the lack of input and output modalities in the interface of the animation-based sketch - the user cannot (at least per se) interact with or change the dynamics of the modelled system. The user can only observe its dynamic model of reality.

This places animation in an ontologically different position than both traditional pen and paper sketching and interactive prototypes when it comes to exploring a digital system.

Traditional static sketches enable the *depiction* of a bounded model of a reality, but they do not represent dynamics or interactions - unless they leverage established idioms for the viewer to fill in the temporal blanks on the paper. Thus, a static sketch is only able to depict the bounded model of reality in single states, without input, without output and without the dynamics between the elements of the simulator.

On the other hand, prototypes can provide a dynamic model of reality together with functionality mediated by interactive input and output, thus showing the complete simulation of the interactive system. A prototype can be defined as *"a limited representation of a design that allows users to interact with it and to explore its suitability"* (Preece et al 2011). However, this limited representation involves all aspects of the digital simulator, and the designers' decisions thus concern whether to reduce complexity involving the breadth of different features or involving the details in depth of a specific function. Usability pioneer Jacob Nielsen terms this the division between the *'Horizontal prototypes'* and *'Vertical Prototypes'* of the full system (Nielsen 1993):

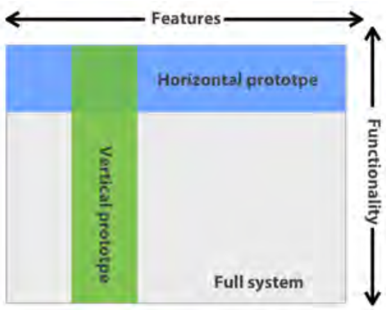


Figure 29: Nielsen's (1993) concept of either prototyping a limited set features vertically with much detail, or prototyping a wide set of features, but with limited functionality in each feature.

Whether prototyping vertically or horizontally, the essential feature of prototypes is that they express the model, the functions and the interface of the simulator. This fits with Buxton's notion of prototypes as a means to 'getting the design right' and our definition of prototypes as a way of reducing the complexity of information (concept ideas and variations). As soon as we have a prototype, as limited a representation as it may be, we have a unified set of information about how the digital simulator *'might be'*, and thus we need a testable expression in order to move the design process forward. But making a prototype outside established design patterns, conventions and idioms of interactions can make the prototyping process lengthy and costly (Buxton 2010). Even though methods have been proposed to *sketch in code* (Lindell, 2012 & 2012b, Forséna et al 2010), they also tend to narrow down the focus, converging the design process rather than maintaining the divergent sketching mindset of creating design alternatives. Furthermore, even when sketching in code, the time spent creating the sketch is still far longer than the time required for static sketching. This underscores the role of sketching seen from a more design logistic viewpoint - making it affordable to create and compare alternative design proposals throughout the design process (Buxton 2010).

We argue that situated between *depiction* and *prototypical simulation* as modes of representation, animation provides a third distinct mode of representation. By manipulating the position over time of different graphical elements to provide a model of reality, and by generating temporal information, an animation can illustrate the dynamics of the interactive system, even though the input and output are not realised as a full simulation. This means that animation-based sketching is ontologically different from both static sketches, which depict, and prototypes, which simulate. On the other hand, we drew on Frasca and Omar to establish that the animation process itself is a process of simulation. This makes animation-based sketching complex, in that we simulate motion and change in the inanimate in general. But when it comes to using motion and change to explore a proposed digital system, we simulate something which is already a simulation, and thus we are actually not simulating the digital system: we are *emulating the digital simulator!*

Emulation is best described as *'the imitation of a certain computer program on another platform or program'* (van der Hoeven et al 2007). An emulator is by itself a designed application that creates an extra layer between an existing computer platform (a host platform) and the platform to be reproduced (the target platform). In the context of emulating a not-yet existing technology with animation, this setup could be modelled like this:

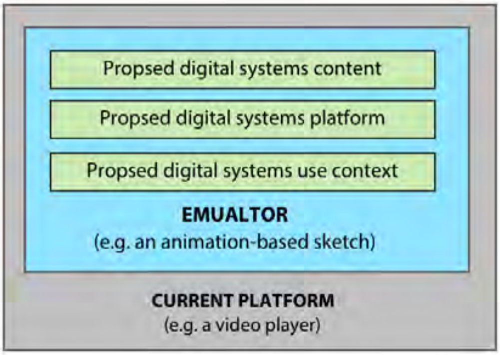


Figure 30: Our proposal for viewing animation-based sketches as an emulator - being able to emulate the digital simulator as well as its context on another platform - like e.g. a video player.

The term emulation is specified as the complete imitation of a machine, while simulation refers to computer simulation, which involves the computation of a bounded model of reality with input and output (Pugh 1995, 274)

Even though the term *emulation* is typically applied in computer science with reference to compatibility insurance, to digital preservation or to hardware development platforms (van der Hoeven 2007 ; Magnusson 2004), we argue that animation-based sketching is yet another instance of emulation. When we employ digital animation to sketch aspects of a proposed technology (software as well as hardware) while using a playback medium to express the sketch, we are in essence using animation as the *extra layer* between the playback medium and the proposed future technology. In doing so, however, we do not represent the fully realised system, but only a scripted sequence of the system - a scenario in which the dynamics are set, thus leaving out the input and output functions of the simulator. Turning back to Jacob Nielsen's notion of vertical and horizontal prototyping, we might say that the emulation of a scripted sequence of the full proposed system is to be seen as one specific instance of multiple different ideas of possible digital systems*:*

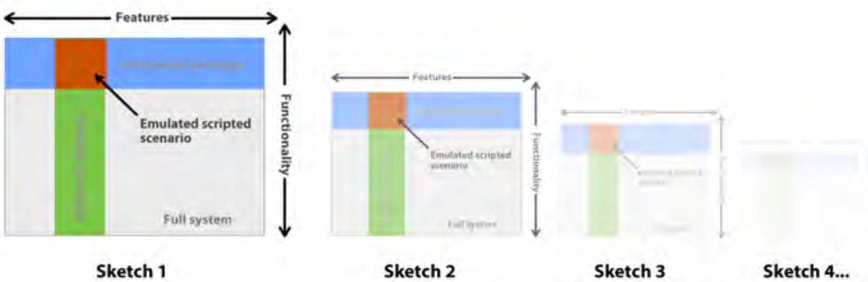


Figure 31: In the notion of Nielsen's model, an emulation of a simulator would be a limited representation of features and functionality, like when an animation-based sketch would present a scripted sequence of the proposed simulator. Each sketch could represent different overlaps of feature and functionality, expressing either multiple concepts of the simulator, or different aspects of the same.

This demonstrates the fit between emulation and sketching. By emulating small aspects of the fully realised system, even if it is limited in its fidelity regarding the expressed features and functionality, animation-based sketching generates information about different possibilities in the design space, rather than prototyping the breath or depth of a defined system.

Prototypes, static sketches and temporal sketches such as animation-based sketches thus make up a typology of the representations of a digital system:

Figure 32: A functional digital system, like a prototype, represents the full full simulators representation of a dynamic model of reality, which can be approached through input and output. A static sketch on the other hand can only depict the simulated model of reality, but not show its dynamics or be manipulated via input or output. Animation-based sketches, while still not able to manipulate the model by input and output, can still represent the dynamics of the model, thus generating more information about the simulated than depiction.

Thus, animation-based sketching involves the emulation of a sequence inside a proposed digital system, whereas non-temporal sketching enables depiction, and prototypes enable full simulation[2]. We have now isolated not only how sketching and prototyping in general differ (uncertainty vs. complexity), but also how a temporal sketching approach such as animation is different from both static sketches, and prototypes. This provides us with one of the final building blocks needed to describe animation-based sketching as a specific design approach in exploring interaction design and user experience in non-idiomatic design situations.

A final question remains to be answered: how should this way of using animation to emulate the digital simulator be understood in comparison to the other uses of animation inside and outside the design domain which were reviewed earlier?

[2] The idea of animation-based sketching as a emulative genre of representing the digital simulator was coined in collaboration with my good colleague Claus Rosenstand in Vistisen & Rosenstand (submitted)

CHAPTER 7: DEFINING ANIMATION-BASED SKETCHING

This chapter finally proposes a definition of animation-based sketching as a design approach. We initiate the chapter by reviewing the use of 'functional animation' as the catch-all definition for the use of animation outside the domain of entertainment and art. We explain why this definition is problematic and show that animation-based sketching, as opposed to the functional genres, has as much in common with the creation of fiction as it has to do with the factual genres of animation.

We define animation-based sketching as:
Using animation to portray a fictional reality that is intended to become fact

We conclude this chapter by placing animation-based sketching in the ontological map of animation proposed by Paul Ward (2002). We place animation-based sketching along the tradition of Art & Design studies, with sketching emerging as yet another epi-center. It is not defined as functional animation, but rather overlaps with the characteristics of both Art & Design and the notions of functional animation.

IS ANIMATION-BASED SKETCHING FUNCTIONAL ANIMATION?

For our final approximation to the definition of animation-based sketching, we must go back to the very beginning of the book, and to the ambition of the Animation Hub Network to understand the concept of 'functional animation' (p. 5). We will seek to discuss whether it makes sense to define animation-based sketching as a sub-type of functional animation, or whether its definition needs its own ontological place in animation studies.

Functional animation is a problematic concept since it essentially has no scientifically based definition. Furthermore, since its definition is so broad and takes cues from a multitude of other ways of describing animation, it has been influenced by various definitions proposed by educators, practitioners and researchers. The main problem is that the term is used to describe widely different concepts of animation, and not only the use of animation within other domains than entertainment and art. To the best of our knowledge at least three concepts exist in the current discourses, which we will argue contradict each other: *as part of interfaces*, *as factual information*, or as a *way of producing animation.*

As part of the interface

One use of the concept stems from the UX practitioner publishers' 'Smashing Magazine", which has featured functional animation as "*subtle animation that we embed in a user interface design as part of our process [...] functional animation has a clear logical purpose"* (Daliot 2015). This definition corresponds to earlier research contributions by Baecker & Small (in Laurel 1990) addressing animation in digital interface design.

They describe eight uses of animating '*functions*' in the interface of products:

Animation	**Function**
as Information	*What is this?*
as Transition	*From where, to where?*
as Choice	*What can I do now?*
as Demonstration	*What can I do with this?*
as Explanation	*How do I do this?*
as Feedback	*What is happening?*
as History	*What have I done?*
as Guidance	*What should I do now?*

Baecker & Small 1990

While Baecker and Small do not use the term 'functional animation', their use of animation to portray functions in the interface of digital system is closely aligned with the logical purpose proposed by Smashing Magazine. However, one could ask whether the qualities of animation also affect the emotional character of the interface, just as different variants of motion affect the appearance of an animated entity. In this sense, functional animation is a way of using animation to support interaction through motion. It can add a sense of causality, pacing, rhythm and character to a web-site, for example. In line with this, Chang & Ungar (1993) published an inspiring study of how different user interface elements utilise Disney animation principles such as squash and stretch, anticipation and follow through (Thomas & Johnston 1981) to make the computer system easier to use.

The important part here is that this application of animation contrary both traditional animation and other ways of using animation does not see animation as an independent expression, but as a functional component in a design.

Figure 33: Examples of functional animation as components in interfaces. The 'genie effect' of stretching ton Mac OSX when minimising (left), and animating browsing through multiple screen on iOS (right).

This notion of animation is an intriguing concept that has become increasingly relevant with the advent of multi-touch interfaces and pervasive computing devices. With the non-idiomatic interactions involved, animation might help users understand the conceptual model of interaction with such technologies. Additionally, as part of the Animation Hub Network, another Ph.D research project was initiated to explore this further (en.animationhub.dk), although no results have yet been published. A working definition of this type of functional animation is *the use of animation as a design component to support interface design through motion inspired by both reality and fiction.*

As a factual information

The use of animation in formal learning and instructional contexts was discussed at great length in part I, and this specific way of using animation is also within the scope of the Animation Hub Network's label 'functional animation' (Thorning 2014). Baecker & Small speak of the *animation of process* as revealing or explaining complex processes or phenomena - in their case, primary algorithms and program code. However, the use of animation to convey information about a factual phenomenon is not necessary constrained to learning or instructional materials alone. Flight routes or animations of medical procedure to communicate with patients are instances of visualisations of dynamic information, and variants of what we would label *functional animation as factual information.*

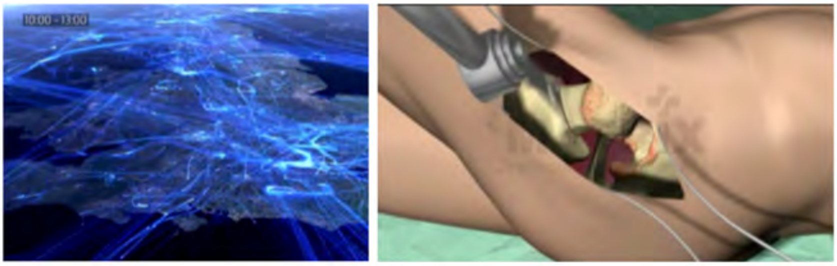


Figure 34: Functional animation understood as factual information communicated through animation, like illustrating flight routes (left) and the function of a knee prosthesis (right).

According to the Animation Hub Network notion, this functional aspect af animation is the degree animation is used to portray aspects about factual reality - the here and now, or as in formal learning to predict the outcome of phenomenons affect in a context. The network do not relate to the fictive domains of entertainment or art, or to the abductive sensemaking of 'what if' scenarios in design thinking. However, the portrayed reality in this type of functional animation is not necessarily a neutral or objective portrayal. As we have seen before, animation can never really be objective, since it is a visual expressive capacity based on the contingent decision making of the designer/animator. Consequently, even factual information presented via animation will be based on a certain perspective, leaving something in and something out of the expression. Animated propaganda has existed for nearly as long as the animated film (e.g Nysten 2015), and an animated visualisation of scientific phenomena will also be based on the choice of which details to include, which established paradigm to support, and so on. Thus, functional animation as information is to use animation to portray facts about reality - with a higher or lower degree of objectivity.

As a way of programming animation

Finally, the label 'functional animation' has been used in computer generated effects (CGI) and computer graphics research as a term for the adoption of principles from 'functional programming' in the domain of computer animation (Elliott & Hudak 1997, Arya 1986, Elliott 1998). This field sees functional animation as a high level programming vocabulary that can describe an animated model while omitting details of presentation (Elliot 1998). This approach to animation is a sub-form of so-called functional programming language (Bird & Wadler 1988), making the animation models reusable and composable for integration in interactive applications.

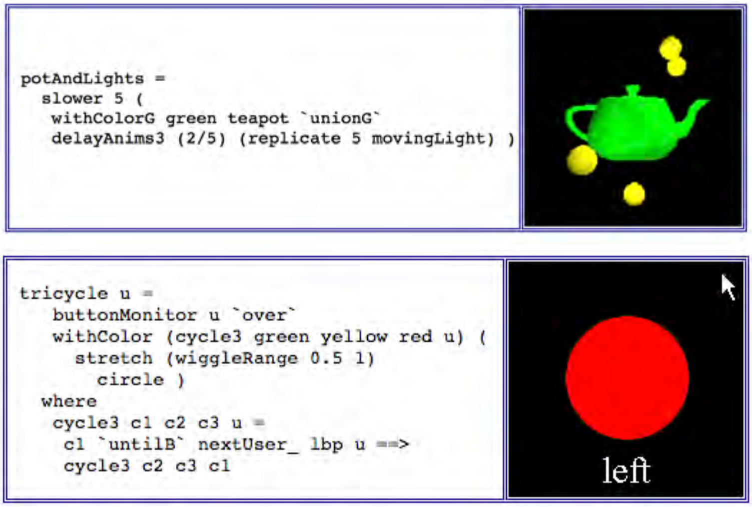


Figure 35: Functional animation understood as part of functional programming, where animated behaviour can be formulated through computer code to act according to different variables.

This is a completely different way of looking at animation, since its concern is not the *external qualities* of animation as a expressive capacity, but the optimization of the *internal aspects* of creating animations as a computer science craft. This concept is not part of the very broad definition of the term proposed by the Animation Hub Network. That the concept already existed and has so few ontological links to the other two descriptions of functional animation leads us to view this perspective as an anomaly, albeit it is because of a loose conceptualisation by the Animation Hub Network. To brand a concept from an already existing and radically different perspective on the animation domain as the common dominator for a new branch of animation is rather unfortunate; nonetheless, it is the foundation that we will use in our further efforts to position animation-based sketching.

A taxonomy of functional aspects in animation

Our short review has indicated that the Animation Hub Network's concept 'functional animation' is problematic due to its overlap with a concept from the domain of functional programming. It is also evident that we need a clearer taxonomy of *how* the different variants of functional animation use animation, and what the *aim* of each use is. This is also grounded upon how these uses of animation differ from what is labeled 'traditional animation' within entertainment and art.

LESSON LEARNED:

We propose the following categorisation of functional animation types:

Traditional entertainment & art
Using animation to portray a fictional reality with the aim of creating an experience

Functional animation - Factual information
Using animation to portray facts about reality with a high or low degree of objectivity

Functional animation - Design Component
Using animation as a design component to support interface design through motion inspired by both reality and fiction.

Animation-based sketching might also be described as a way of using animation outside the domain of traditional entertainment and art. However, as was discussed earlier, it is not described fully in terms of learning, instructions or any other factual portrayal of information - be it subjective or objective. Moreover, while an animation-based sketch might explore a potential use of technology through animating aspects of its user interface and interaction, it is not itself the design component, but rather the vehicle in which we might use the functional animation genre of design components under given circumstances.

A DEFINITION OF ANIMATION-BASED SKETCHING

As an antidote to intertwinement with the troublesome definitions of functional animation, we have proposed above that animation-based sketching actually takes many of its essential qualities from the historical development of animation as a communicative genre. This correlates with the definition of design sketching as creating new information about the world so we can explore it and reflect upon it. Thus, animation-based sketching might be labeled as 'functional' to the extent that it uses the principles, traditions and methods of animation outside the domain of entertainment and art. However, due to the ambiguity of the origins and uses of functional animation as a term, we hesitate to use this label to refer to animation-based sketching. Instead, we argue that animation-based sketching is better described as 'developmental animation', without orthodox adherence to the aim of creating motion that is as realistic as possible and without being fixed on purely abstract uses of motion graphics to evoke emotions.

Animation-based sketching uses the qualities of animation to speculate about the future, filling the idiomatic gap of temporal information in dynamic design cases with few established patterns or conventions – or none at all. The important difference from other uses of developmental animation in entertainment and arts is that even though the sketch portrays a fictional reality, it does so with the clear aim that it might become real. The idea explored in an animation-based sketch is thus 'diegetic'; in other words, it is a product whose functions and implementation are true within the ontological boundaries of the narrative of which it is a part (Kirby 2010). This is an important notion, and it further relates to the poetic theory of 'possible worlds' (Ryan 1991, Dolezel 1998, Pavel 1975), which states that fictions can be understood on the basis of how easy or difficult they are to *access* from our real world. Accessibility can be understood as basic ontological laws in possible world that either enable or inhibit behaviour, and which are familiar to, and not in violation of reality.

In this regard, animation-based sketching differs from animation in entertainment and the arts by concerning itself only with possible worlds - scenarios in which the explored non-idiomatic technology would be able to leave its diegetic state and become part of factual reality. This provides us with the last element needed to establish a working definition of animation-based sketching:

Animation-based sketching is defined as:
Using animation to portray a fictional reality that is intended to become fact

Animation-based sketching uses the process of deciding about and manipulating the differences between a set of graphical positions, with enough difference to produce a sequential illusion of apparent motion, and it explores a design space in the dialectic between framing the problem and formulating a possible solution. Furthermore, it uses animation-based sketches as the outcome of the animation-based sketching process to explain and persuade about the idea, to varying degrees that help others to obtain a visceral, intellectual and emotional understanding of a concept. Animation-based sketches thus provides shared points of reference which can act as frame of reference for other ideas, thus enabling further reflection.

However, our definition also entails that the sketches are only means to and end, and never the end goal itself. An animation-based sketch portrays a fictional reality, not for the sake of the experiential values in the fiction itself, but to facilitate the decision as to whether it should become real or not. It reduces uncertainty about the preferred state of the design space by generating information about the temporality and dynamics of a given idea. When the idea is a digital system, for instance in an exploration of the potential interaction designs and user experiences of a non-idiomatic technology, the animation-based sketch serves as an emulator of the digital simulator. As a design approach, animation-based sketching might best be described as a meta-medium which can portray other mediums in context and in use, providing temporal feedback about dynamics outside established design idioms.

The ontological fit for animation-based sketching

We now have a definition of animation-based sketching that is independent of the tools, mediums and genres of animation used and which is not tied solely to the sketching of digital systems. However, we have also defined the specific instance in which animation-based sketching is applied as a digital sketching approach to emulate a digital simulator, and we have discussed how this differs from static sketching and prototyping.

We now turn back to Paul Ward's ontological mapping (2012) and can place functional animation along the path of Art & Design studies. Here, design sketching emerges as yet another epi-center. It is not defined as functional animation, but rather overlaps with the characteristics of both Art & Design and functional animation from the perspective of using animation outside the domain of entertainment and art:

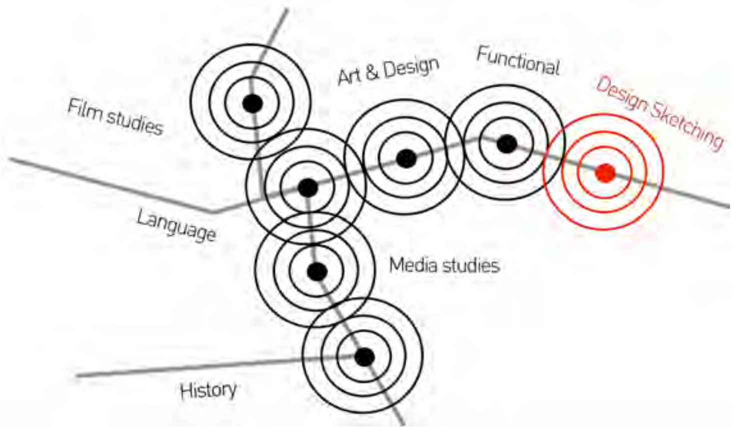


Figure 36: Separating the use of animation in design sketching from the topic of functional animation, we can now map two new epi-centers in Ward's model, along the fault line of Art & Design, with design sketching having overlaps with, but not bein equal to that of functional animation.

While we have seen that animation-based sketching takes many of its cues from discussions of animation in media and film studies, we argue that these are secondary features compared to the those of animation in art & design studies. The foundational ontological aspect of animation-based sketching is that it is animation used in the constructive activity of design: deciding and manipulating graphical positions to create the illusion of apparent motion with the aim of exploring possible futures states of the world.

CHAPTER 8: ANATOMY OF ANIMATION-BASED SKETCHES

To further describe the ontological aspects of animation-based sketching, we now explore the archetypical features of an animation-based sketch In doing so, the chapter presents five archetypical perspectives of animation-based sketches. These five perspectives are to be used and combined through six archetypical narrative discourses. These archetypical features are realised through the use of either high or low visual and temporal fidelities, which often exist in a mix in animation-based sketches, as this chapter will detail.

THE PERSPECTIVES OF ANIMATION-BASED SKETCHES

The identification of one specific description of what constitutes an animation-based sketch might be rather difficult. Despite being used in many variations in various interactions and user experience design projects, there are common traits shared by animation-based sketches. We have gathered a substantial number of sketches during the research project behind this book, and certain patterns seem to emerge among the variety of techniques, materials, styles, and intents of the sketches.

The first task is to describe the macro level of animation-based sketches. We have already established that animation-based sketches can emulate a proposed digital system, and in doing so, they generate information to reduce uncertainty about the design possibilities and thus also serve to frame the design setting. After examining animation-based sketches f both from our own design processes, from the workshops we have facilitated, the examples found the previously reviewed contributions, we have derived five *perspectives* animation-based sketches has been observed to take:

- ***Isolated interface and artifact interactions***
- ***Present User scenarios***
- ***Future user scenarios with a positive framing***
- ***Future User scenarios with a negative framing***
- ***Systems perspective***

In the following pages we will go through each sketch perspective one by one

Isolated Interface- or artifact interactions

This perspective uses animation to make the interface and/or interaction modalities of a proposed technology come to life and to provide temporal information about the input and output in the system. These sketches do not refer to of the user the context or the user(s) themselves, or else they only hint at them. While they show 'use over time' they are limited to only showing the dynamics of the technology itself, and not the dynamics of the interaction between user, context and technology. This perspective of sketching encompasses graphical, industrial and interaction design, which Buchanan (2001) argues are the first three orders of design, all being concerned with the artefacts and their immediate interplay with the user.

Figure 37: The sketch explores an idea of specialised smartphone to be used at hospitals and care facilities, in which animation is used to explore how one nurse would be able to notify other nurses in close proximity about a critical situation. See the sketch at http://goo.gl/i5tfLW.

We often see these sketches when the designer needs information about the fine grained details of the interaction with a system, for example when there is a need to generate information about different ways in which a system can represent information to the user. This type of animation-based sketch has a lot in common with instructional videos that show how to use a specific system, but with the clear difference that here we are sketching not-yet-existing interactions, whereas instructional videos convey instructions about existing interactions.

Present user Scenarios

These sketches are not really sketches in the sense of generating information to reduce the uncertainty about design possibilities, since they do not sketch any new design ideas. Instead, the they use animation instead of video to illustrate the current context of the user. Sometimes this choice is made as the faster and more practical approach, but it may also be used to realise what Scott McCloud labels ‘amplification through simplification’ (McCloud 1994). Here, the specific nature of live video is reduced to a more ambiguous representation, which could possibly act as a stand in real people and help the designer represent user contexts in which live filming has not been feasible.

Figure 38: In this sketch, LEGO mini figures are used in a stop motion sketch to frame the daily service routines of using a public employee program and illustrate the break downs in communication, simplifying the expression of the stakeholders in the process to refocus from the individual persons to the problem setting as a whole. See sketch at http://goo.gl/lUwUx5

We would argue that while they do not represent a future ‘what if...’ scenario, but stick to the ‘as is...’ of the present, these sketches still serve a sketching purpose for design. To adopt Schön’s (1983) terminology of problem setting and problem solving, these sketches act as the designers’ way of framing the temporal sequence of user actions and situations within which the further conceptual design ideas are created. As such, these scenarios act as the problem setting in animation-based sketching, forming the boundaries which can then be discussed by stakeholders and be reframed where necessary.

Future user Scenarios with a positive framing

This is the type of sketch we most commonly see as animation-based sketches. These sketches use animation to show how a proposed technology is used in context, acting as a diegetic element in a fixed scenario. The sketches are characterised as presenting the proposed idea from a perspective of being viable, feasible and desireable. The sketches vary in terms of whether the entire sketch is animated or whether there is a mix of live filmed elements and animated elements (aligned towards the mimetic end of Furniss's continuum of animation uses (p. 44).

Figure 39: In this sketch, the future of hospital care is explored throug keyframe animating a series of diegetic elements, such as interfaces on the wall and tables, as well as the movement dynamics of an intelligent bed concept. The diegetic elements are shown in context with a live actor placed inside the animation-based scenario through green screen recording, showing an entire user journey as a patient using the new advanced concepts in the hospital. See sketch at http://goo.gl/oPJn7Z

These sketches also vary in terms of their narrative discourses and their communicative intent, as will be touched upon later in this chapter. What is important is that these sketches present a perspective on problem solving, asking 'what if we had X in this context'. Thus, these sketches frame a possible resolution to design problem, providing the positive perspective of a preferred future state on the information generated.

Future user Scenarios with a negative framing

These sketches are more or less identical to the future user scenarios just discussed, but with an important difference in how the proposed problem solving is framed. Some sketches are generated to either explore the possible disadvantages or to provoke us about the prospects of a proposed 'solution'. These sketches present a diegetic design concept in context and in use but show the negative sides of the possible implementation of a technology in the use context.

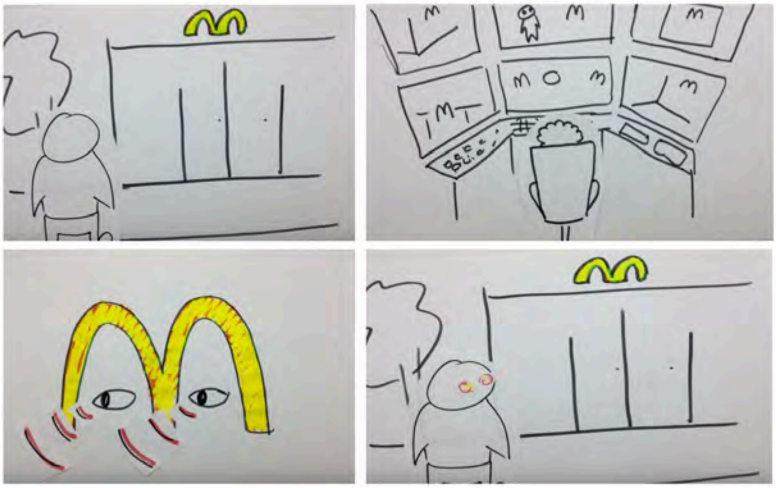


Figure 40: A simplistic sketch from the early concept development of digital service designs to prevent unethical use of persuasive customisation. The scenario uses stop motion to explore a scenario in which a large corporation is able to gather enough meta data about a bypassing citizen, to create a specially tailored offer, which persuades the citizen to buy. This sketch was made to clearly state the direction the designers would avoid to go in their efforts to create user customisation in shops. See sketch at https://goo.gl/dfCVgb

While often created as part of a more speculative or critical design practice (Dunne & Raby 2013, Markussen & Knutz 2013), such sketches can also be used to frame a continuum of solutions in the problem setting, thus representing the edge cases of undesirable future states.

A Systems perspective

The sketching perspectives introduced so far have focused on specific user scenarios - either as an indirect index of the interface and artifact interactions, or directly in animation-based user scenarios sketches. That is, they have been sketches which represent what Richard Buchanan labels 'interactions' among services, interfaces and artifacts (Buchanan 2001). However, sketches can also take on a broader perspective than the individual contexts of the users and instead generate information at what Buchanan describes as a 'systemic level' (Buchanan 2001). 'Systemic' in this regard is not understood as referring to digital systems, but rather to the systematical structure of organisations, groups and other stakeholders on a societal scale, which may be influenced by the proposed design. System perspective sketches use animation to facilitate an overview of the complexities of large systems, abstracting and distorting the systems to create a clearer conceptual model of the essential features of either the existing state or a new proposed state.

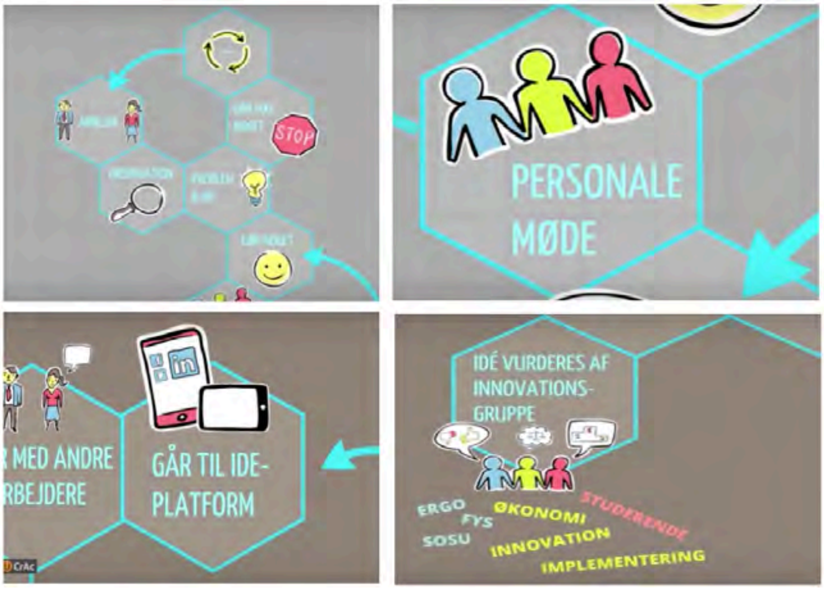


Figure 41: In this sketch, the designers envisioned a new digital service platform, connecting multiple different stakeholder platforms to ease the process of creating new ideas bottom up from the organisation. The designers depicted the possible break downs, and possible solutions by animating an overview of the abstracted flow of information between channels, people and contexts. See sketch at http://goo.gl/k04rds

While system sketches do not necessarily involve the exploration of new technologies, and thus fall out of our scope, we do also observe examples of sketches which explore the influence of new technologies on a systemic scale. For example, animation may be used to represent the flow of information between different societal stakeholders through a proposed service portal.

Five perspectives intertwined

The five perspectives presented form what we see as the ‘genres’ of animation-based sketching in the domain of generating temporal information about non-idiomatic technologies. In practice, the five perspectives are often mixed in the realised sketches - some starting by showing the present, moving on to later show the preferred future state. Others might zoom in and out between up-close interface and artifact interactions to show how these specific interactions affect the systematic scale.

The point of separating them into five specific perspectives is to point out the difference between the *sketch* and actually *sketching* it through animation in the first place. While a sketch might consist of multiple animation-based elements, each of these elements is itself a product of the designer’s sketching process. This process is based on the contingent nature of design, dependent on choice and compromise (Buxton 2010). The designer has an *intent,* which we might relate to our matrix of the investigative, explorative, explanatory and persuasive functions of sketches.

When using animation-based sketching to sketch a certain proposed idea, the designer more or less deliberately frames the problem setting. Whether the aim is to acquire temporal feedback on a specific issue such as the non-idiomatic nature of a given interface interaction or it is to explore the user interactions mediated by a given technology in a given context, the designer's intent frames the perspective of the output sketch. The designer sketches to generate information that can reduce uncertainty, but the process gives the information a specific angle, indicating specific choices and compromises made. If the problem setting at the moment is the non-idiomatic nature of an interface, it would be superfluous and distracting to include too many contextual details. Likewise, if it is technological mediation in the use context which is in focus, the inclusion of details about the fine-grained interface interactions would be superfluous and distracting. Design researcher Bryan Lawson puts it this way: "*...it is usually helpful if the drawing does not show or suggest answers to questions which are not being asked at the time*" (Lawson 2006, 242). That is to say, if they are certain about a given matter, the designers' visual thinking through sketching is not aided by generating fine grained information about it. This is also true of animation-based sketching. The designer chooses which elements to include on the basis of the aim of the sketching process, and this forms the perspective of the sketch.

The animation-based sketches that we see are thus often in a more edited form than when then were originally part of the designer's animation-based sketching process. They have been digitally cut together to form a more coherent sketch. What started as individual and divergent investigative and explorative sketches might later be edited together to create a more explanatory or persuasive sketch which answers questions about the interface and artifact interactions or about positive and negative use scenarios. It may also provide a systematic overview.

THE STRUCTURE - LINEAR NARRATIVES ABOUT INTERACTIVE TECHNOLOGY

Building upon the five archetypical perspectives of animation-based sketching allows us to relate them to the overall structure of the sketches as a temporal sequence. We have previously analysed the perspectives of animation-based sketches in terms of the archetypical structure of a sketch (Vistisen et al 2016). Here we proposed a model showing the rather paradoxical nature of representing non-linear interactive technologies in the linear sequence of an animation. In the model, we fused some of the frequently used tools in explorative user-centred design; archetypical user *personas* (Cooper et al 2011, Nielsen 2012) and design scenarios (Carroll 2000), and explained their role in creating the *narrative of animation-based sketches (next page):*

Figure 42: Framework for creating linear animation-based video sketches which explores new technological concepts with an emphasis on how the users are affected by the concepts, using the plots of the sketch to constantly refer back to the user stances explored.

The persona becomes the characters in different scenarios, thus forming the main plot and sub-plots of the narrative of the use scenario. The interactive technology is inserted into this linear narrative, not just as another diegetic element, but as something which has agency of its own. In a classical narrative sense, based on Greimas' structural narratology (1983), the technology acts as the actantial 'helper' in helping the persona 'subject' to overcome the problem 'opponent' to achieve the preferred user experience as the desired 'objective'.

The animation-based sketch becomes a contextualised and user-focused narrative, telling story about addressing a specific problem in a specific manner. This is true regardless of perspective - a isolated interface & artifact interaction sketch still implicitly implies the presence of a user who acts on the technology with an objective. In the animation-based sketch, the designer frames the problem and represents a proposed solution to the problem in a sequence. After sketching, the sketch becomes a piece of visual communication which encourages the designer, and other stakeholders to comment, critique and propose interpretations that were not consciously integrated in the sketch by the designer. This is why the model has double arrows between the viewer and the sketch: they indicate the common intent of all animation-based sketches, and sketches in general, to facilitate reflection. This is a different type of reflection than the reflection-in-action of designers while they are sketching animation-based sketches; in the latter, the reflections are based on constant choices and compromises in the dialectic between designer and design material.

The viewer's reflection is more akin to reflection in *design critique* (Sennet 2008, Buxton 2010), in which peers comment and act upon the sketches, annotating the sketch with additional information. Some of the viewers might be design peers, able to *read* sketches as sketches and provide precise design critique. Others will be stakeholders from widely different knowledge domains and thus with different foundations for reading and responding to sketches than trained designers (Buxton 2010). That is not to say that the reflections the animation-based sketches invoke in such viewers are uninformed or 'bad'. Rather, they indicate the sensitivity required of the designer in creating a design compromise that balances different knowledge domains and perspectives on the problem. The sequentiality of animation arguably helps create a frame of reference akin to watching a movie, which makes it more natural for most non-designers to form an opinion than rough sketches. Ylirisky & Buur (2007) presented a similar argument about the temporal medium of video as a tool to facilitate a more conscious design process.

The viewers' reflections should enable them to reveal the possible blind spots and ambiguities in the way the designers have framed sketches. Thus, the viewers' reflections upon animation-based sketches are actually reflections upon the intent behind the sketch, as much as they are reflections on the idea expressed.. This is positive, since it incorporates the narrative structure of generating temporal information through animation-based sketching. The viewer interprets both the narrative plot (the proposed idea) and the discourse of *how the plot is told* as a single coherent *narrative discourse* (Genette 1983). The viewers' response to the narrative discourse of animation-based sketches reveals yet another aspect of the archetypical animation-based sketch for us to discuss - the common discourses that are applied.

NARRATIVE DISCOURSES IN ANIMATION-BASED SKETCHES

Earlier in the book, we touched upon David Kirby's (2010) concept of technologies described as 'diegetic'. The term "diegetic" derives from literature and theatre studies and refers to a product whose functions and implementation are true within the ontological boundaries of the narrative of which it is part. A narrative has a story, but it also has all the settings, places, props, technologies, and other signs to support that story (Kirby 2010). Kirby uses the term 'diegetic prototypes' about such diegetic elements in his analysis of science fiction films, in which the visual fidelity of the portrayed technology is too high for the portrayal to be viewed as sketching. However, the terminology is applicable to sketches and prototypes since it describes the discursive way a narrative might *'tell'* us about the potential of new design ideas. This happens in combination with the aforementioned theory of 'possible worlds' (Ryan 1991, Dolezel 1998, Pavel 1975). Herein also is the rhetoric of arguing for the plausibility of the diegetic technological concept if realised.

For example, an imagined design scenarios in which we used a non-existing technology to achieve faster-than-light travel would break the ontological laws of physics and would thus be part of an inaccessible world. On the other hand, a scenario in which we proposed to use an emerging non-idiomatic technology to solve a problem in a given context in a novel way would be ontologically sound and thus be part of an accessible possible world. Thus, diegetic elements in design scenarios differ from those in speculative scenarios which use animation to create seemingly plausible concepts but whose ontological rules differ from our reality. Kirby argues that a diegetic design exists to show that a technology can exist in the real world and has a rhetoric aimed at facilitating discussions about this viability (Kirby 2010). In other words, a focus on the diegetics of the designed elements creates certain discourses through which the animation-based sketch can be expressed.

From our sampling of animation-based sketches, we have inductively categorised patterns of narrative structures which adhere to different ways of dealing with discursive elements such as *frequency, order, voice, mood* and *duration* (Genette 1983). Through this process, we have induced at least six different discursive formations describing how the narrative in animation-based sketches is *told.*

In accordance with genres of common storytelling discourses, we labeled these sketching discourses as:

- ***Natural***
- ***Documentary***
- ***Instructional***
- ***Promotional***
- ***Dramatic***
- ***Comedic.***

Below we will elaborate these discourses one by one.

Natural

Natural discourse seeks to reduce the number of extra-diegetic elements in the sketch, that is, elements which comment on the narrative and exist outside it (e.g. voice over). This discourse of telling involves seeking to establish perception that is as neutral as possible. Technology is shown in use, but how it solves a specific problem is not explicitly shown, and there is not even any indication -that we should focus on the proposed technology. This discourse mostly occurs in the user scenarios perspectives, both positive and negative, but it is also present in some interface & artifact interaction sketches, where the sketch is just showing interactions without much sense of sequence or consequence for the user.

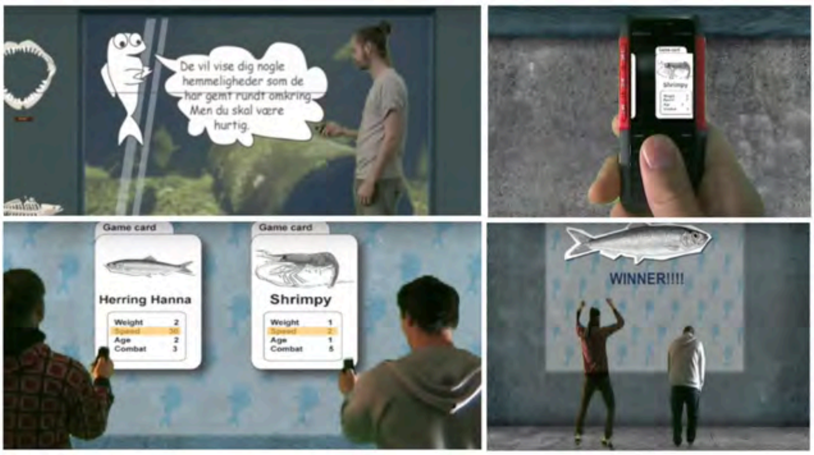


Figure 43: This sketch depicts a user journey through a digitally augmented North Sea Oceanarium aqua zoo. The two users er shown interacting with a series of proposed interactive assistents and mobile experience zones. This is done with no narration, text signs or other non-diegetic elements, establishing a natural setting of the sketch. See sketch at http://goo.gl/HWezsG

This discourse is obviously the most ambiguous of the five, since it leaves extensive gaps for the viewer to fill interpretively, in regard to both the point of viewing the sketch (the plot) and the idea behind the sketch. Consequently, this discourse seems best suited to the investigative and explorative functions of sketching, and less for explaining and persuasion.

Documentary

The discourse of documentary film is often employed when designers use video in design processes (Ylirisky & Buur 2007, Bolvig & Botin 2015). This "creative treatment of actuality" (Ylirisky & Buur 2007) traditionally forms a contract with the viewer that the events portrayed will, to some extent, be identifiable in reality. In these cases, it is not the contract of actuality and factuality with the viewer, but rather the discursive element of telling 'worlds' instead of 'stories' (Sterling 2013) which is driving the discourse.

Figure 44: This sketch uses 3D animation from a level editor of a game engine to portray a documentary walk-through of the 'park of the future'. An animated flyover is portrayed as a very fact-based portrayal of the possible future of the park area of Marselisborg. See sketch at http://goo.gl/x3CkMb

The documentary discourse has multiple variations, such as the presence and role of the narrator, which can be present or stand outside the diegetic elements of documentary. Animation-based sketches which employ this narrative discourse are often used to portray the perspective of a user scenario of the present, since such sketches fits the documentary goal of presenting actuality from a certain perspective. However, some authors have claimed that fiction in documentary can provide a 'documentary of the near future' (Kirby 2010, Forlano 2013).

Instructional

This discourse adopts the same style of telling as many of the animation-based learning concepts discussed in chapter 4, in which animation is used to walk the viewer through the use case of a technology. These sketches undertake a step-by-step walkthrough of the different elements of interactions with the technology in a normative description of how it should be used. The difference between traditional instructional animations and the discourse used in here is the shift in focus, from instruction about 'what is...' to instructions about 'what could be'.

This discourse mostly occurs in user scenarios of the future with a positive perspective and in interface & artifact interaction perspectives. It is quite clear that the discourse is applied to 'mimic' the discourse of traditional instructional animations, leveraging structure, diegetic elements of voice over, text signs and extrapolations to express the use case of the technology.

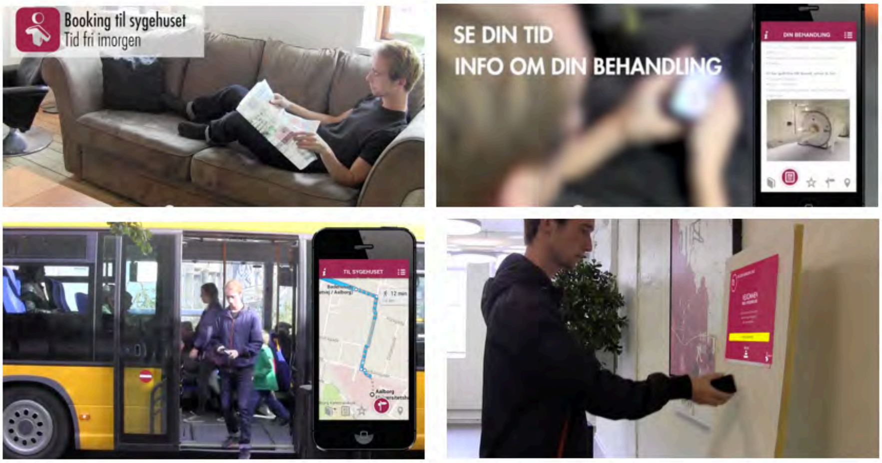


Figure 45: This sketch explores a digital wayfinding solution aimed at reducing wait time at hospitals. Cutting through multiple contextes, the video is supported by animated diegetic interface elements, as well as non-diegetic overlays describing the user journey step by step. As such, the animation-based sketch functions almost as a instruction video, if the proposed concept was to be realised. See sketch at http://goo.gl/2KBJSA

The normative nature of this discourse removes much ambiguity: the sketch 'tells' the viewer something specific, rather than exploring an unfinished concept. Consequently, animation-based sketches using the instructional discourse often fall into the trap of becoming too specific - that is, unless they adopt a rough visual fidelity to set the balance between the normative discourse and the aesthetic appearance of the expressed idea.

Promotional

In the same way as instructional discourse borrows from its non-sketch counterpart, promotional discourse also draws heavily on marketing and the advertising of actual products. This discourse has a clearly persuasive intent and employs tropes aimed rhetorically to gain traction, support and funding for the concepts realisation. Promotional discourse uses animation-based sketching to frame narratives which show the proposed idea from its best sides and hides its ambiguity and unanswered questions. Animation-based sketches using this discourse are in fact often only sketches by virtue of their visual fidelity - they look like sketches - while their intent is more or less solely to gain acceptance by persuasion. Thedanger is that the viewer may be persuaded into thinking that the proposed idea is actually real and realised as it is, a phenomenon typically referred to as 'vapourware' (Sterling 2013). Animation-based sketches with a promotional discourse use fiction in the theatrical sense but must avoid to being perceived as fact.

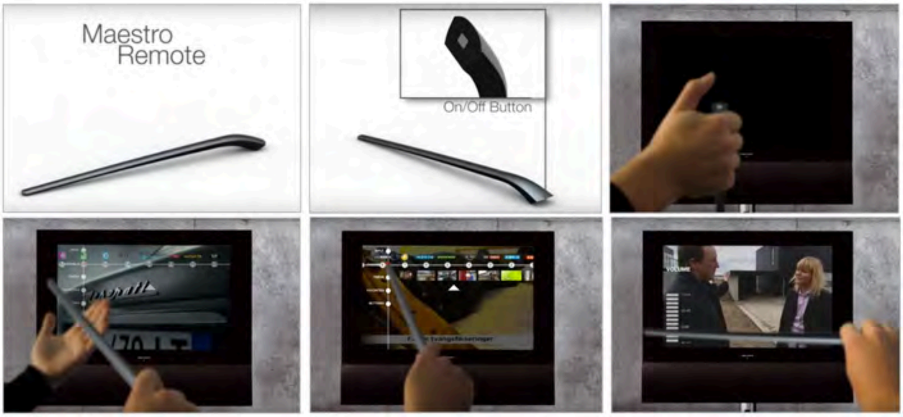


Figure 46: This sketch explores a concept for a gesture controlled interactive television, where the gestures are inspired by the directing motions of a musical maestro. The sketch initiates by presenting the physical remote, and then continues on to highlight the features via a series of keyframed interaction examples. The animation is more polished and uniform in its techniques and materials, creating an expression which could be easily mistaken as a real promotion of a real product. See sketch at http://goo.gl/XIlCRX

This illustrates a paradox of both promotional discourse, and the persuasive function of sketching in general: can they really be thought of as sketches? A way to establish that it is fair to use the concept of sketching in relation to expressions with a persuasive intent can be found by returning to Bruce Sterling's analysis of 'design fiction'. Design fiction is *"the deliberate use of diegetic prototypes to suspend disbelief about change"* (Sterling 2011). The important part here is the 'suspension of disbelief', since it tells us that the use of fiction to express design ideas has a built-in ethics. An animation-based sketch with a promotional discourse can 'advertise the near future' as a creative way of taking the viewer into proposed conceptual space, and then letting them go again to reflect upon what was experienced again. Sherdrof & Noessel (2012) further argue that such fictions enable the viewer to look for ways to apologise for the design; that is, they think about ways in which the design could work in the way it is depicted, if it were to be realised. We use what works in a promotional narrative discourse to arrive at new ideas and decisions. As vehicles that aim to enable reflections about preferred future states by overcoming the barriers formed by preconceptions, promotional discourse and persuasive intent are arguably a viable mode of animation-based sketching.

Comedic

This discourse leverages the qualities and tropes of popular fiction to create an engaging narrative about the proposed technology by using humour as both a disarming and ambiguous instrument. These sketches often use slap stick elements, in which the persona characters in the animation-based sketch 'fool around' or ironically show the role of the proposed idea in context. In animation-based sketches of both positive and negative user scenarios, the comedic discourse can serve to emphasise the nature of the sequence as a 'sketch'. This is also noted by other scholars such as Buxton (2010) and Laurel (1993), who examine the role of play in design processes and its frequently humorous side effects. While the trope of narrative comedy is as old as storytelling itself (Aristotle 1996), when used for sketching this discourse sometimes affects the output sketches in a less favorable manner. The risk is that the comedic discourse may divert attention from the proposed design idea so that the animation-based sketch essentially becomes nothing more than a comedic ‘sketch’. Nevertheless, animation-based sketches using comedic discourse in tandem with enactments such as bodystorming (Oulasvirta et al 2003) seem to support the process when there is an explorative intent behind the sketches. The comedic discourse may lower the participatory barrier for some to act out the idea in a user scenario perspective, augmenting the acting with animated effects to support the explorations.

Figure 47: A sketch portraying a gamification concept aimed a facilitating partent to child conversation about the negative effects of narcotics. The sketch uses keyframed animation of the mobile game interface and game elements, but uses a highly ironic tone in both the graphism, the animated effects, and the live actors responses to the animated content. This creates a more comedic take on the concept idea, underscoring the sketchy nature, but also questions the the validity of the idea. See the sketch at http://goo.gl/QdEABl

Its often slapstick appearance and lack of explanatory focus should not lead comedic discourse to be discounted if the process of making the sketch has a beneficial investigative and explorative function internally in the design team. It remains however, a discourse which walks a fine line between using humour to suspend disbelief and simply distracting focus from the idea.

Dramatic

Dramatic discourse uses storytelling to make user scenarios from either positive or negative perspectives come to life in a poetic structure resembling classic narrative structures such as the actantial model (Greimas 1983) and the Hollywood model (Harms-Larsen 2003). These sketches take on the properties of other types of dramatic content, like animated feature films, by employing characters, conflict and actions to dissolve the conflict. While the four other discourses also uses narrative structure to a greater or lesser degree, dramatic discourse does not break the narrative in the same way as the ‘sales pitch’ of promotional discours or the ‘step by step guide’ of instructional discours.

Figure 48: This sketch depicts a user journey through an augmented reality experience at cultural heritage context, in which the sketch is organised as a clear narrative. The users go through the full user journey, and the live actors act like they are fully immersed in the experience. The dramatic structure of a beginning, middle and end is clearly present, and the use of various animation techniques are used to support diegetic elements at each phase. See sketch at http://goo.gl/64Ga6o

Dramatic discourse could be seen as a ‘meta discourse’ for the other four discourses, since the dramatic structure forms the basis of most other story telling structures (Aristotle 1996). This means that just as one animation-based sketch can combine several perspectives,, it can also contain more than one discourse, but almost always with the narrative discourse as the foundational layer. However, the dramatic discourse of animation-based sketching differs from the dramatic discourse of traditional storytelling, since the character personas in the sketch share the lead role with the proposed technology, which is normally ‘just a diegetic prop’ in the story. The central role of the diegetic design indicates that the sketching of the sketch has not been undertaken to construct a compelling drama for an audience to experience. Instead is has been to construct a drama around the diegetic element and to get people to concentrate on how that technology enables the drama - rather than how the entire story world unfolds. Thus, the dramatic discourse is not aimed at fiction: it is aimed at design and uses fiction to get there.

A narrative about 'what could be'

Supporting the design process is central to all five discourses. Whether the intended function of the animation-based sketches is investigative, explorative, explanatory or persuasive, the perspective and narrative discourses serve as a frame of reference for the evaluation of the potential facts of the design proposal. When used to explore non-idiomatic temporal issues involved in the interaction design of a new technology and the user experience in a given context, the discourse helps us create materialised thought experiments (Bleecker 2009) about 'what could be'. As touched upon earlier in this book, the abductive sensemaking of design synthesis, is thus manifested in the way in which the animation-based sketches tell a story about these thought experiments. They amount to qualified guesses: 'If these conditions were in place, these events might occur for the users in this context'. Moreover, they allow the designer and others to reflect upon the utility, usability and desirability of that outcome.

VISUAL VS. TEMPORAL FIDELITY

The abductive logic of the arguments presented by animation-based sketches is based on the way in which the perspective tells us *what* the sketch expresses, and on the narrative discourse telling *how* it is expressed. There is however also an important addition to this argument in the aesthetic *looks* of the sketch. Thus, one last thing to discuss about the general anatomy of an animation-based sketch is the fidelity of the different rendering styles commonly used in the sketches we have sampled.

As one of his central arguments, Buxton completely dismisses the notion of 'high' and 'low' fidelity renderings in design and instead proposes that any appropriately used technique is always the 'right fidelity' (Buxton 2010, 295). He does so in referencing McCloud's concept of *amplification through simplification,* which we also touched upon earlier in this book (McCloud 1994). Buxton argues that the fidelity of a sketched rendering can actually be higher than reality in terms of experiential feedback about the design problem in early design. We agree with this notion but still argue that the distinctions in fidelity are valid distinctions, especially in regard to animation-based sketching. Creating even a crude and simple animation takes longer than, say, drawing a crude stick man on a piece of paper. Consequently, we argue that animation-based sketching involves at least two types of fidelity: visual fidelity and temporal fidelity.

It is visual fidelity that is discussed in most studies which address the fidelity issue (Walker et al 2002, Sefelin et al 2003, Rudd & Isensee 1996). The question concerns how 'finished' the produced sketch (or prototype for that matter) looks in terms of rendering quality. A hand drawn paper sketch with jaggy lines in black and white would be considered low fidelity, and a Photoshop drawn computer wireframe with clear typography and iconography would be considered high fidelity. As discussed previously, one cannot judge one approach to be inherently better than the other, since the value is completely dependent on the questions raised at a given time in the process. It makes more sense to conclude that the sketching approach and the sketch output clearly speak in a visual vocabulary and that it is through this vocabulary that the sketch informs us of the character of its fidelity. Buxton includes an intriguing example of the sketches of a new mountain bike prototype, which gradually evolve from a rough drawing to a more and more refined model in a CAD drawing software program (Buxton 2010, 110).

Figure 49: Buxton's examples of gradually more and more refined renderings of a mountain bike.

Buxton shows that the sketches of the same product tells us inherently different things about the issues each addresses, some concerned with the overall concept ('this is just one of our many ideas') and others concerned with details ('this specific structure in the idea needs special focus'). The point is that the way a sketch 'speaks' to us about its fidelity helps us decide how to approach the sketch in our reflections - should we put the details under scrutiny or focus on the overall concept? During sketching as a reflective process, the level of fidelity also determines which aspects of the design problem the designer will address at a given time and which will be left out. In a sense, visual fidelity is actually what defines the framing of the design setting in sketching.

Temporal fidelity is a tangent to visual fidelity. In design situations without established idioms for how the dynamics of a digital technology will affect the users interaction and user experience in context, visual fidelity is not the only variable. Whether they employ deep graphical detail or only use crude and unfinished renderings, static sketches only expresses aspects about interactions and dynamics to the extent that available idioms act as frames of reference. Animation-based sketching generates temporal information to fill these non-idiomatic gaps.

When dealing with non-idiomatic design problems of temporality, the designer frames the design problem in terms of the level of temporal fidelity of the specific animation-based sketching techniques, materials and tools applied. Thus it makes sense to describe temporal fidelity in terms of 'low' and 'high', as one does with visual fidelity. It might be argued that the fidelity of apparent movement and change is also an aspect of visual fidelity. In non-idiomatic design situations, however, it makes sense to separate the two fidelities, since we might mix a low-fidelity visual representation with a high-fidelity temporal expression, and vice versa. In the designer's sketching, it might make sense to take hand drawn visuals and use animation to move elements around to explore the details of a proposed interaction modality. In the same way, the temporal fidelity of an animation-based sketch tells other stakeholders something about which aspects of the dynamics in the design provide the focus of the sketch, thus guiding their interpretations, critique and proposals towards the appropriate temporal aspect.

Temporal fidelity and visual fidelity are thus two central aspects in the abductive sensemaking of animation-based sketching, indicating which details of the argument to focus on, and the level of detail required to assess their index to reality.

CHOICES ON ALL ANATOMICAL LEVELS

We have now discussed four fundamental anatomical aspects of animation-based sketches: perspective, discourse, intent and fidelity. Each aspect allows deeper reflections on other sub-categories than the ones presented, such as specific animation techniques, specific repetitive storytelling aspects, and ways of combining different aspects in the same sketch. We argue, however, that these aspects constitute the macro level aspects that an animation-based sketch can represent. What can be derived from the four aspects is a return to our notion of the contingency of design and to Buxton's notion of 'design as choice' (Buxton 2010, 145).

Given that the animation-based sketch inserts a non-linear technology into a linear sequence, the perspective, discourse, intent and fidelity of this sequence are all based upon non-coincidental choices by the designer. Sometimes the choices might be made to frame a certain aspect of the non-idiomatic problem in the way that is most practical for the designer. At other times the choices might be based upon a wish to portray the interaction design of an idea and user experience as elegantly as possible. In either case, in the use of animation to emulate a digital system by creating a narrative sequence, complete objectivity can never really be achieved. Just as animation can never be neutral (Wells 1998), the choice of what to sketch and how to sketch involves choosing something and leaving something else out. Design sketching, and especially animation-based sketching, is all about these contingent choices throughout the design process before the production of a realised 'product', which stands as the fossilised remains of all the choices made.on the journey to completion.

The aspects of animation-based sketching on a macro level, which we have proposed on the basis of the sampled sketches can now be viewed as series of categories. The categories are not meant to read as a strict scheme, but rather as a way of highlighting the different mix of choices that are possible. On the horizontal level, we can describe a given animation-based sketch by highlighting its use of one or more of each of the vertical aspects, thus describing its overall anatomy.

PERSPECTIVE	DISCOURSE	INTENT	FIDELITY
Isolated interface & artifact interaction	Natural	Investigative	High Visual
Use scenario - present	Documentary	Explorative	Low visual
Use scenario - positive	Instructional	Explanatory	
Use scenario - negative	Comedic	Persuasive	High Temporal
Systemic view	Dramatic		Low Temporal

Figure 50: The final framework of the anatomy of animation-based sketches, with five perspectives, five discourses, four intended functions, and four types of fidelity.

This anatomy does not specify the technical aspects of how the animations were done or the reflective process in which the designer may have iterated back and forth in the production environment. Instead, it gives us a tentative overview of the potential structures that an animation-based sketch might assume when creating an abductive argument of 'what if?' is proposed. This argument contains temporal information from a given perspective with a given fidelity, a given discourse, and a given intent.

ANIMATION-BASED SKETCHING - A DISTINCTIVE DESIGN APPROACH

We have now reached the end of part II of this book, and reached a definition of animation-based sketching.

We define animation-based sketching as:
Using animation to portray a fictional reality - aimed at becoming fact

Furthermore, we have distinguished between animation-based sketching and the concept of functional animation. Even though animation-based sketching and the way in which functional animation uses animation outside the scope of entertainment and art overlap, , animation-based sketching differs in that it is still closely related to the use of animation in the fictional domain. This kinship to animated fiction is further evident in our mapping of archetypical animation-based sketches, which take on perspectives and discourses from narrative genres of fiction. In other words, animation-based sketching in its many variations occupies its own ontological place in animation and design studies.

The final part of the book moves from theoretical studies of animation-based sketching to an examination of the practical application in design processes.

PART III - APPLYING THE APPROACH

The third part of this book turns to the applied side of animation-based sketching in search of practice-based examples of the multitude of methods, techniques and tools that can be used for sketching with animation. This section draws on examples from empirical material, and it reports small-scale experiments that showcase specifics techniques as well as the design knowledge we can extract by use of the technique in design sketching.

We begin by discussing the core principles of digital production environments that are suitable for animation-based sketching. This allows us to assess the important distinction between being able to make something which looks like a sketch and actually being able to conduct the process of sketching as visual thinking in a digital production environment.

Subsequently, we present the results from two workshop experiments in which we explore how animation-based sketching can be applied by designers with little animation expertise. We also assess the potential of adopting animation-based sketching as a viable design approach. We pursue the same line in examining two case studies from praxis. The case studies explore various attempts to apply animation-based sketching in praxis.

These empirical investigations were conducted as explorative studies that sought to 'expand' knowledge about the field of animation-based sketching in practice. We borrowed this notion from Krogh et al (2015) and their notion of 'drifting' in design research, which involves letting the empirical observations take us through multiple different instances of the animation-based sketching being applied. These observations are not necessarily linked, especially not between the different cases, but, in their disparate areas, they all the expansion of knowledge about animation-based sketching. The studies covered in this chapter are:

- **User-Driven Creative Academy (workshop):**
  Through this workshop study I experiment with introducing animation-based sketching to design students with little or no previous experiences with animation or temporal sketching.
- **Service Systems Design in Copenhagen (workshop):**
  Through this second workshop study I continue the track of study B, but in a more constrained setting, to explore wether animation-based sketching is viable to apply in constrained settings.
- **Design of the 'North Sea Movie Maker' application:**
  Through a year long involvement with the North Sea Oceanarium, I explore animation-based sketching applied in practice, throughout the entire design process,
- **Facilitating the design of game concept with external agency:**
  Through this final study, I experiment with introducing animation-based sketching in an existing design practice, and through a case of designing a new mobile game, reflect upon the possible benefits and challenges of integrating the approach into practice.

CHAPTER 9: THE PRODUCTION ENVIRONMENT

In this chapter, we discuss some of the quality criteria for the digital production environments of animation-based sketching. Rather than investigating the features of specific software packages in depth, we seek instead to condense the features needed in present and future production environments to enable both the production of sketches and a reflective sketching process.

We identify the following criteria:

- *An interactive timeline or control mechanism* that is akin to timeline controls to enable an iterative back and forth exploration while the designer is using animation-based sketching.

- *Live preview of the animation-based sketch* that can establish the reflective practice of sketching, whereby the designer constantly receives temporal feedback from his temporal sketching using animation.

- *A component library (graphism)* that can either create or import graphical components to be used in the designed motion or change to create the graphism of animation

- *Reusable components and animations* which use the component library to save configurations of both graphism and animation to be reused in other sketches. This establishes a more efficient pipeline for sketching, making the process more practical and thus facilitating the generation of more information

- *Sketches as components in layers of other sketches -* here, entire animation-based sketches as output emulators are used in multilayer edits with a new animation-based sketch to function in a pipeline, but in entire sketched sequences rather than as individual graphical or animated components.

These quality criteria are not necessarily existing in all production environments, which is why we often see animation-based sketching being conducted through a multitude of different software and hardware environments.

THE CHALLENGE OF DIGITAL SKETCHING

Sampling digital design software and providing informed commentary about that software involves a race against obsolescence. Whenever a new set of instructions or a new guide book is published, it only remain relevant until the next version of the software changes everything, or until a new piece of software completely replaces it. The same often goes for design literature which attempts to recommend software to operationalise the principles, methods and theoretical frameworks presented for a design topic (see Unger 2009, Buxton 2010, Löwgren & Stolterman 2004, Greenberg et al 2012). These recommendations tend to become obsolete after only a few years, and the principles and interactions are not transferable to other software packages. Consequently, we will not examine the specific details of examples of digital software for use in animation-based sketching, or the guides to their use. Rather, we will seek to discuss some of the qualities that we argue must be present in the production environment of animation-based sketching to facilitate the reflective practice of sketching and to enable the myriad of different animation techniques applicable in design.

When it comes to broadening the concept of sketching, digital sketching environments have long been of interest to the design community (Goldschmidt 1994, Djik 1995, Landay & Myers 1995). Goldschmidt (1994) argued that no computerised tool could surpass the visual thinking enabled by sketching but that the computer might be adapted to simulate the qualities of sketching to the point of allowing visual thinking on a par with pen and paper - or even better.

The problem, however, has precisely been that much of the ambition in digital sketching has been directed at replicating the qualities of pen and paper in digital formats (Wu et al 2012, Djik 1995, Jonson 2005). Arguably, this could in part be because of the more specialised competencies required to use digital software for design. Coyne et al. (2002) found in their studies, that lac of experience with computing seemed to limit design capabilities. Using digital tools demands a form of digital literacy that requires the designer to understand different conceptual models for each type of software applied. This amounts to a rise in complexity from sketching thoughts down on paper.

A focus on reproducing or remediating pen and paper may lead to a failure to notice important ways in which digital systems have the potential to facilitate sketching. Landay & Myers (1995) suggested the need for computerised tools, which allow rough design ideas to be sketched quickly while offering the features associated with digitals tools: *easy to edit, store, duplicate, modify,* and *search*. As such, computer-based sketching tools should leave the 'design memory' embedded in the discrete interactions with the software, thus producing a memory of the *design moves* in the terms proposed by Schön & Wiggins (1992). Design moves reducing uncertainty about the problem setting and problem solving possibilities do not need to be constrained to simulated pen & paper on a monitor: they can also be applied to the process involved (e.g. digital animation), thus facilitating temporal sketching.

Can digital sketches be investigative?

In Chapter 1, we discussed the four functions of sketching derived from Olofsson & Sjölen's (2007) categorisations, and there we argued that these functions changed according to the situation in which the sketch was used. This represented the intertwined relation between sketching as visual thinking and sketching as visual communication. An investigative sketch made by a designer as a way of thinking through a design problem might later be used as the basis for an explanatory sketch shown to an external stakeholder. It could be adapted by just adding a few annotations and pitching it differently.

The investigative function of sketching is interesting when it comes to digital sketching, that is, sketching with a material which has no material qualities in itself. As Landay and Myers (1995) have suggested, computerised sketching potentially gives the same editing variables and manipulative variables as any other digital production environment. In essence, this mean that in the creation of a sketch in a digital production environment, 'the sketch' never really exists until it is saved or exported into a finite output version. During the process, digital sketching may involve a constant flux of different design moves captured in a material which can change in an instant and erase any trace of what was sketched. This is very different from traditional pen and paper sketching, or, for that matter, sketching in almost any physical material. In sketching on paper, design moves are captured physically, and they stay captured alongside the next sketch or the annotations on top of the first. This raises a question: can digital sketches ever really be said to be investigative, or do investigative sketches only exist momentarily in the digital sketching process itself?

At the very least, it seems reasonable to suggest that digital sketching in almost any form is different from analogue in terms of investigative intent, in that it it does not 'save' the design moves unless the designer or the production environment deliberately chooses to do so, creating a fixed *version* of the digital sketch. This adheres to what media philosopher Lev Manovich has labeled *the variation principles* of the digital medium:

> *"A new media object is not something fixed once and for all but can exist in different, potentially infinite, versions"*
>
> (Manovich, 2001, 36.

If one adopts this train of thought, a digital sketch can be defined as a new media object which can exist in potentially infinite versions. This challenges the capturing of the investigative sketches done via digital sketching. This important challenge leads us to an examination of the inherent qualities of the multitude of potential production environments for animation-based sketching.

LESSON LEARNED:

The design moves of a digital sketch are not fixed in the same way as in static (physical) sketching. A digital sketch is essentially only investigative while the designer is sketching inside the production environment, unless the designer or the production environment constantly creates output versions of every design move.

THE PRODUCTION ENVIRONMENT OF ANIMATION-BASED SKETCHING

We have already briefly discussed animation software such as K-Sketch (Davis et al 2008), 'Sketch-n-Stretch' (Sohn & Choy 2010) and idAnimate (Quevedo-Fernández & Martens 2012) as dedicated animation-based sketching environments.

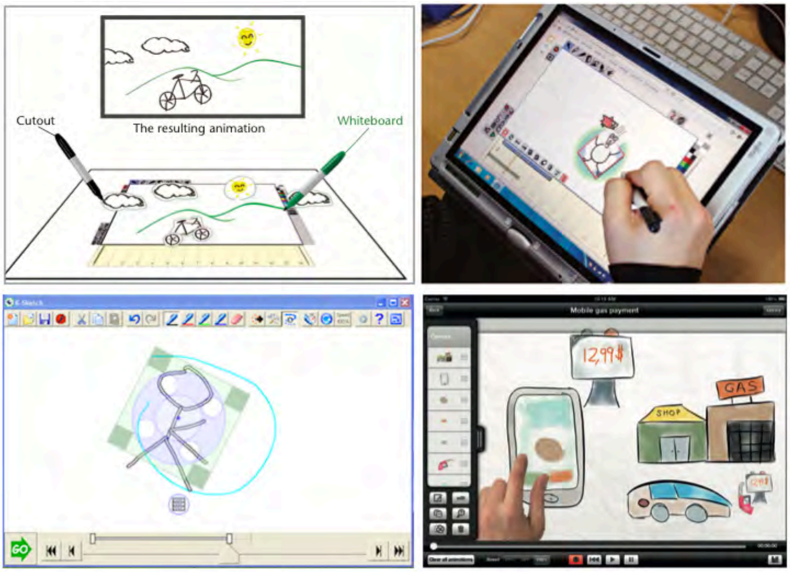


Figure 51: The examples of Stretch n' Sketch, K-Sketch and idAnimate - all specialised production environments for using animation in design sketching.

As we said earlier, these software contributions deserve praise for their attempt to lower both the participatory barrier and the time cost of creating animation, but they also limit the sketching process to a few materials or techniques. As production environments, however, animation and authoring software do illustrate some of the essential features needed to enable animation-based sketching.

The interactive timeline

First and foremost, all the previous approximations enable an iterative back and forth process in activities by representing a *timeline* in the production environment. The timeline allows the designer to obtain temporal feedback on the arrangement of graphic positions by iteratively cycling back and forth in design moves. This enables the investigative function of sketching, and we would argue that it enables reflection-in-action for the animation-based sketching process. Not limited by sequential playback and with the possibility to preview and adjust the arranged positions, the designer constructs new information in a reflective dialogue with the digital material. This echoes the lessons learned from the studies of animation-based learning, where Tversky et al (2002) found that *interactivity* was essential for the students' understanding of the phenomenon. Likewise, the ability of the timeline to facilitate the production of easy-to-edit material in iterative design moves is enabled by interactivity between graphical content and the arrangement of movement and change in that content.

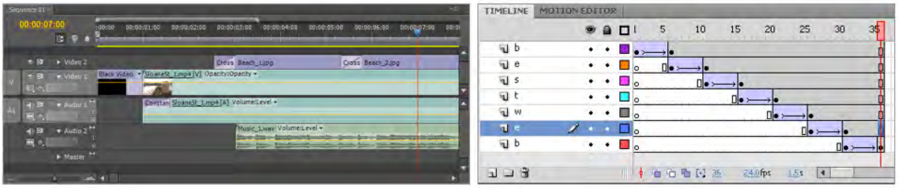


Figure 52: Examples of interactive timelines in Adobe Premiere (left) and Adobe Flash (right), enabling back and forth exploration of the configured motion.

The interactive timeline is an essential quality, but it can be replaced. Promising results have been obtained in recent attempts to sketch using responsive code (Lindel 2012, Forsén et al 2010) in production environments which combine animation with code. Here the timeline is replaced by algorithmic variables which give the designer the same iterative back and forth adjustments of the animated positions as afforded by a timeline. Designer and academic Bret Victor has produced an intriguing example of code-based sketching of temporal information (Victor, 2012).

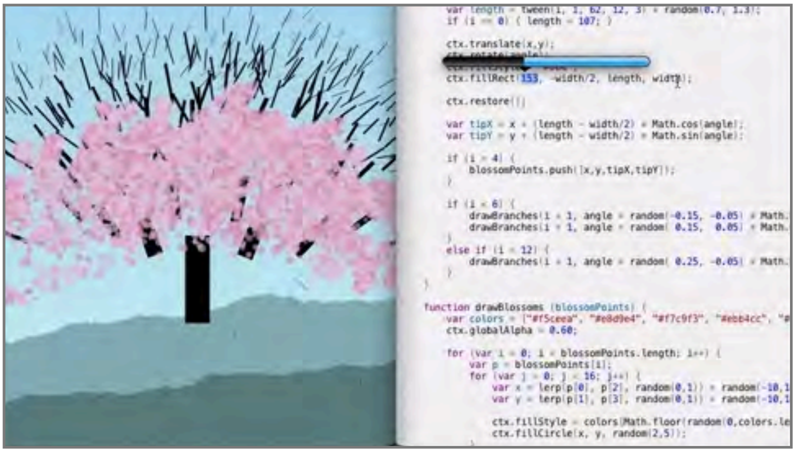


Figure 53: Victor's demo software showcasing how interactive control of the configuration of animation does not necessarily bound to a timeline metaphor, but might as well be enabled by responsive program code.

Although only exhibited as a closed setup, Victor's demo shows that what we label 'interactive timeline control' might easily be replaced by other interactive features enabling the iterative feedback loop of sketching. The important aspect of this criterion is direct temporal control, the ability to go back and make quick adjustments without having to redo the animation completely, and live preview. Live preview is important enough to constitute a quality criterion in its own right.

Live-preview

Another feature of animation-based sketching environments that can be derived from the importance of interactivity in the timeline or from variables that control features akin to the timeline is the capability of *live-preview*. Live-view is a basic feature of many video editing environments, where the applied changes to a video clip (e.g. the cut between to clips or the adding of colour filter) are rendered and displayed live or close to live. In most video editing software, the ability to live preview is determined by the processing power of the hardware running the machine; that is to say, faster hardware allows live-preview of a larger amount of content. In production environments traditionally used for animation, however, the fidelity of the content to be animated is often so high and the motion to be created so complex that live preview is not feasible. In the animation of a complex 3D figure with high resolution textures, the animation of the pose-to-pose animation can only be achieved using commonly available hardware by *rendering* the sequence. Rendering calculates all the changes in the sequence, frame by frame, and often makes the production environment unavailable in the meantime.

This is acceptable and more or less part of practice for animators, movie editors and other practitioners using authoring software in general. In design sketching, however, the lack of design preview essentially rules out reflective practice. When the designer is required to wait for a sketched sequence to be rendered or is held back by a preview which does not run at live speed, the iterative adjustment of positions is limited, as is the reflective dialogue with the material. The lack of live-preview leads to another type of reflective process, in which the designer develops the idea, maybe in another medium, and plans its execution prior to using the animation production environment. In this way, the output might both look like an animation-based sketch and be framed as a proposal, both in terms of Buxton's sketching characteristics and in accordance with the optic of information generation. Thus, it could be described as an animation-based sketch, but it would not qualify as a product of animation-based sketching, since only limited reflective practice was possible in the production environment – or none at all.

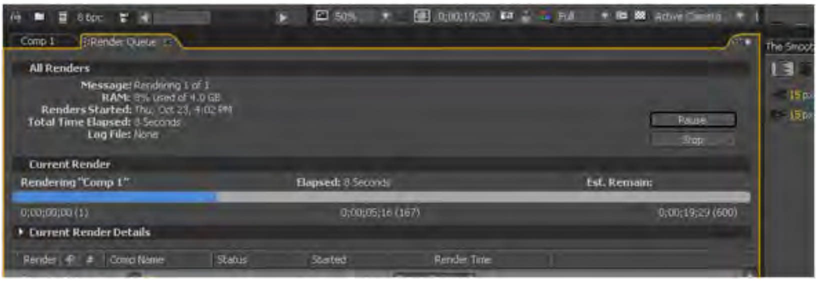


Figure 54: An example of Adobe After Effects, and the 'RAM rendering' process necessary to preview animated content, making it hard to get immediate feedback from the sketching material.

It may be useful to compare two examples of production environments: Adobe Premiere Pro and Adobe After Effects (adobe.com). Although they look alike, they create different sketching conditions. We set out to create a quick conceptual mobile app sketch in both production environments. We used the timeline and the different features of the software packages to animate movement in the interface and in some effects in the context. In Adobe Premiere, which offers video editing with limited animation capabilities, we were able to sketch back and forth in the timeline, investigating different ways in which the app interface would behave with constant live-preview. Through the live-preview, we constantly generated temporal information and received temporal feedback in what we would argue was a reflective dialogue with the material. In Adobe After Effects, which is specifically aimed at creating special effects, we were quickly forced to render our production to preview the interface behaviour. In other words, we had to break off from our sketching process for a while to gain temporal feedback, then return to make new configurations, and then break the sketching process for a new rendering. While the temporal fidelity of the information generated through After Effects was arguably more detailed and fine grained, the process of creating the sketches was a constant process of imagining how something should be and then just executing it; that is, it was production rather than sketching.

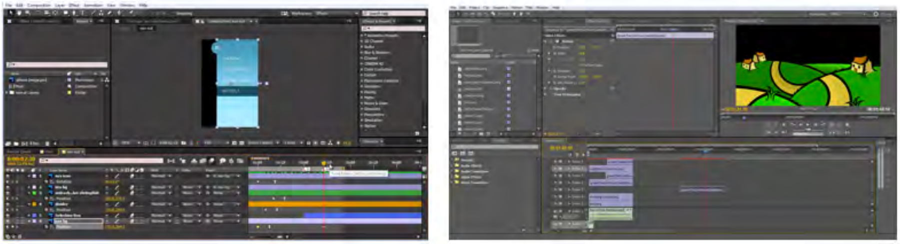


Figure 55: Adobe After Effects (left) and Adobe Premiere (right) both featuring the timeline metaphor, but with Adobe Premiere able to live preview simple animations, whereas After Effects can make more complex animations, but with limited live preview for feedback in the sketching process.

This demonstrates the importance of live preview for the use of digital production environments in sketching and especially why it is essential for sketching with animation. If the designer cannot reflect-in-action but constantly faces 'break downs' in the design tools, the reflective practice of sketching will be inhibited. Löwgren expressed similar concerns in reflecting upon his experiences with animated use sketches (Löwgren 2004); they took more than 24 work hours to complete. Löwgren notes that while the animated use sketches looked like sketches, their purpose was to visually communicate the tentativeness of the idea, not a characteristic of actual the process.

Of course, one might argue that this comparison merely reflects the fact that the hardware running the software is not equally potent: a stronger computer could probably enable universal live-preview in Adobe After Effects. While this might be true here and for other potential advanced production environments for sketching such as 3D Studio Max and Maya (autodesk.com), it does not change the fact that live-preview is an essential quality needed for the production environments of animation-based sketching. While it may be subject to both hardware and software limitations, the principle stands as an important factor in assessing the appropriacy of a given software for animation-based sketching purposes. Furthermore, this is where the dedicated purpose contributions of idAnimate, K-Sketch and Sketch-n-Stretch have the advantage: they were specifically developed to create sketches, and thus they are also suited to live preview. This illustrates the compromise of being limited to one set of animation techniques, which ensures that sketching can happen, but also somewhat limits the sketching capacity.

DESIGNING GRAPHISM AND DESIGNING MOTION

Observation of idAnimate, K-Sketch and Sketch-n-Stretch reveals a pattern in how the content of animation-based sketching is both created and manipulated. Whether hand drawn digitally or imported as graphical elements from other sources, the three types of animation software all separate the design of graphical elements from the design of motion and change. This echoes McLaren's notion of *graphism* (Sifianos 1995), touched upon in part I, as involving something more than deciding upon and manipulating the difference between positions over time. We see this division in play in production environments usable for animation-based sketching - the graphical elements are designed prior to animation and used as *components* in the sketch.

Graphical components

The notion of components or assets is a concept commonly used in both video production, animation and software development (Rosenstand 2002). Regardless of production environment, a component library is invariably featured in made-to-sketch software such as idAnimate, K-Sketch and Sketch-n-Stretch and in general purpose software such as Adobe Premiere and After Effects:

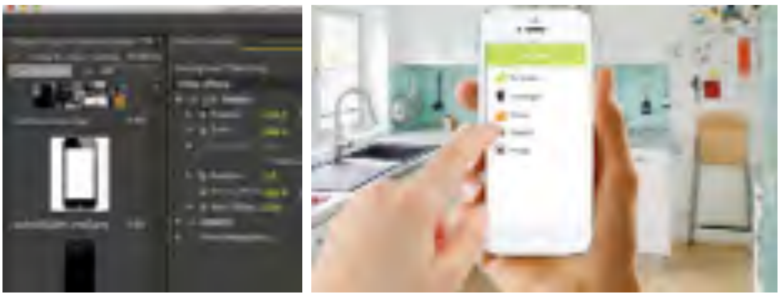


Figure 56: The different graphism components in the production environment (left) applied in specific configured instances in the animation-based sketch (right)

These libraries contain the graphics previously created by capturing material, by designing it digitally or by gathering pre-made material digitally or physically. This is where the variety of graphical materials that can be used for sketching comes into play – for example, the components can be clay, paper drawings, cut outs, puppets, pixelated humans, or digital 2D and 3D content. The production environment for the components might not be digital in the first place, and this is the case when a camera is used to capture hand drawn sketches in various poses for use in stop motion animation.

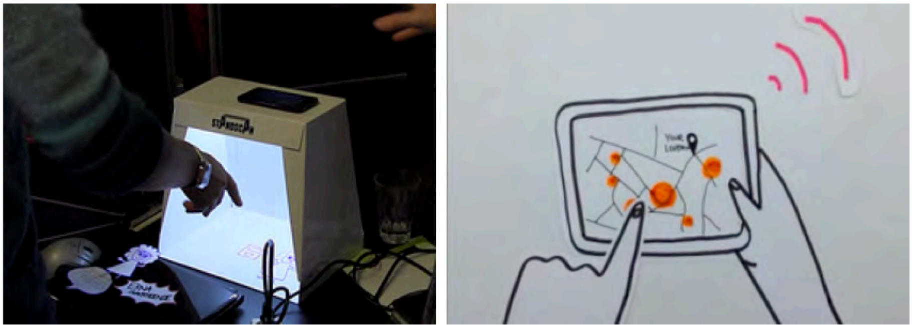


Figure 57: An examples of using cardboard stands to capture frames for stop motion (left) which are later assembled in a timeline as a digital sketch (right)

Sometimes, the production environment itself contains the design tools needed to actually produce graphical elements and then create motion or change (e.g. Adobe Flash and 3D Studio Max). This is also true for the limited material possibilities of idAnimate, K-Sketch and Sketch-n-Stretch. Another core quality of the production environment of animation-based sketching is that it supports either the creation or import of components which can be used in animation. The creation of graphical components thus adheres to the *apprehension principle* of effective graphics: the aesthetics of the components should be conceived in connection to the domain and directed at the functional aspects of *what* information we should gain from watching the graphics at any given moment.

Reusability in the sketching pipeline

It is a major advantage if the production environment further enables the designer to *reuse* the graphical components over and over in multiple animation-based sketches. For example, the same animated character might be used and animated differently in different user scenario sketches. Some production environments even allow the user to save the configured animations as components in themselves. This makes it faster and easier to reuse temporal information, which can then be assessed in another user scenario, for example, or in a completely different concept. The re-use of either graphics or temporal components is not as essential a quality as the timeline editor or live-preview, but it is still a quality which supports the practical application of animation-based sketching.

Figure 58: Multiple components bein reused in different stop motion sketches - like using the same graphical figures and context, with new technology concepts introduced in each.

We saw an example of this a workshop series with service design students in Copenhagen in 2014 and 2015. Some of the groups of design students focused on reusing the graphical elements produced, and they used Adobe Premiere to save presets for different interface animations, frame by frame movement paths, etc. (Appendix 3.2.1, and 3.2.10). Instead of constantly recreating the graphics of the sketches, they reused this library to focus their animation-based sketching on generating information about the temporal dynamics of their proposed ideas. These students managed to produce far more animation-based sketches than the other groups in the workshop. Since the sketches were then used to explore more concept ideas than the other groups could manage, this may amount to a strengthening of reflective practice. It also created an effective pipeline of graphical components and animation presets, which became a catalyst enabling animation-based sketching in the group's design process. The important thing to note here is how it is only the idiomatic aspects of the sketches which are reused throughout multiple sketches (e.g. characters, everyday objects, and standard interface components), whereas the non-idiomatic aspects of the proposed concept was the unique element produced for each individual sketch.

One sketch as a component in another sketch

Alongside the multiple different animation materials, tools, digital production environments and pipelines of reusable graphical components is the possibility of *exporting* the animation-based sketch into a playback medium - often separated from the production environment itself. At the instant the sketch leaves the production environment, the animation-based sketch as an emulator of another digital system is essentially complete, since it is now represents a *fixed* emulation of one specific scripted instance of the proposed idea displayed over time. But this may also mean that the entire animation-based sketch is now a design component in its own right, with the potential to be used in other sketches. This is not a dynamic of traditional physical sketching; it is possible due to the digital material. The output sketch can thus be seen as part of an ongoing sketching pipeline. Here, entire sequences are reused in other sketches, which either feature the same interaction or use the original sketch and features in the production environment to manipulate the visual and/or temporal fidelity of the original sketch.

The use of sketches in other sketches often draws on the ability of certain production environments to edit in 'layers'. Here, graphical components can be placed on top of each other in layers which can be manipulated independently and which thus also contain different animated properties. In one layer, an animation-based sketch, from an isolated interface and artifact interaction perspective, may be resized and repositioned to fit in the context of a character in a different layer of the production environment. In this way, layers not only make it possible to arrange different graphical elements in relation to each other, but also to reframe the problem setting of prior sketches entirely. What once was an independent sketch used to generate temporal information for the investigation of an interface might later be reused as an animated component in an explanatory user scenario.

Figure 59: This sketch explored a 'smart garden' concept in which caretakers could control experience stimuli in a care facilities sense graden. The designer had initially explored an animated interface sketch to learn about the interface constraints of such device. Later on the sketch was reused in a user scenario sketch, now placed inside a live action context to explore the contextual setup of the proposed concept.

In this regard, the reuse of sketches in sketching new ideas is subject to the *congruence principle*: changes in the animation should map changes in the conceptual model of the idea. This is so even though reuse distorts the realism of the representation of the idea, as may be the case when using another sketch in a completely different scenario.

Qualities of the production environment for animation-based sketching

As discussed earlier, no production environment can be described as the definitive enabling technology for animation-based sketching. Instead we have proposed a number of quality criteria as critical factors enabling reflective sketching processes in a practical manner: an interactive timeline, live-preview, a graphical component library, the reuse of components, and the reuse of entire sketches in new environments. Even if one piece of animation software does not support all of these criteria, this does not mean that it cannot be used for animation-based sketching. One piece of software might be utilised to enable a specific animation technique with a specific material and later be combined with other techniques and materials in another piece of software. Hence, the practical ability to apply animation-based sketching as a design approach does not solely depend on mastering a specific set of software environment; it involves knowing how to use specific features in different software packages for sketching purposes. Some of these products might be dedicated purpose software, such as idAnimate, K-Sketch and Sketch-n-Stretch, while much of it might be general purpose or specialised software which meets some or all of the quality criteria discussed. Thus, animation-based sketching is enabled by any production environment, as long as it enables the designer to engage in a reflective conversation with the design material and to sketch temporal information about possible future states of the non-idiomatic design situation.

CRITERIA LEARNED:

An ***interactive timeline,*** or a control mechanism akin to timeline controls, enables iterative back and forth exploration in the designer's use of animation-based sketching

Live Preview of the animation-based sketch establishes the reflective practice of sketching, where the designer constantly acquires temporal feedback from her temporal sketching with animation.

A ***component library*** either creates or imports graphical components to be used in the designed motion or change, thus creating the graphism of animation

Reusable components and animations: the component library is used to save configurations of both graphics and animation to be reused in other sketches. This establishes a more efficient pipeline for sketching, making the process more practical and facilitating the generation of more information

Sketches in layers of other sketches: entire animation-based sketches as output emulators are used in multilayer edits with a new animation-based sketch to function in a pipeline as entire sketched sequences

The next question concerns how practical and approachable these criteria are for designers with no experience of animation or digital sketching. In the following chapter, we present some lessons learned from experiments involving the introduction of animation-based sketching to designers in different setups.

CHAPTER 10: MAKING ANIMATION-BASED SKETCHES

This chapter concerns the practical feasibility of using animation-based sketching to explore non-idiomatic technologies in design processes. We present a range of examples of different visual fidelities of animation-based sketching and discuss the difference between visual and conceptual fidelity in the generation of temporal information to reduce uncertainty. Furthermore we investigate the competencies required for designers to apply the approach.

The experiments indicated that animation ties the dynamic temporal information into a narrative and to the context of the proposed idea. By the use of simple animation approaches, sketching time was reduced and more branches of ideas were generated in less time. The participants used simple animation-based sketches to discuss and communicate their ideas, identifying the most promising potential user experiences, and went on to sketch proposals for the more fine grained interactions in their ideas. We further suggest that it is not the fidelity of the visuals or animations which matter the most in animation-based sketching. What matters is the way in which the animated graphics are used to make an idea understandable and relatable so that the designer and other stakeholders can reflect upon the potential user experiences made by the ideas proposed.

Finally, on the basis of experiments which constrain the time available to produce animation-based sketches, we suggest that the approach is also applicable in constrained design processes where resources are more limited than in experimental design workshops in academia. However, this applicability is constrained when too much emphasis is given to making the sketch adhere to the animation principles of orthodox realistic physics. Animating orthodox physics is counter-productive in the early phases of the design process. If the temporal fidelity required to answer a question needs to include complex physics, the designer is no longer sketching; she has actually begun prototyping.

WHAT DOES IT REQUIRE OF DESIGNERS TO SKETCH WITH ANIMATION?

In part I of the book, we posed the following two questions:

Is animation at all suitable outside big budget future visions? and if it is suitable, ***how can we appropriate animation to explore future scenarios with non-idiomatic technologies without spending more resources than it would take to build a functional prototype?***

We discussed these questions in terms of defining animation-based sketching and, in comparison with static sketching and prototypes, in terms of what the applicability and purpose of animation-based sketching might contribute to design processes. In the previous chapter, we discussed the quality criteria production environments must meet to act as enabling technologies for animation-based sketching. These considerations have given us an idea about the features needed for sketching, and we have seen that designers need to use different software environments in order to fully employ animation as a sketching capacity.

However, we still need to reflect upon the actual application of animation-based sketching as an approach for designers in praxis. In the course of the research project leading to this book, we conducted a series of design experiments which explored different aspects of the practical application of animation-based sketching. In creating these experimental setups, three core concepts had to be balanced: the design knowledge generated through sketching, the sketching process itself, and the specific animation techniques. We might seek to evaluate the quality of the temporal information, which would be different from evaluating the sketching process itself, which in turn would be very different from evaluating the practicality of different animation techniques.

EXPERIMENT 1: INVESTIGATING USER EXPERIENCES

This experiment was part of a research collaboration reported in Vistisen & Poulsen (2015). We conducted the experiment to sample a substantial number of animation-based sketches in a praxis-oriented design process. To create a substantial base of animation-based sketches, we facilitated the U-CrAc yearly workshop. U-CrAc is the abbreviation for 'User Driven Creative Academy'. A total of 36 design-oriented cases from the private and public sectors were included. These cases were given to multidisciplinary groups of design students from interaction design, experience design, industrial design, entrepreneurship design, and cultural service design. A total of 203 students participated (Appendix 2.2). However, 79% af the students had limited experience with video and animation or none at all, and 48% had limited experience of traditional sketching and prototyping (Appendix 2.3). We therefore argue that the majority of participating students could be characterised as *novices* (Dreyfuss & Dreyfuss 1980). The students provided a basis for experimenting with the introduction of animation-based sketching to others, and an examination of whether the approach was viable in the short workshop context. The large number of students and stakeholders ensured breadth in the sketches produced.

How do animation-based sketching support investigating user experience design?

Our research aim was to examine how the proposed design ideas were portrayed as diegetic elements in the animation-based sketches that were produced, and to compare these with the applied animation approach.

The evaluative criteria for assessment of the sketches were based on the broad definition of a 'product' by design researcher Richard Buchanan (2001). Buchanan suggests that, in its broadest sense, the user experience of a product can be understood as the synthesis of three factors: *the aesthetic (desirability)*, *the usefulness (utility)*, and the *user friendliness (usability)* (Buchanan 2001). According to Buchanan, it is the way in which these three factors are combined that distinguishes one product from another. This is true regardless of whether it is a concrete thing such as a smartphone application on a phone or an abstract concept such as a service or policy. Buchanan only implicitly mentions the role of the *use context*, which most design discourses emphasise as a crucial factor in assessing the experiential value of a design product (Hassensahl & Tractinsky 2006, Jensen 2013). We included the contextual integration and representation of the touch points among the evaluative criteria for the sketches

Sampling animation-based sketches

To record the sketches, we instructed the students to use a web-platform (www.urac.dk) as a modified type of technology probe (Hutchinson et al 2003) to gather sketches at different stages of the workshop proceedings.

Figure 60: The U-CrAc web-platform acting as a technology probe for the design students sketches (left), and a collage of the students sketching activities during the workshop (right).

The design students were ask to categorise the animation-based sketches they produced in relation to the sketches produced during the initial period of ideation and the ones produced during a final period of synthesis. This was done in an attempt to separate the sketches aimed at investigation and exploration in the ideation phase from the more explanatory and persuasive sketches in the synthesis phase.

After sampling all the produced sketches, we watched all 158 produced animation-based sketches, and developed a qualitative categorisation based on which of the four user experience aspects (utility, usability, desirability, or context) was present in the sketch. We crossed this with a mapping of the techniques or combinations of techniques that were applied in each sketch produced (Appendix 2.4).

GROUP 4 - AskCody	VIDEO	STOP MOTION	ANIMATIC	PURE KEY FRAMES	MOTION OVERLAYS	3D ANIMATION	PRE-MADE	UTILITY	USABILITY	AESTHETICS	CONTEXT	NARRATIVE
Sketch 1		x						x	o		x	x
Sketch 2		x						o		o	x	x
Sketch 3		x						o			o	o
Final Sketch	x		x		x			x	x	o	o	x
GROUP 5 - LandShape	**VIDEO**	**STOP MOTION**	**ANIMATIC**	**PURE KEY FRAMES**	**MOTION OVERLAYS**	**3D ANIMATION**	**PRE-MADE**	**UTILITY**	**USABILITY**	**AESTHETICS**	**CONTEXT**	**NARRATIVE**
Sketch 1	x	x			x						o	o
Sketch 2		x									o	o
Sketch 3		x						o			o	o
Sketch 4	x		x				x	o		x	x	o
Final Sketch		x						x		o	x	o
GROUP 6 - LandShape	**VIDEO**	**STOP MOTION**	**ANIMATIC**	**PURE KEY FRAMES**	**MOTION OVERLAYS**	**3D ANIMATION**	**PRE-MADE**	**UTILITY**	**USABILITY**	**AESTHETICS**	**CONTEXT**	**NARRATIVE**
Sketch 1		x							o			x
Sketch 2			x			x		o	x		o	x
Final Sketch	x				x			x	o	o	x	x
GROUP 7 - HjørringLIVE	**VIDEO**	**STOP MOTION**	**ANIMATIC**	**PURE KEY FRAMES**	**MOTION OVERLAYS**	**3D ANIMATION**	**PRE-MADE**	**UTILITY**	**USABILITY**	**AESTHETICS**	**CONTEXT**	**NARRATIVE**
Sketch 1 - ikke tilgængelig												
Sketch 2		x					x	x		x	o	o
Sketch 3				x			x	x	x	x		o
Final Sketch	x			x			x	x	x	x	o	x

Figure 61: Our mapping of different animation techniques applied in the sketches, crossed with the user experience factors expressed in the sketches.

The original hypothesis was that we would be able to see a clear correlation between the use of animation techniques offering high visual and/or temporal fidelity, and the expression of user experience aspects. However, the results were not as expected.

No direct link between fidelity and portrayal of user experience aspects

In the results of our earlier experiment (Vistisen & Bolvig 2015), a comparison of the sketches indicated no clear link between the choice of animation approach and the resulting expression of the user experience of the non-idiomatic technology. This was surprising, since it also seemed to indicate that our discussion of fidelity in animation-based sketches might not be dependent on whether the visual or temporal fidelity was high or low.

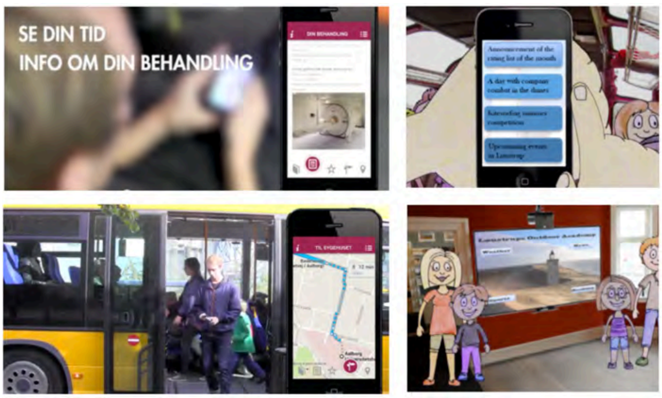


Figure 62: Wether high visual and temporal fidelity (left) og lower fidelities (right) we saw no clear correspondence between the visual or temporal fidelity, and the expression of user experience aspects.

However, if we turn back to our distinction between sketching and prototypes as the difference between generating information about design possibilities on the one hand and reducing the amount of information on the other, it actually does make sense. When generating information through sketching, the designer seeks to reduce uncertainty about the design possibilities. With animation, the designer further gains the ability to generate temporal information about non-idiomatic technologies where few conventions or idioms can provide information about the potential dynamics of the technology. The important thing here is that the focus is on generating information in a problem setting which lacked information before sketching started - a negative measure of information. Thus, the fidelity of the temporal or visual information generated matters less than the fact that information was generated about the questions posed in the problem setting (e.g., how would a given technology behave if the user interacted with it in a certain way, in a certain context). Once the information has been generated, the designer needs to reduce the complexity of the question regarding which of the proposed pieces of design knowledge is the best way to solve the problem. Here the designer needs to be more specific, so prototyping approaches are deployed to test which information is best, that is, most useful, most usable and most desirable. Here, visual and temporal fidelity matters, since the prototype has to be tested and assessed as a limited functional version of something that is potentially 'final'.

LESSON LEARNED:

In animation-based sketching, it is not the fidelity of the visuals or animations which matter most in the expression of user experience aspects. What matters is how the animated graphics are used to make an idea understandable and relatable by making the designer and other stakeholders reflect upon the potential user experiences in the proposed ideas.

Animation ties the diegetic prototype to the narrative

The sampled sketches from the workshop included examples of more or less all the perspectives, narrative discourses, intents and fidelities that we have categorised as anatomical features of animation-based sketches. Moreover, the sketches categorised as having explored most user experience aspects of the non-idiomatic design situation all had a clear representation of narrative. The sketches in which interaction with a technology was shown without any narrative structure to indicate what came before or what happened to the user afterwards were considerably harder to *read*. Even the sketches which mainly used an isolated interface & artifact interactions perspective could imply a narrative through the use of either narration or user dialogue or through the use of animation to zoom in and out of the interactions in focus.

The overall narrative in these animation-based sketches could be categorised as adhering to a 'finite dramaturgy' (Nielsen 1988) which uses the principles of classic Aristotelean poetics: a *beginning, a middle* and *an end.* In a finite dramaturgy, there is a high degree of causality between scenes, which builds up tension and interest in the scenario. In various configurations, this is often portrayed in a range of sub-elements such as the *teaser, the point of no return, the climax and the resolution* (Vogler 1998, Harms-Larsen 2003).

We used Harms-Larsen's narrative model (2003) to map out the sketches that we had identified as having a clear narrative and mapped how the classical dramaturgy provided a rather close fit to the structure of the animation-based sketches, regardless of perspective, discourse, intent and fidelities. The problem setting is teased quickly and elaborated by showing the context or hinting at it before commitment to the proposed idea at the sketch point of no return. Subsequently, the details of the idea are introduced in an escalation towards the sketch climax, which reveals how the problem is resolved by using the proposed idea before the resolution illustrates the effects on the user experience:

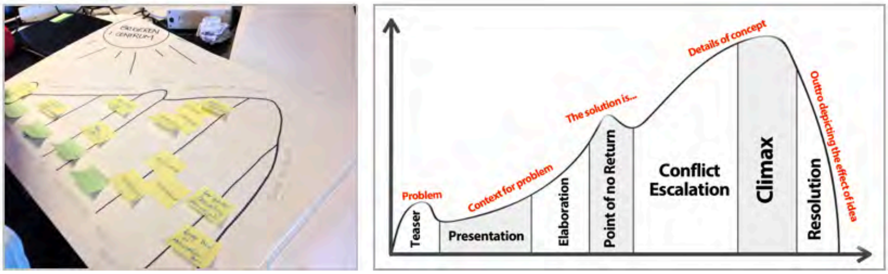


Figure 63: The narrative structure as presented by Harms-Larsen (2003) with escalating tension, towards a climix, the a following resolution.

Consequently, we suggest that the generation of the most articulated design knowledge about the user experience aspects was actually due to following a narrative structure, and thus grounding the proposed idea in a causality which made perception and reflection easier.

It is important to note that the effect of the finite dramaturgy on the ability of these animation-based sketches to express user experience does not imply anything about the quality of the idea itself. The utility, usability, desirability and contextual fit of the proposed idea is not inherent in the structure of the narrative, but rather in the way the non-idiomatic technology is tied into the narrative as a diegetic element. This is where animation makes its main contribution to the sketches. Scenarios, storyboards and other static methods also use dramaturgy as their foundation, but unlike animation-based sketches, they do not tie the dynamics of the proposed design into this story and its context; they represent states and idioms and count on our ability 'to fill in the blanks'.

Through the design of apparent motion and change and thus the generation of temporal information about the non-idiomatic technology as an actant in the narrative, the potential of the idea is illustrated without dependence on the use of established idioms. Novel interactions and use cases can be emulated freely and tied into the context of the narrative. In theory, a static depiction could include all the visual content of an animation-based sketch, drawing out every single frame into one long series of static images. In this manner, all the content would be the same, but something would still be lacking - the temporality itself. When events unfold over time, they have pace and rhythm, which creates anticipation in perceivers (Wells 1998, Block 2007). That is what temporal information consists of: the information which is not inherent in the visual content but in the temporality of the interaction between the visual elements.

LESSON LEARNED:
Through animation, non-idiomatic technology receives temporal feedback - information which could not be generated without expression of the dynamics as a sequence. Animation ties the dynamic temporal information into the narrative and context, while remaining a sketch in terms of being a proposal that is framed in a certain way to show certain aspects and to omit others.

Starting simple generated the most detailed design knowledge

While we did not see any correlation between animation technique and the ability to express user experience aspects in the individual sketches, we did subsequently identify a pattern when examining the totality of sketches produced during the design students' sketching process. The 158 sketches were divided into approximately five sketches from each of the 36 groups, and they presented a clear picture of *when* certain animation approaches were applied. In 25 out of 36 groups, the design students' first animation-based sketches used forms of stop motion animation (frame by frame recording) or simple animatics (static storyboard images in a temporal sequence) to express their ideas. These two techniques are radically simpler to apply than other techniques, such as working with key framed animations with graphical components in Adobe Premiere, for example. This pattern could indicate a variation on the classical design tendency of starting in low fidelity renderings and later building higher and higher fidelity renderings (Walker et al 2002, Sefelin et al 2003). Another explanation could be that being novices in the use of animation, the design students chose to start with a technique which required less skill and with which it was easier to get results.

However, an alternative explanation might be that the stop motion and animatic approaches were sufficient for the initial investigative and explorative intent behind the animation-based sketching. Simple stop motion sketches with cut out paper drawings or with arranged objects such as LEGO bricks provide an impressive amount of temporal feedback in relation to their visual fidelity and the relative low time cost of making these often crude animation-based sketches:

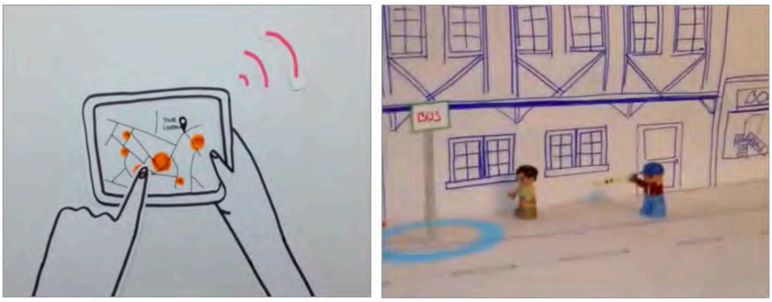


Figure 64: The simple animation techniques, such as stop motion with cutouts (left) or LEGO bricks (right) provide a surprisingly high level of feedback on the user experience of a concept, without taking up much production time. See the sketches at https://goo.gl/RZ6MSc and https://goo.gl/q2WOj9

This supports the earlier point: low visual and temporal fidelity are sufficient in the early sketches. Even with low fidelity, the generation of temporal information provides feedback about dynamics, interactions and user experience in the user context, thus providing information about the uncertain non-idiomatic aspects of the proposed ideas. Essentially, none of these early and crude animation-based sketches represent the proposed technology in a realistic sense; they are highly distorted. Instead they represent the underlying conceptual model of the proposed idea, creating a superficial understanding of the potential of the idea.

This understanding is open for reflection and re-interpretation within the frame of reference of the representation. This shows how the congruence principle comes into play in these early animation-based sketches. The sketch distorts realism to leave gaps for further questions, while providing enough visual and temporal information to allow an understanding of the overall synthesis of utility, usability and desirability in the use context. Here the apprehension principle comes into play, as the graphism of the animation-based sketches follows the conventional graphic representation in the specific domains and is stripped of cosmetic features that are not directly useful for understanding. We argue that it is the combined workings of the congruence and apprehension principles that make the early rough animation-based sketches work.

Apprehensible idioms are used for the aspects of the sketch which should not be questioned - for example, the representation of the user through a hand drawn figure or a LEGO figure. Non-idiomatic aspects such as the interaction design of the proposed idea are thus brought into focus by simplification or distortion so that the attention-guiding principle can guide the viewer to see exactly which aspects of the idea are novel and interesting. Thus, the simple nature of the animation-based sketches actually supports an understanding of the important non-idiomatic aspects in the sketch by emphasising what to question and what to take for granted.

This application of the apprehension, congruence and attention-guiding principles to animation-based sketches also links back to the previous point about the role of narratives. Ulla Ryum (1983) argued that the role of the designer of dramaturgy was to stage the frames within which the audience would be able to perceive a narrative. The designer's aim is to get the audience to accept the conditions of this particular narrative structure and to guide them towards the points in the narrative at which the audience should think about the narrative and criticise or appreciate it . In conjunction with the three principles for facilitative animation, the finite dramaturgy thus reduces the interpretive space by framing the problem setting as part of the problem-solving proposal of the sketch. The reduced interpretive space of the narrative which this produces is essentially equal to the reduced uncertainty of the design process. Reflections upon the proposed design idea can occur in the interpretive space, adding to the total sum of information about the potential of the idea.

So, the tendency to start with simple animation was evident in 25 of the animation-based sketches from the workshop. 16 of these projects continued to use the techniques in their later synthesis sketches, where what was a predominantly investigative and explorative intent had changed to one that was more explanatory and persuasive. However, 19 of the projects, also experimented with other, more sophisticated animation approaches for their later sketches, often in combination with the simpler methods. Methods such as the use of key-framed animation, the application of motion graphic layers on top of live video, with and without green screen, and the use of 3D animation are all to be found in these animation-based sketches.

Some of the sketches used these more sophisticated animation approaches to investigate and explore more complex visuospatial concepts whose temporal dynamics cannot be expressed through simple cutout stop motion or animatics. This can occur, for example, when the designer explores a new interaction design based on gestures, in which the interplay of animated components and live footage is needed to express the user experience.

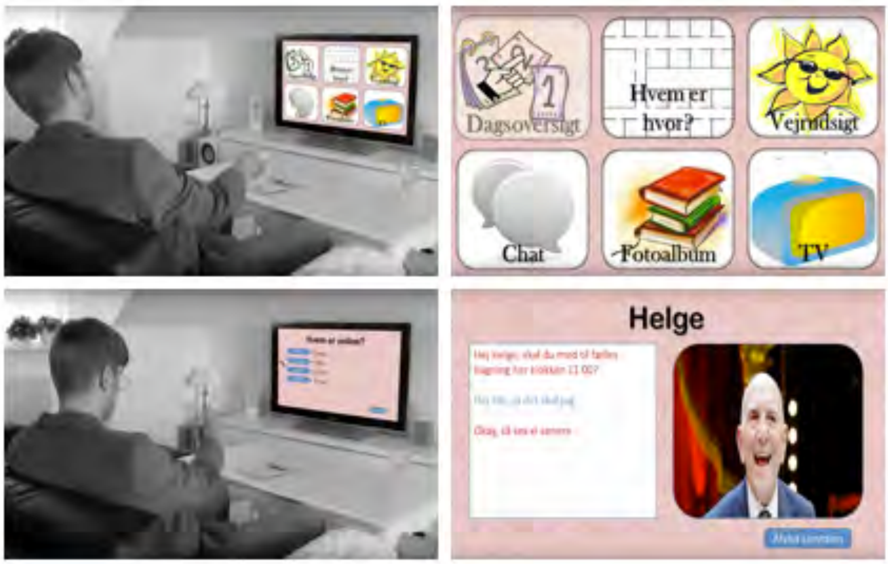


Figure 65: This sketch explores smart TV solution for elderly people, which uses the traditional remote control as a gesture-based controller. The sync between the live actors movement, and the response on the television was created with keyframed animations timed with the actors motion, and thus had a higher temporal fidelity than what e.g. stop motion could have provided. See the sketch at http://goo.gl/4hm6nd

Despite the higher complexity of the animation approach and the longer sketching time spent in their creation, these sketches still expressed both investigative and explorative sketching intents in the exploration of new ideas, and they generated new temporal information about the dynamics of the technology involved. This was so even though many of these sketches were also later used as communicative vehicles outside the team of design students.

Another type of more complex animation-based sketch involved the remediation of existing ideas from previous sketches to create refined versions of the investigative and explorative sketches with a more explanatory and persuasive intent. On the surface, these sketches essentially only looked like sketches, but were part of a sketching process, since the idea had already been conceived in a previous sketch. In many instances, the representation in a new visual and temporal fidelity also established a new interpretive space for the narrative. Even though the basic nature of the idea was the same, the conceptual model changed because the new representation changed the visual and temporal feedback, thus reframing the problem setting. What might superficially appear to be just a higher fidelity rendering of an existing idea is essentially a new idea in its own rights, due to the new information generated. This in turn shows why these sketches might both be used for explanatory and persuasive purposes while having an investigative and explorative function in the sketching process itself.

While we saw a significant pattern in sketches which progressed from initial simple animation-based sketches to more complex sketches, a few also started with complex sketching approaches. However, in terms of their ability to express user experience aspects of the non-idiomatic technology used, these sketches actually generated less relevant information. While one sketch might express the utility, usability and desirability of the proposed technology, the totality of the sketches produced showed far fewer ideas, or only small variations of the original idea. In contrast with the cases which started simple and used more complex animation later, it seems that the use of complex sketching approaches at an early stage leads to the initial idea taking hold. This corresponds well with the established notions in both sketching and prototyping that high fidelity tends to make the initial idea 'stick' (Buxton 2012, Greenberg et al 2012).

This experiment indicates that in animation-based sketches too, overly complex visual and temporal fidelity may restrict the interpretative space for understanding the interactions and the user experience of the technology in the user scenario. As a consequence, far fewer ideas are generated and less information is available to reduce the uncertainty of the non-idiomatic aspects in the design process. Of course, fewer ideas might still lead to a relevant solution - the idea *might* be good enough. But adopting Buxton's notion of 'inertia in innovation' (Buxton 2010, 39), we can see that the designer runs the risk of making an uninformed decision, which in turn will increase the risk that the solution will not match the preferred state.

LESSON LEARNED:

The simple nature of animation-based sketches actually promotes understanding of the important non-idiomatic aspects of the sketch by emphasising what to question and what to take for granted.

Overly complex visual and temporal fidelity run the risk of creating an interpretative space that is too narrow to promote understanding of the interactions and user experience of the technology in the user scenario.

To a considerable extent, novice design students were able to adopt animation-based sketching as a design approach in just two weeks. When the basic method, principles, techniques and theory had been introduced, the students went on to explore a multitude of software and hardware production environments in their sketching. However, we only took this to mean that it was *possible* to use animation to sketch interactions and represent user experience aspects of non-idiomatic technologies, but not necessarily that it was *practical*. To test its practical applicability, we needed to evaluate whether the approach could be taught and applied in days rather than weeks.

EXPERIMENT 2: FROM INTRODUCTION TO ANIMATION-BASED SKETCHES

We constructed the second experiment to resemble the setup from the U-CrAc workshop and thus create a basis for a comparison of sketching input with time as a variable. A five day workshop was held for a small group of 25 service design students in Copenhagen in 2015. The participants had the same novice experience in animation and sketching as participants in the U-CrAc workshop.

We introduced the same amount of methodological and theoretical material as provided in the U-CrAc workshop and provided the same lecture material. In the U-CrAc workshop, the students had a total of 5 days for ideation and 4 days for synthesis. In the Copenhagen workshop, however, we limited ideation to 2 days, and synthesis to just 1 day. The students were given one day of lectures and hands-on training with production environments such as iStopMotion (boinx.com) and Adobe Premiere Pro (adobe.com), and with the same animation approaches as in the U-CrAc Workshop. Thus, the conditions for adapting animation-based sketching were radically tightened to challenge the viability of animation-based sketching as a practical design approach rather than an academically interesting use of animation.

Our hypothesis was that the approach could be deemed viable in practice if, following a one-day introduction to animation-based sketching, the design students could investigate and explore user experience design ideas after only three days, finally merging them into an explanative and persuasive sketch.

Animatics representing scenarios of non-idiomatic interaction

Prior to the workshop, the design students had already carried out interviews and ethnographic field observation in their respective user contexts. All students were already practiced in discussing different design ideas and problem settings when they were introduced to animation-based sketching. While many discussions had occurred, however, none of the ideas had really materialised, and few of the discussions had focused to any notable extent on utility, usability, desirability or context. We asked the design students to orient these loose ideas towards actual representations of the proposed technology in the use context by integrating their ideas into *scenarios of interaction* (Caroll 2000). The response to this instruction revealed a pattern that was similar to the one observed in the U-CrAc workshop: the majority of design students began sketching their ideas with simple stop motion or even simpler animatics.

The main difference her, however, was that the simple and fast animatic technique was far more frequently used in the initial ideation phase than it was in the U-CrAc workshop. From a practical point of view, this seems natural, due to the limited time available and the need to sketch many diverging ideas. This raises an important question: does an animatic which does not create the illusion of apparent motion in the sketched state contain enough temporal information to inform the design process? In theory, these animatics do not include more information than they would if portrayed in static sketches storyboard scenarios. But when we consider that the temporality of sequences of events over time has pacing and rhythm, extra information is added to what would otherwise only be static. Although the animatic does not generate much information about the specifics of the interaction, it serves to anchor the proposed technology to the context. The pacing and rhythm of the animatic creates anticipation in the viewers and thus also opens up the interpretative space of the sketched narrative as they begin to reflect upon *what will happen next* (Wells 1998, Block 2007). Thus, although the non-idiomatic technology itself is still only portrayed in static images, the reflections about the dynamics are supported by the temporality of experiencing the narrative as a sequence over time.

Figure 66: Two examples of animation-based sketching using animatics, in which little or no motion is essentially animated, but rather just adding timed sequentiality to static sketches. See examples of these sketches at https://goo.gl/TvKhJ1 and https://goo.gl/KL3X3w

It is also evident that animatics do not enable the same temporal feedback as the other possible uses of animation: this is probably because animatics have very low temporal fidelity. It was also evident from the students' animatic sketches that the interpretive space might have been too wide, given the possible interpretations of the potentialities of the concepts proposed in the narrative. While design sketching in the early phases of design should be ambiguous and open for further reflections, too much ambiguity prevents a reduction of uncertainty about the details of the possibilities within a non-idiomatic design context. The initial animatic sketches created by the participants did not provide sufficient support for exploration of the non-idiomatic interactions and dynamics of the technology itself.

What the sketches did, however, was to support the exploration of the non-idiomatic design context where the finer grained interactions of the applied technologies would take place. In this way, animatics creates a sketching process of divergent design thinking heralded by Buxton (2010, 338):

Figure 67: Buxton's (2010) depiction of the divergent branching of concepts through sketching.

Buxton argued that branching explorations should avoid the inertia of innovation by initially exploring multiple branches rather than just incrementally working down one idea branch. The rapid creation of animatics enabled the students to explore many ideas in one day, while also getting temporal feedback about the dynamics, although the temporal fidelity was low. The branching nature of the students' ideas was shown in the variety of concepts explored in each of the groups: the number explored in just a short time was actually higher than the number of ideas the groups in the U-CrAc workshop produced in five days.

LESSON LEARNED:

By using simple animation approaches, sketching time is reduced and more branches of ideas are thus generated in less time.

Simple animatics can be used to investigate problem settings and explore future scenarios, identifying the most promising potential user experiences to be further explored by the application of finer-grained techniques.

Fast transition from low to high temporal information

As was the case in the U-CrAc workshop, when the design students began exploring the different interaction design possibilities within their design context, most of them adopted more complex animation techniques. In contrast with some of the U-CrAc cases, however, here there were few examples of complex animation approaches being applied to generate entirely new branches of ideas. Instead, observations from this workshop showed that the higher visual and temporal fidelity of the complex animation approaches was invariably used to extend, elaborate and combine user experience aspects from the previous sketches. One sketch, for example, used the static sketches from the animatics and added more dynamics to both the user context and the interaction with the proposed digital application, a mobile game in sync with a crowdfunding platform (Appendix 3.1.10).

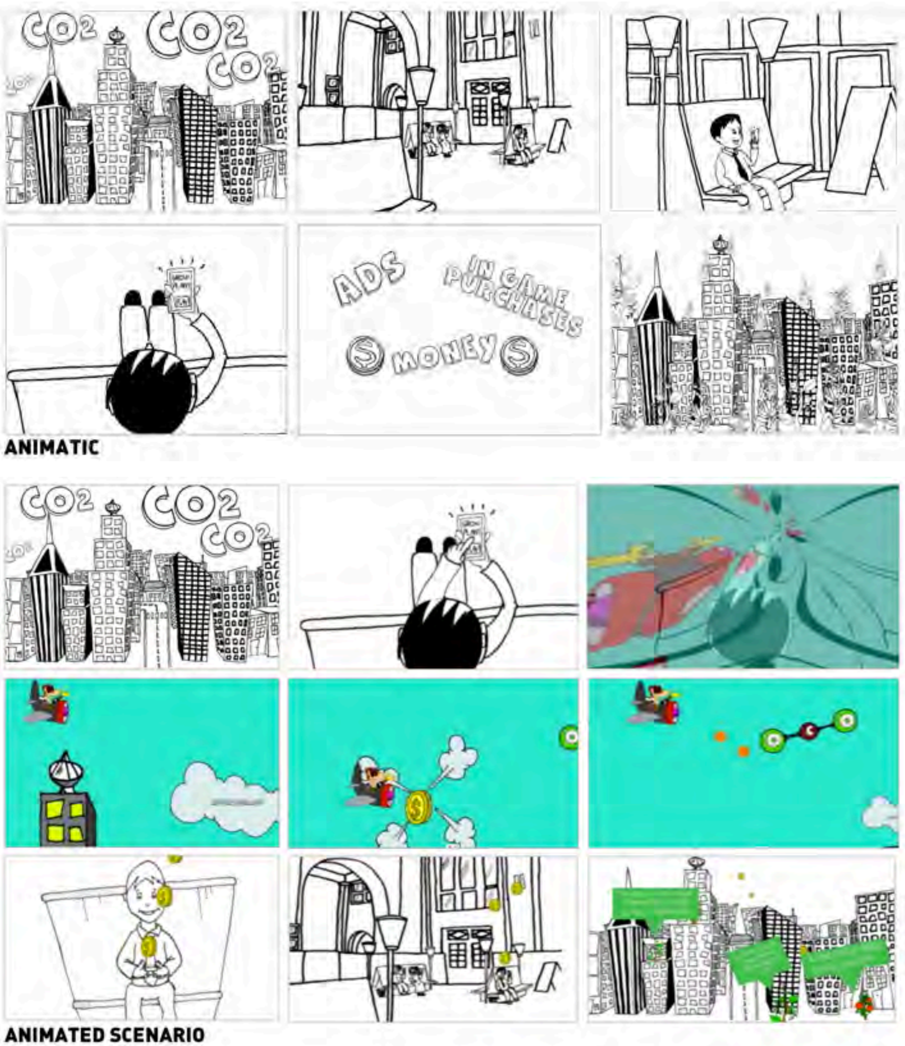


Figure 68: The static images from the animatic (top) were later reused and reworked with more temporal information in a later animation-based sketch, with keyframed motion to better illustrate the game elements of the proposed crowd-funding game (bottom). See the animatic at https://goo.gl/Q2FyEG and the final sketch at https://goo.gl/EmSpZV

As we can see in (Appendix 3.1.10), the basic graphics of the two animation-based sketches are the same, but the later sketch has added higher temporal fidelity to the interaction with the mobile game and a distorted expression of crowd-funded cash flow to show the conceptual model of the sync between game and crowd funding. The choice of this specific branch of their ideation and the use of animation to explore the dynamics of the interaction with the digital service reduced uncertainty about the non-idiomatic aspects of the design possibilities of this type of game. During the last day of the workshop, the animation-based sketch was further used in a design critique session (Buxton, 2010), in which the group was challenged with new questions about the details of how the specific idea might be realised. The questions added to the complexity of what was already an uncertain situation, marking the students' transition to developing testable prototypes of variants of the game in the weeks following the workshop.

A plausible approach in praxis?

The group took only three work days to produce the initial five animatics, the three extrapolations of these ideas, and the final synthesis of their proposed solution. The same productivity was evident in the other four groups participating in the workshops, with small variations in the number of early animatic sketches (4-7). We argue that the results from this workshop indicate that the benefits of animation-based sketching with its multiple different approaches and production environments can also be achieved in shorter design sprints than seen in the U-CrAc workshop.

LESSON LEARNED:

As a design approach animation-based sketching is also potentially applicable in constrained design processes in which resources are more limited than in experimental design workshops in academia.

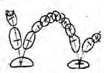
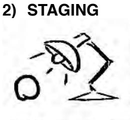
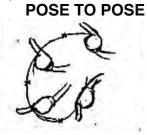
SKETCHING BACK TO SIMPLER TIMES

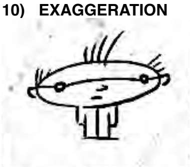
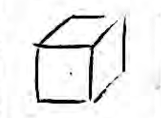
In re-examining the animation-based sketches sampled for use in this book, we noticed a rather intriguing pattern in the animation techniques commonly used in animation-based sketching. The majority of the investigative and explorative approaches did not do much to follow the orthodox principles of animation, such as Disney's 12 animation principles (Thomas & Johnson 1981). This was also largely true of the explanatory and persuasive approaches. As we have seen in our examples, the archetypical animation-based sketch uses varying visual and temporal fidelities to communicate the underlying conceptual model of the idea it proposes and does not necessarily seeks to do so in the most factual or detailed way possible. Instead, the animation-based sketch leapfrogs many of the animation practices which would traditionally take a considerable amount of time to get right. This ensures that the appearance is still sketch-like while saving time and thus making it viable to sketch with animation.

This corresponds with our previous observation that the heritage of Disney's hyperrealism is that an animated sketch will always portray a 'second-order realism'. Animated sketches must address the ontological laws of reality, but they need not necessarily prioritise a strict adherence to the orthodox movements and physical aspects of objects. We hypothesise that animation-based sketches do not need to refine their creation of motion on the basis of the 12 animation principles of 'the illusion of life', but might actually achieve their sketching goal by adopting the earlier principles of animation.

The 12 principles of animation - revisited for animation-based sketching

In relation to our sampling of animation-based sketches, and the examples we have presented so far, we will now revisit the overview of the 12 principles of animation, but now examining their inclusion in design sketching – or their exclusion:

1) SQUASH & STRETCH 	This principle is based on either following or distorting the material properties of the object animated, which is a level of material detail rarely considered in animation-based sketches. Squash and stretch is only used to the extent that the sketch needs to make a point about how the rigidity of something in the scenario is affected.
2) STAGING 	Staging is similar to what we have previously discussed in relation to the attention-guiding principle (Betrancourt in Mayer 2005) in animation-based learning. Therefore, staging can be seen in almost any animation-based sketch, regardless of the perspective of the sketch, although user scenario perspectives are arguably more clearly staging events than isolated interface & artifact interactions alone.
3) ANTICIPATION 	Anticipation in animation-based sketches occurs mostly in sketches that apply more complex animation approaches. The often higher temporal fidelity of the sketch makes it easier to focus on what will happen. In the simpler sketches, for instance using crude stop motion with paper cut outs, anticipation is harder to achieve due to the jagged motion and the lack of enough drawn elements to clearly demonstrate the upcoming change in the details of the sketch.
4) STRAIGHT AHEAD & POSE TO POSE 	Straight ahead motion is techniques often seen in stop motion and animatics, in which animation is done continuously, while keyframed pose to pose is typically applied when digital production environments are used to interpolate between different configured positions.
5) FOLLOW THROUGH & OVERLAPPING 	This combination of principles is rarely seen in animation-based sketches, due to the careful details of tweaking the animation to adhere to the orthodox motion of synchronous motion and overlapping motion.
6) SLOW IN & SLOW OUT 	Again, due to its reliance on the creation of orthodox motion or change that replicates aspects of realistic or exaggerated physics, this principle is also somewhat rare in animation-based sketches. The principle may come to expression as specialised pre-defined functionality in some production environments that suit sketching; here, crude interpolations of slow in and slow out may be used in sketching.

7) ARCS 	In the orthodox sense, arcs are absent from animation-based sketching due to the rigidity of tweaking motion paths to follow realistic arcs. To make the animation process faster, many of the animation-based sketches observed use straight lines, rather than arcs, to follow more mechanical movement arcs.
8) SECONDARY ACTION 	This is akin to the apprehension principle (Betrancourt in Mayer 2005) in animation-based learning, which is also followed in much animation-based sketching. Visual and temporal fidelity should only be emphasised to the point of portraying essential qualities in the idea, without the addition of details which do not address the problem setting or guide the perception away from it.
9) TIMING 	This principle takes its cue from the other physics-based principles but addresses the overall sequentiality of the actions animated. Thus, timing always plays a role in determining the pacing and rhythm of an animation-based sketch, but there are limits to how much time the designer can dedicate to creating fluent and emotionally readable timing.
10) EXAGGERATION 	Exaggeration can serve both dramatic and comedic purposes and is thus one of the most variable principles of animation. We might argue that the unfinished visual and temporal fidelity of animation-based sketching is in itself a form of exaggeration which distorts the realism of the proposed idea in the representation, making it more open for reflection and re-interpretation.
11) SOLID DRAWINGS 	Many of the animation-based sketches we have discussed show little adherence to the three dimensional space per se. This is especially true for simple stop motion techniques. Especially when combined with live action footage, some keyframe based animation uses simple perspectives, for example, to make an interface sketch fit within a given object in the actors' context.
12) APPEAL 	Even though the animation-based sketches we have sampled do not all show signs of attention to the creation of a specific appeal, appeal is a potentially important aspect of explanatory and persuasive sketching that can frame apathy, sympathy, empathy or even antipathy for a given user (Vistisen et al 2016).

Half of these principles are based upon the creation of realistic or hyper-realistic physics in animations (Squash & Stretch, Follow-through & Overlapping Action, Slow-in & Slow-out, Arcs, Timing and Solid Drawing). As we mention above, most of these physics-based principles rarely occur in animation-based sketches. This might be due to a lack of animation experience on the part of the design students and designers who created the sketches we sampled. Another explanation might be that even for a skilled animator, it takes a considerable amount of time to make the physics-related principles actually behave in accordance with orthodox physics (Wells 1998, Thomas & Johnson 1981). This would correspond to Chang & Ungar's findings (1993): correctly implementing the animation principles in user interface design requires a significant amount of extra labour. This still rings true now, more than 20 years later, despite the advent of more accessible production environments.

LESSON LEARNED

When applying animation-based sketching, animating orthodox physics often becomes counter productive in terms of actually sketching and not just designing an animated output.

If the required temporal fidelity needs to include complex physics, the designer is no longer sketching but has actually transcended into prototyping.

Without adherence to the physics-based principles of animation, representations of simple or naive physics (Sheet-Johnstone 2011) are able to generate information about the overall dynamics of interaction, while complex physics can reduce the complexity of the choices faced by clarifying which dynamics will work best. In essence, this reduction of complexity is prototyping based upon the branches of information about possible interaction designs, and it is more practical and viable in simpler animation. Thus, the 12 principles of orthodox animation are usable in animation-based sketching to the extent that they tell us about staging, anticipation, exaggeration, appeal, the creation of secondary actions, and the variation between straight-ahead or pose-to-pose animation. However, the applicability of the six principles of physics varies, depending on the ability of the production environment to speed up the process and on the extent to which the principle is central to the temporal fidelity needed for the information generated.

Simple animation principles in animation-based sketching

If only six of the 12 principles of orthodox animation are universally seen in animation-based sketches, we should examine other less sophisticated practices of animation to identify simpler animation principles that are applicable to sketching. In describing the process of developing the 12 principles of animation at Disney, Thomas & Johnson (1981) provided a series of examples of the more primitive predecessors of what we now consider modern orthodox animation. These included the *cycles* of animation which animates back into itself, the *repeated actions* of reused animations in multiple scenes, *cross overs* multiplying different animations in different drawings, and the general *rubber like physics* of the movements.

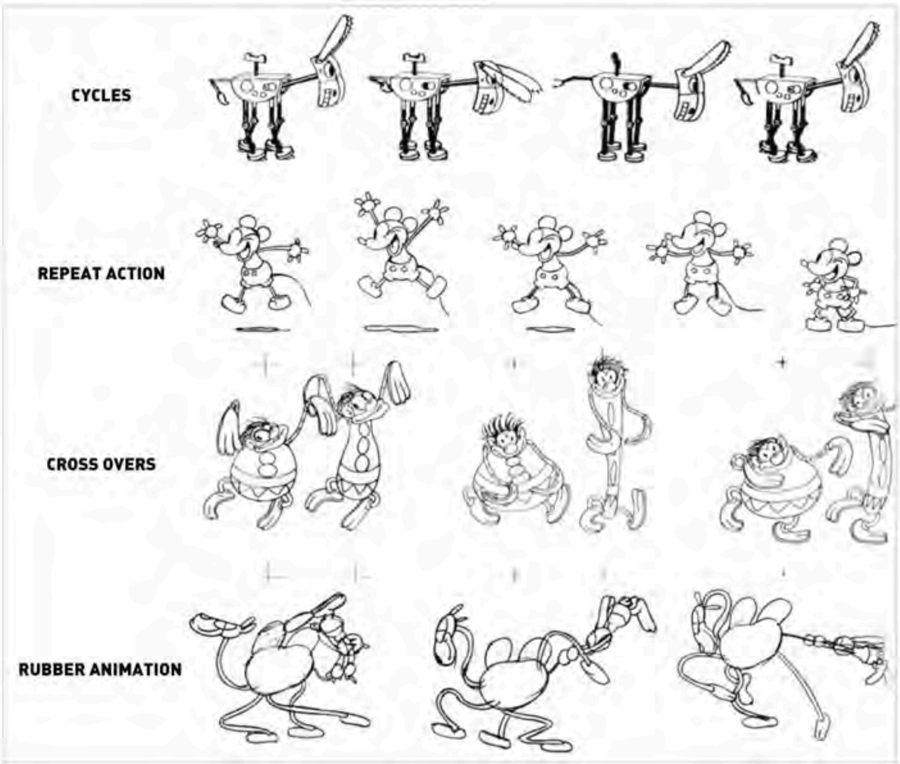


Figure 69: A range of the pre-Disney animation principles, all used to either decrease production time or to accomodate for not adhering to orthodox physics. Sampled from Johnston & Thomas 1995).

These simple techniques were originally born of the necessity to meet the needs of the still infant animated film genre in the 1920s. Disney studios did not have the funding to experiment with the realization of Walt Disney's ambition of hyperrealism (Thomas & Johnson 1981). Thus these techniques simply saved time and production costs by creating apparent motion and change which the audience could still perceive.

When we examine the sketches from the U-CrAc workshop and the Copenhagen workshop, we see that the majority of these sketches actually employ these *good-enough* principles of the pre-Disney era of animation. The physics mostly adhere to a plastic like feel, with little effort put into making character movements fluid or sticking to proportions. In addition, the animated sequences are often run in cycles or repeated at different moments in the sketches to save production time. Furthermore, the same animation presets, digital copies and edits of one interpolated set of motion or change are often employed as cross overs to other objects - again to save production time while sketching.

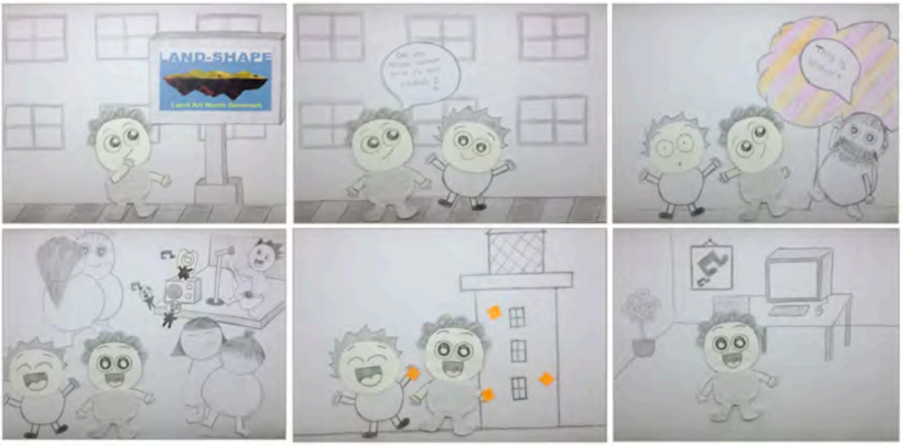


Figure 70: This sketch, exploring a cross media marketing concept for a sustainable festival serves an example of how pre-Disney principles such as cycles, repeated actions and synchronous cross overs are often used in animation-based sketches to decrease time spent animating, freeing time to explore more ideas. See the sketch at http://goo.gl/vGN5AK

This indicates that the principles of creating apparent motion or change in animation-based sketches seem to rely more on the simple principles of animation than on orthodox physics and hyper-realism. Of course, animation-based sketching may use all 12 principles of animation to create high temporal fidelity in the graphic components animated. The risk is that this will demand too much production time, be too specific, and be 'too narrow' in reducing uncertainty about the possibilities in a non-idiomatic situation. This echoes much of the previous critique of the use of animation in design sketching (Buxton 2010; Ylirisky & Buur 2007). The use of simple animation principles overcomes much of this criticism.

LESSON LEARNED

Animation-based sketching can be undertaken as a developmental genre of animation using the principles of the traditional orthodox and artistic genres of animation - but in a simpler and more eclectic manner.

This again demonstrates the limits of using animation for sketching purposes. When temporal feedback is needed about specific and detailed movements which require adherence to physics-based principles, the amount of time and the animation competencies required do not suit sketching. As we saw from the use of animatics in the workshop cases, the ability to quickly explore multiple ideas branches is crucial to sketching. The simple principles of animation and the adherence to some of the 12 orthodox animation principles define the limits of the expressive capacity of an animation-based sketch. Thus, animation-based sketching is not a universally viable method, but it can contribute to non-idiomatic design situations where temporal information needs to be generated rapidly before a decision can be taken about more specific and complex rendering and production approaches.

CHAPTER 11: THE VALUE IN PRAXIS

On the basis of a series of empirical examples, this chapter shows how animation-based sketching can be applied in praxis to explore design issues concerning non-idiomatic technologies in the early design phases. We attempt to show a range of implementations: our own research through design activities, implementation of the approach in an external company, and an examination of the experiences of companies who have experimented with animation-based sketching.

These lessons learned from practice illustrate the potential advantages and the possible pitfalls of using animation-based sketching in the practice of design. The first case illustrates how animation-based sketching can facilitate decision-making throughout an entire digital design process. This indicates that the role of animation-based sketching need not necessarily be limited to the early phases of design. Furthermore, we see that time and care invested in the creation of animation-based sketches in the design stage might subsequently be recouped in designing the equivalent graphical and temporal aspects in the later development.

The second case shows that the expressive capacity of animation also entails risks. While temporal information is necessary to inform the sketching of the dynamics of non-idiomatic aspects, it also runs the risk of posing too many questions at once. In other words, the information generated raises the level of complexity faster than the level of uncertainty regarding the design possibilities is reduced. This, we argue, is a crucial aspect of animation-based sketching.

To some degree, the industry has already experimented with the use of animation-based sketching approaches, at least as a means of visual communication. This indicates a recognition of the potential of using animation to represent the interaction design and user experience of new digital systems prior to development.

CASE 1: THE NORTH SEA OCEANARIUM - EXPLORING AUGMENTED REALITY

We participated as active constructive design researchers during a year long digital design process at the North Sea Oceanarium. This state-recognised zoo receives an annual subsidy from the Danish Ministry of Culture, supplemented by income from ticket sales and other activities. The aim of the zoo is to inform visitors about the North Sea through edutainment activities (Appendix 4.1). The zoo covers different maritime topics, from underwater biology to sustainable human use of the seas,. The oceanarium displays a wide selection of maritime creatures and plants from the North Sea.

In 2012, as part of the zoo's 2020 strategy, the organisation began to focus on creating digital extensions of the physical experience at the zoo, which led to our involvement in a research-through-design project (Gaver 2012). In this project, we participated in a multidisciplinary design team working on the development of a mobile augmented reality application, the North Sea Movie Maker (Huge Lawn 2013). In mobile augmented reality, a digital layer is superimposed on the real world through a mobile medium in a context. In this regard, augmented reality may be considered an example of a non-idiomatic technology. At the time, augmented reality had not yet been fully commercialised (Höllerer 2004), and it lacked well-established user experience idioms (Mekni & Lemieux 2014, Kloss 2011).

The app that was developed makes use of a novel approach to markerless augmented reality platforms to allow users to record live footage during their visit to the zoo. The footage is manipulated and distorted in real time by the app, while digital special effects are superimposed on the video, generating scenes in which fish and other virtual actors interact with the filmed guests. The video is then saved on the smartphone, and the app subsequently cuts seven short video bits into a one-minute coherent movie with special effects (Appendix 4.2).

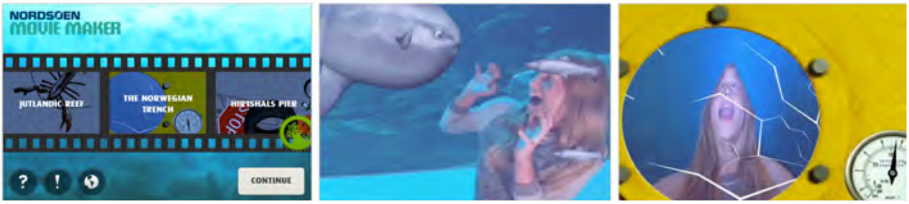


Figure 71: Images from the final ‘North Sea Movie Maker’ mobile application’s interface as well as the augmented reality effects generated.

The application was launched on the iOS App Store in October 2013 and went on to gain award-winning recognition for its innovative blend of new technology and user experience (AAU 2014). We argue that because of the recognized success of the app, it can be viewed as a case example of a non-idiomatic design situation resulting in a viable solution, where the major design decisions were facilitated by the use of animation-based sketching.

Facilitating consensus between stakeholders

The main challenge faced by the project was the need to attain consensus between the multidisciplinary stakeholders in a design team consisting of a biologist, zoo keepers, marketing personnel, interaction designers and developers. We understand consensus as involving a dynamic and iterative group discussion process coordinated by a moderator, who helps experts to approach agreement (Kacprzyk & Fedrizzi 1988). This definition can be further elaborated as a process of cooperative decision-making in *“...finding the best alternative(s) from a set of feasible alternatives according to the preferences of a group of experts”* (Herrera-Viedma et al 2007). In a digital design process, consensus-making can be understood as the generation of a range of possible design alternatives followed by stakeholder evaluation of the information as a way of reducing uncertainty about the scope of the design.

The initial ideation with brainstorming sessions and static papers involved sketching a large number of ideas for creating digital experience design in the zoo context. However, it quickly became evident that the non-idiomatic aspects of many of the ideas were hard to grasp and assess on the basis of the static sketches alone. This particularly affected members of the team such as biologists and zookeepers who did not have domain specific knowledge about digital design. It presented a problem because these team members had invaluable contextual knowledge about the zoo, including how to guide guests in the best way. In discussing this challenge, we realised that the problem arose every time something happened 'between' the depicted states in sketches (Vistisen & Rosenstand, submitted). As a consequence, we introduced animation-based sketching so that we could investigate the temporal dynamics of the concepts, but also as a means of visual communication to facilitate consensus-making in the team.

We applied various animation-based sketching approaches throughout most of the early fuzzy front end of the design process, even after the first interactive coded prototypes were developed. Below we will briefly introduce some of the findings, which are further extrapolated in Vistisen & Rosenstand (submitted).

Investigating the form of the augmented reality

Several concepts for the mobile experience took shape in response to the idea of giving the visitors the possibility of shooting short movies with the sea animals superimposed as special effects. This required the initial establishment of the augmented reality content and its aesthetic fit when it was superimposed on the physical context of the zoo. The zoo keepers in the design team argued that for the idea to function as an extension of the physical experience at the zoo, we needed to know the exact extent to which we could go 'over the top' with content before it became a parody of the living creatures in the zoo.

Thus, the design problem was to establish design alternatives: whether to take a 'slapstick' direction or to aim for a more realistic depiction of real sea animals. This presented two issues to be dealt with: the overall look and feel of the content on the one hand, and the interactive behaviour of the content on the other.

At this stage, several animation-based sketches were created (Appendix 4.4). The first explored a slapstick aesthetic using simple stop-motion animation: drawn elements were superimposed on a still image of a smartphone pointed towards a guest in the zoo . The stop motion effects were animated using the simple off-the-shelf software 'iStopMotion' (Boinx.com). Each graphical element was placed in the scene, moved frame by frame, and smoothed out by adding motion blur when the final sketch was being processed. Afterwards, we introduced a 3D scan by using the free consumer grade app '123D' (autodesk.com) and scanned one of the toys in the zoo, a sunfish. This model was superimposed on top of live footage from the zoo to investigate different ways in which realistic-looking content could augment live video. These sketches were done in just a matter of hours, and while the investigative function took place in the digital production environment, the explorative function was evident in the ensuing discussions between the stakeholders.

Figure 72: The first stop motion animated sketch of the app concept (left), a 3D-scanned model of a sunfish (middel) and the same model with crude textures animated on top of live video to emulate the augmented reality (right). See the sketches at https://goo.gl/3wbfHy and https://goo.gl/9mA0UR

The animation-based sketches allowed the team to actually see a temporal representation of how the two aesthetic genres might affect the zoo's guests. The information generated provided a basis for discussing 'what' the future user could experience. Having seen the sketches, a zoo keeper and a biologist argued strongly in favour of the realistic aesthetic, while the user experience designer and the marketing manager of the zoo argued for the more over-the-top slapstick approach. One party primarily advocated the fact-based learning objectives of the zoo, and the other primarily advocated the experiential and thrill seeking side of the zoo experience. This illustrated a typical consensus issue, in which experts with different perspectives favour different design alternatives entailing widely different courses for the design.

In this situation, we could see how the ability of animation-based sketching to mix the aesthetic and interactive aspects of the content had a mediating effect. We used the discussion which arose from watching the sketches to create a combined perspective. From this point on, it only took a few hours for the team to mix together the elements from the two sketches and create a new animation-based sketch in which the realistic looking animals interacted in slapstick comedic ways with the users in front of the camera. We created this animation-based sketch by using a simple keyframe animated distortion of the live video footage to make it look as though it was being squeezed by the fish model.

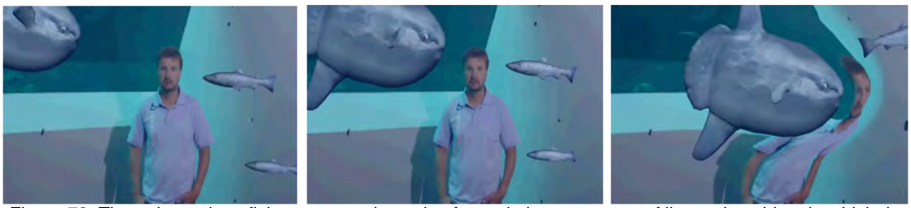


Figure 73: The animated sunfish was reused as a keyframed element on top of live action video, in which the video layer itself was keyframe animated to become distorted in the direction of the animated sunfish to how the make the augmented reality content fun and immersive. See the sketch at https://goo.gl/aY7Fyg

When we created this sketch, our investigative intent was to investigate whether it would work if the superimposed augmented reality content distorted the live footage in real time: would it create a humorous effect? Once we had established the setup in the above sketch, the explorative function took over as we involved other stakeholders from the team in the sketching process, watching them respond to the different variations we made in the animations. We expected this sketch to create even more discussion about the mix of genres. On the contrary, since the sea animals performing the actions were realistic, the zoo stakeholders no longer had any reservations about the slap stick humour. This indicated that the conceptual model for the concept had to adhere to orthodox visual fidelity, while the actions and effects could take more artistic liberties. Thus, consensus regarding the overall content criteria for the design was facilitated through the temporal information generated using animation-based sketches.

Exploring interaction between the mobile app and the users

After establishing consensus regarding the content criteria, the team had to assess how the features of the content could be interacted with - both in terms of user interface design and of the broader set of interaction modalities available in the mobile medium. These questions concerned the non-idiomatic aspects of using augmented reality in the zoo context: *"Should we use fixed markers or marker-less methods? Should the user be able to interact with the augmented overlays? Which elements should be affected by the overlays?"* (Vistisen & Rosenstand submitted).

None of these issues could be discussed in a meaningful way on the basis of the static sketches since they dealt with highly interactive and temporal features, with few best practices or idioms to lean on. Furthermore, the two programmers in the team estimated that using coded prototypes in generating information to inform a decision about these questions would be costly if we ended up not deciding which idea branch the prototype would take.

Using the animated content sketches from earlier, we created a series of sketches in which the content could be evaluated in different interaction designs. We used simple keyframe animation in Adobe Premiere, in which the software interpolated movements between two or more designated key positions. We animated still images of a transparent smartphone superimposed on footage from the zoo and used the content sketches in tandem to illustrate how different types of augmented reality could be controlled and experienced by users.

Figure 74: Sequence from one of the sketches, exploring how the augmented reality effects would become activated on the mobile medium. A image of a hand holding a smartphone is animated on top of video from the zoo, with the animated content sketches placed on top to simulate the augmented reality when the interaction occurs. See the sketch at https://goo.gl/U2UqH9

While sketching, we investigated numerous ways in which the augmented content could be activated. After outputting a series of sketches, the sketches served an explanatory role for the other team members, enabling the team's transgression into further explorative sketching. The important advantage was that creating the animation-based sketches of the interaction design enabled the fast exploration of a wide range of concepts.

Despite its non-interactive nature, the use of animation in temporal sketching provided viable insights into the interaction possibilities and possible breakdowns implicit in the non-idiomatic technology of augmented reality. It was evident that in watching the animations, different team members noticed different elements from the perspectives of their respective domains. The zoo personnel noticed that having the guest standing in front of a camera at specific places in the zoo might affect the 'rush hour traffic' of guests and potentially disturb both the users of the app and other guests. On the other hand, the developers saw potential usability issues concerning visibility and feedback if no physical constraints were imposed on the context of the app. Although the observations were different, they were based on the same temporal information. As a result, it was easy for the group to communicate, to gather the inputs and to prioritise them with the animated sketch as a frame of reference. This meant that the team members who did not have technical domain knowledge could participate in the interaction design by discussing a narrative about the concept: they did not need to understand the technical constraints in detail. The team members would pause and rewind to certain points of interest; here, they would ask questions and give feedback, which initiated the consensus process among the team. The non-interactive aspect of the animation helped the team to maintain its explorative focus instead of becoming didactic; in other words, this was a sketch rather than a prototype.

One recurring topic of debate concerned the effect the proposed interaction designs would have on the interior decoration of the zoo context. The designers in the team proposed to design visible information posters, light spots on the floor to indicate where the user could use the app, and movie scenography as the context for use of the app. The zoo stakeholders, on the other hand, wanted to keep the physical settings as authentic as possible, without posters and other elements distracting attention from the zoo context. Again, the initial sketches provided insufficient information to reduce uncertainty about the most viable path to take. Instead we had to generate more information about the dynamics of the context, combined with the dynamics of the digital system.

We made an animation-based sketch which combined elements from the sketches into a representation of the use context in the zoo. Animation approaches and visual modalities were mixed via stop-motion, key-frame animation and live video footage. Having recorded a video of two children visiting the zoo and having bodystormed how to use the app, we edited our animated content and interaction sketches into this footage. We took pictures of the aquariums and made them into scenography backdrops, mounted a flashlight to act as a spotlight, and used a series of printed icons as guiding signs. The final video scenario consisted of a brief narrative recounting the children's visit to the North Sea Oceanarium.

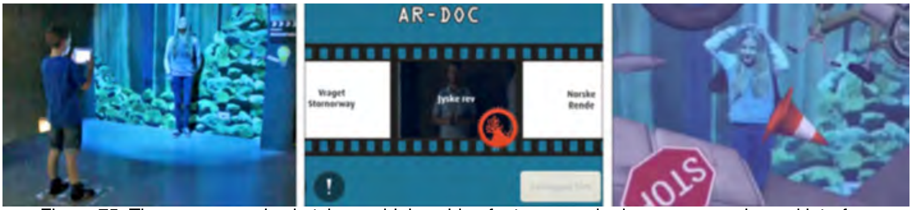


Figure 75: The user scenario sketch, combining video footage, mocked up scenography and interface elements, to sketch how the physical context of the zoo could be integrated with the digital design. See the sketch at https://goo.gl/Pv5tKT

The sketch evolved into a short narrative set in the zoo context. The uncertainty about the extent to which the addition of scenography would affect the look and feel of the context could now be addressed temporally and visually through the animation-based sketch. The zoo personal conceded that some background scenography might be useful to support immersion, provided it had the same realistic appearance as the digital content. The developers were also concerning about the extent to which posters and spotlights would be allowed to stand out from the more natural-looking setting of the rest of the zoo. A consensus was reached limiting the guiding signs to a single signpost at the entrance to the zoo, and the augmented reality spots were indicated by unobtrusive footprints painted on the floor.

This scenario facilitated consensus between the team members by representing temporal aspects of the design which would have been hard to grasp without a coded version. However, compared to the previous sketches, the sketching process did not involve the same degree of investigative and explorative emphasis in terms of iteration back and forth between different temporal setups. Instead, the process was clearly defined as the generation of temporal feedback about a specific set of uncertainties and their representation in a way to which all stakeholders would be able to relate. The output sketch was thus explanatory and to some extent persuasive, as each scenario argued for a specific proposal.

It is interesting, however, that when the questions asked became very specific and referred to previous questions posed by animated sketches, the creation of new animation-based sketches was less investigative and thus entailed less visual thinking. Moreover, it took considerably longer to decorate the context, capture the material, and edit it together, than we used in the production of the previous sketches. This was in part due to the consistency of visual fidelities in this sketch: by way of contrast with the U-CrAc sketches, for instance, no mixtures of cut out stop motion and live footage were used. The sketch thus evoked a consistent and almost ‘real’ sense of the context, but at the expense of the investigative and explorative nature of sketching. This application of animation-based sketching happened at a relatively late stage in the design process, when many of the non-idiomatic aspects of the mobile app itself had been explored. It might therefore be argued that the process had simply reached a stage where the sketching activities had gradually begun to transcend into more specific issues to be tested by producing the actual elements.

Persuasive sketching to inform technical platform constraints

After consensus had been reached about the interior design, and after the transition to development of the first technical prototypes of the augmented reality app, the team began to reduce the complexity of the information that sketching had generated about the design concept. This process followed the traditional iterative cycles of testing, refining, and testing again (Boehm 2000). As the functionality and content began to take shape in the coded iteration, the developers came to the conclusion that not all features of the app would be able to run fluently on iOS devices. Almost all devices running the Android OS would be unable to render the superimposed augmented reality effects in real time; they would have to record the scene and then render the effects for about one minute.

This created much debate in the team and in the organisation itself. The organisation wanted the mobile augmented reality experience to reach as many guests as possible, while the design team feared that a wait of one minute would affect the user experience negatively. The only thing we knew for certain was that we would have to compromise on the final polish of the iOS version if we had to build a functional Android prototype, When no consensus could be reached on whether to carry on with the Android version, we conceived the idea of using animation-based sketching to reduce the uncertainty about this ‘one minute waiting experience’.

We generated the sketch by filming an action video in context and then combining it with a key-frame animation of one of the augmented reality scenes. This scene was followed by a new key-frame animated interface of a load screen, which ran for one full minute before presentation of the augmented reality content. This was the fastest specific animation-based sketch the team created; due the established pipeline of live-video material and content from previous stages of the project, it took no more than 10 minutes to produce.

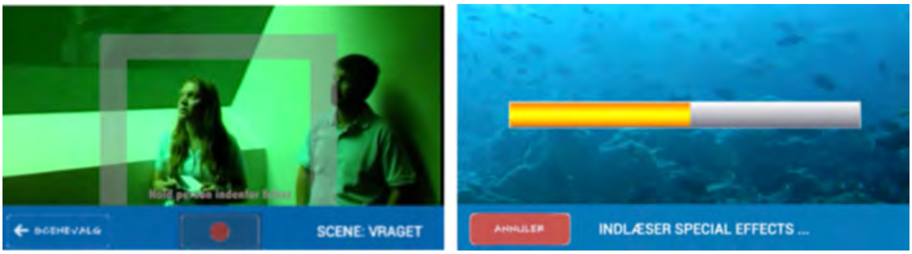


Figure 76: The interface of the app’s camera viewfinder is animated on top of video footage from the zoo to illustrate how the user records the scene without live effects (left). The scene is followed by a key-frame animated load screen, running for 1 minute and presents the recorded scene with the augmented reality special effects (right). See sketch at https://goo.gl/EHjts1

We placed this video on a smartphone and used the sketch in combination with a Wizard of Oz (Buxton 2010, Kelley 1984) setup, in which the same actors played the same roles in front of the same aquarium. In this way, we emulated the entire user situation and observed the feedback from stakeholders and users when they had to wait one minute before any action happened in the app. Unsurprisingly, the wait was negatively received; most people actually thought that they had waited for more than one minute.

Due to the feedback from this sketch, the decision was reached not to realise an Android version of the first edition of the app. This decision saved enough of the budget to allow the purchase of a series of iOS units to rent out to guests who did not have an iOS device, enabling all guests to enjoy the full augmented reality experience if they so wished. The primary role of this late animation-based was persuasive: it was aimed at providing evidence for the negative effect of load times on potential user experience. On the other hand, in terms of exploring the non-idiomatic technology of this type of augmented reality, the sketch also provided the design team with new exploratory knowledge about the limitations of this type of technology across different platforms.

This illustrates how animation-based sketching can take on different sketching functions over time, as was suggested in part I.

LESSON LEARNED

Animation-based sketching is not an isolated approach for the early design phases. Even at a late stage and well into development, it is a way to reduce uncertainty about temporal dynamics which are unpractical to create by other means.

CASE 2: COLLABORATING WITH AN AGENCY ABOUT A GAME DESIGN

The North Sea Oceanarium case provided an industry perspective on animation-based sketching used to explore the dynamics of the interactive elements of augmented reality. It has shown how the sketches facilitated consensus. Our next industry case sought to combine this perspective with the lessons learned from the workshop cases by exploring how an agency of professional designers would employ the approach. We did this together with the marketing and design agency 'Tankegang' (www.tankegang.dk) in an exploration of the possible user experiences of a new mobile game. The game aimed to create awareness about recycling and its environmental impact on citizens. The project was entitled 'Recycling Animation' and was organised as an internal R&D project to produce understanding of the non-idiomatic aspects of a new game design model combining elements of augmented reality and the endless runner genre. The app allowed the user to capture him or herself with the help of a mobile camera. This image was used in the game as an avatar. The user avatar was involved in recycling different kinds of incoming garbage at an increasing rate until the user inevitably failed and received a final recycling score. The non-idiomatic elements of the game included the way in which the augmented reality effects functioned alongside the game mechanics, as well as the way in which the user avatar would behave during the game in order to make it fun to 'play as yourself'.

The design process started with a series of user studies conducted in-house by the agency. Through these studies, we learned how the target group understood recycling and related to it in their daily lives. On the basis of these insights, a design workshop was conducted. During the workshop, a series of different concept ideas were conceived and sketched as rough static paper sketches (Appendix 5.1.1). From these sketches arose the overall concept of a game design with the user in the role of main avatar. However, the sketches only vaguely described how to achieve this and barely touched upon the interaction design of the game. The team soon realised that it was difficult to discuss these dynamics on the basis of static imagery alone. This led to the introduction of animation-based sketching in a rapid, three-hour hands-on seminar. The design team were already proficient in a variety of graphical design tools, such as graphical design in the Adobe Creative Suite, and in using basic video editing skills in various production environments. Thus, we focused on showcasing how their existing tools could be applied in animation-based sketching with the addition of just a few new features, techniques and approaches.

A delicate balance of not asking too many questions at once

With the introduction of animation-based sketching approaches, the designers at the agency started exploring the dynamics of the variations of the game concept. The process here resembled the process we had seen previously with our design students; they starting by creating a series of animatics of the user scenario.

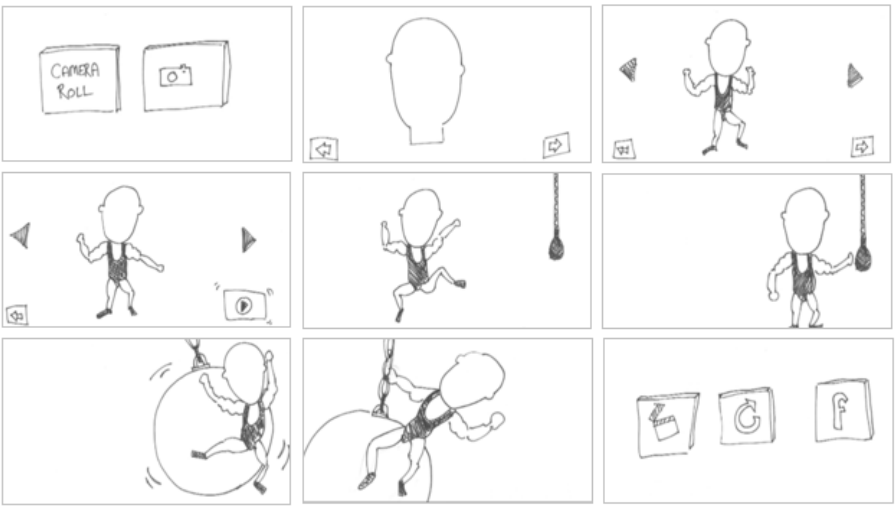


Figure 77: The first animatic adding timed sequentiality to the static sketches expressing the idea of bein able to capture the users face to be used in the game. See the sketch at https://goo.gl/iy1JS7

Figure 78: The second animatic took on a higher degree of details in the static sketches, which in turn made the animatic more expressive, and detailed enough to get a sense of how the capturing mechanism and selection of avatar details might work in the concept. See sketch at https://goo.gl/RQCwCf

Completed in less than two hours, the first animation explored a variation of the game in which the gameplay elements were limited to manipulating the user-generated avatar through exaggerated rag-doll physics inside a recycling facility. In the end, the user would be able to share the most entertaining moments of manipulating the character on social media. While creating the sketch, the designer primarily investigated the dynamics of how users would be able to capture themselves for use in the game, and specifically how to create appeal in the game avatar by using the user's own face. However, the specific game elements were only added as an afterthought - a secondary question posed in the sketch. In watching the sketch with the rest of the agency, it became evident that the two questions posed by the same animatic gave rise to an unclear discussion. The primary question, the appeal of allowing the user to act as avatar, was largely overshadowed by the game elements.

What was shown to be at play at this step was Lawson's (2006) point that one should avoid suggesting answers to questions not under consideration at the moment. This might be even more problematic when assessing 4D sketches such as animation-based sketches. When examining static sketches or individual stages in a static scenario, we are free to focus our perception on certain elements for as long as we need. When presented as a 4-dimensional sequence, the represented flow is over before it has been played, creating the need to actively rewind or repeat the sequence to allow space for longer reflections. This creates a perception of the animation-based sketch as the sum of temporal information, whereas static sketches are perceived in their individual stages.

LESSON LEARNED

Temporal information is needed to inform the dynamics of non-idiomatic aspects, but the risk is that too many questions may be posed to be comprehended at once. In effect, the information generated raises the complexity faster than the uncertainty of the design possibilities is reduced. This is a crucial lesson concerning animation-based sketching.

Animatics - getting a sense of the appeal in the game

On the basis of these observations, we proposed that the designers should narrow down the problem setting to a more focused investigation of how to make the game more appealing.

The designers created a series of very simple and fast cutout animations by merging the faces of each member of the design team with the body of another member. The resulting bodies were animated in a variety of distorted poses using stop motion and manipulations.

Figure 79: These animation-based sketches used stop motion with cutouts of photographs to explore the how to distort the user avatar in humorous ways. See sketch at https://goo.gl/UFbY3r

In examining these sketches, the designers adopted the evaluative criterion of whether their colleagues laughed on seeing the distorted avatar being manipulated. On the basis of these reactions, further poses and examples were created - from investigative to explorative animation-based sketching. The next step was to ask whether this type of rag-doll physics would create the right appeal in the context of a recycling facility. The designers thus created a quick scene depicting a factory workshop, took the ideas from the cut out animations into an animatic with relatively high visual fidelity, and sketched a scenario with the avatar inside the factory.

Figure 80: Based on the previous cutout animation, an animation-based sketch was made digitally to explore the mix of visual fidelities, and how the distorted user manipulations would behave in such contexts. See sketch at https://goo.gl/LlzCAe

These animation-based sketches were clearly narrower in scope and did not present the dramatic discourse of the previous animatics. On the other hand, they did represent a much more focused explorative sketching effort, in which the sketches facilitated a focused discussion about the appeal of the proposed idea of placing the user's face on the avatar. The output was a decision to explore the branch of these user-generated avatars further and to broaden the problem setting to explore how this avatar would interact with the recycling workshop.

Animating interactive game behaviour

Neither the animatics nor the focused avatar cut-out sketches included temporal information about the specifics of how a game could be played with the user-generated avatar. The idea proposed involved merging rag-doll physics, the user-generated avatar, and the genre of 'endless runners'. A few static sketches were made to visualise this idea, and the agency tested a series of existing games from the genre to learn from best practices. It was evident, however, that the patterns of existing games did not make it much easier to assess the entertainment factor provided by the game mechanics and by the fact that the users appearance was transferred to the avatar . This seemed to be the natural point of transition into interactive prototyping to test the combination of these elements. However, the agency developers noted that a prototype would require them both to develop a working version of the endless runner game and to develop the capturing engine to capture the user's face . The R&D budget limited the feasibility of creating this comprehensive coded version, especially if the idea were to prove unsuitable. Thus, the designers spent a day creating a series of animation-based sketches by reusing the graphical components from the user-generated avatars and applying them in variations of animated user scenarios of the full game experience from a natural discourse.

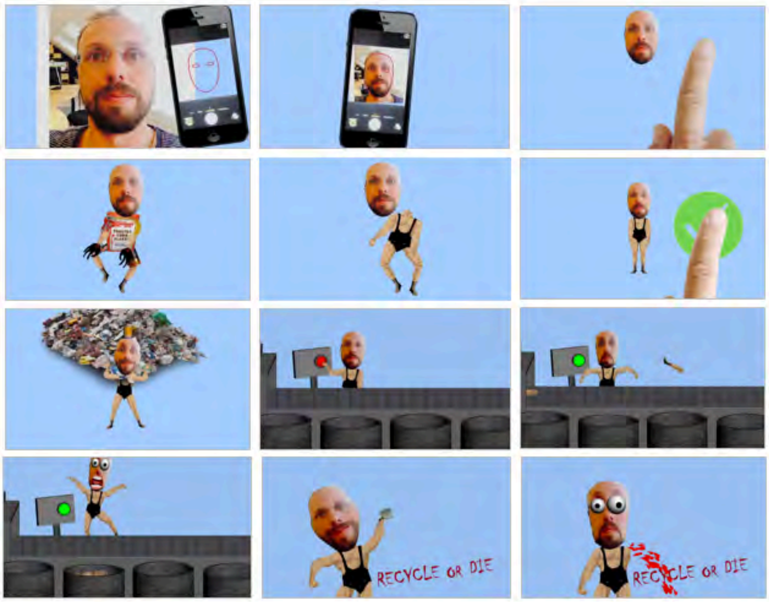


Figure 81: The last animation-based sketch explored the full user scenario in high visual and temporal fidelity, to also gain feedback on the finer dynamics of the end-less runner game mechanics. See sketch at https://goo.gl/o2V2Kb

The intent behind the sketch was that it should allow the team to cooperatively explore the flow between generating the user avatar and using the avatar in a recycling themed endless runner. These sketches had a significantly higher temporal fidelity than the previous sketches, where the designers even experimented with simplified applications of physics-based animation principles such as squash & stretch. Even though these principles were applied, the designers were able to create the effect by combining their existing graphical design skills to quickly generate the graphical components. These could then be edited in the animation production environments. The application of principles such as 'squash & stretch' did not look finished or physically correct, but it gave a clear idea about the dynamic relationship between the game mechanics and the avatar in the variations of the ideas animated.

These animation-based sketches later assumed an explanatory sketching function; they were shown across the agency to other employees, who provided further responses, comments and reflections upon the information generated from seeing the sketches. The important point here was that the previous animatics and cut out stop motions had asked the important initial questions, thus enabling the new animated user scenarios to include both what had already been decided and variations of the new questions. In this way, the sketches portrayed a clear constant in terms of the appeal of the user-generated avatar and proposed clearly articulated questions regarding the game dynamics and interplay with the avatar. This established a basis for assessing the potential of the different game designs and supported the gradual transition into the actual development of game elements based on the reflections about the animation-based sketches. In fact, the developers used the animation-based sketches as the base component layer in their initial work on creating the first interactive prototypes. In doing so, they used the same graphical components and animations but added simulative input and output. In effect, the animation-based sketch as an emulator transcended into an interactive simulator.

LESSON LEARNED

The time and care invested in creating animation-based sketches in the later phases of design can actually be recouped in the design of the equivalent graphical and temporal aspects of subsequent development.

THE END

We have now reached the end of this book. Through descriptions, analysis, and discussions, it has positioned animation-based sketching as a distinctive design approach that generates temporal information to reduce uncertainty about the dynamics and potential user experience of non-idiomatic technologies. The ambition was to address this ambiguous phenomenon by building a stronger basis for fitting together the concepts of design sketching, interactive technologies, animation and facilitation in a unified approach. We have attempted to show how animation-based sketching draws on the theories of design sketching, animation studies, digital media and computation. It is our belief that a strong foundational knowledge of the history, discourse and traditions of a domain is important when establishing a distinctive phenomenon. We have contributed to the existing discourse about the use of animation in design sketching in this regard, uncovering some of its roots and organising them to assist in the definition and ontology of animation-based sketching

We have defined animation-based sketching as the use of animation to portray a fictional proposed reality that is intended to become fact. This is achieved by emulating the simulation of a bounded model of reality in digital systems. It follows that animation-based sketching has a digital sketching capacity, in light of which we have discussed the archetypical perspectives, narratives discourses, fidelities, and functions the sketches can have. We have seen these features manifested in a range of different contexts, ranging from our constrained workshop experiments to constructive collaborations with stakeholders outside academia. From these efforts, we have derived a series of lessons learned about the viability and practicalities of applying animation-based sketching as a design approach in practice.

Here, as the book is drawing to a close, we argue that animation-based sketching has significant potential as a tool for design. By creating the illusion of apparent motion and change, designers can emulate complex dynamics and interactions involving new non-idiomatic technology, and represent it in interplay with users as contexts. This enables designers, stakeholders, and external recipients to reflect upon the proposed idea from a perspective in which the technology seems already to be in use, already implemented, with a proposed user experience. Nevertheless, it is ambiguous because it is unfinished. We have seen that temporal information may provide value in terms of informing us how a proposed user experience may be realised in practice and that animation offers a way of assessing the utility, usability and desirability of new technologies before costly resources are spent on prototyping or on actual development. The animation-based sketch offers an unfinished proposal which asks questions, inviting others to reflect upon whether the proposed idea is a desirable future state of the world.

However we have also seen examples indicating that animation-based sketching is not a ‘jack of all trades’ approach and that ill-considered applications might lead to undesirable design processes. This happens when the craft of animation takes over from the craft of design sketching, animating something which looks like sketches rather than actually sketching with animation. We have sought to show these risks by drawing on practice as well as on our analysis of the principal production environment features needed to enable animation-based sketching. Animation-based sketching is not just about using a specific tool, technique, material, or narrative discourse. Rather, the success of animation-based sketching depends on balancing the digital sketching process with the appropriate visual and temporal fidelity needed to pose the right questions at the right time in the design process. Through animation-based sketching, the designer creates a problem setting which should be wide enough to facilitate reflection but narrow enough not to pose too many questions at once. Whether used to investigate a design problem, to explore possible solutions, to explain an idea to peers, or to attempt to persuade a stakeholder about the viability of a specific idea, animation-based sketching provides the information needed about the non-idiomatic dynamics of the proposed design. This is our contribution to the positioning of animation-based sketching as a distinctive design approach; animation-based sketching makes it viable to generate information about the temporal dynamics of a proposed system, thus reducing some of the uncertainty about the potential of new non-idiomatic technologies.

The next horizon for animation-based sketching?

We framed this book to deal with sketching the user experience of non-idiomatic technologies. This was partially due to the natural limitations of traditional static sketching approaches in this domain. However, the framing of this subject matter was also determined by the fact that previous studies of the use of animation for sketching almost solely originated from within the interaction design and human-computer interaction field in academia. We continued along this road, discussing how animation emulates digital simulators.

However, limiting the potential of animation-based sketching only to the domain of interactive digital technologies would involve giving the approach too little credit. Other domains might also potentially benefit from the generation of temporal information through animation. As it is, we have already seen some indications of this in our experiments from the U-CrAc workshops, which, at the time of writing this book, have been held seven times. We have focused on sketches sampled from the latest workshops, dealing with non-idiomatic aspects of new digital technologies and services. However, many cases in the workshop have also addressed non-digital issues, such as service design, business model generation, and organisational development and learning, We have observed how animation-based sketching provided valuable temporal information in these cases, creating an overview and transparency for the complex systems and relationships in large organisations, networks and services. On the basis of the insights from this book, it is our new hypothesis that many of the lessons learned about animation-based sketching might also apply to these system level domains and potentially support and facilitate decision-making on a grander strategic level. While this topic is outside the scope of this research project and this book, we suggest that this should be the next great venture in the continuing elucidation of animation-based sketching as a design approach.

Part of a larger ecology of renderings

While we have argued the case for the viability and practicality of animation-based sketching in this book, we will leave the reader with a word of caution. A high level of investment in one specific design approach and a commitment to arguing its relevance and potential make it easy to lose sight of its place among a larger ecology of rendering types. In the book we have often compared animation-based sketches with static sketches and interactive prototypes. The choice of animation over static depiction depends on the balance between the extra sketching time required to sketch with animation and the temporal information gained by doing so. Animation trumps depiction when there is a need to reduce uncertainty about temporal dynamics. The choice of animation over interactive prototypes in code depends on the balance between (often) faster sketching time in animation and the loss of interaction with the design.

The emulative capabilities of animation-based sketching always involve the contingent choice of an approach which may excel in generating information in some cases but fail to do so in other situations. The need to be sensitive to this choice is perhaps the most important lesson to take away from reading this book. Animation has great potential for representing the possibilities of non-idiomatic technologies, and we have argued that this is a potential that has yet to be fully realised. But regardless of the situation for which animation is chosen as a sketching approach, it must be used in a different way than traditional animated film and not become ‘the product’ in itself. It should be kept fast, rough, and ambiguous enough to be a process tool for reflection upon both problem setting and problem solving within the setting. Only in this way, can animation-based sketching unleash its potential, using animation to portray a fictional reality about a preferred state of the world with the aim of making it real.

That’s all Folks!

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Abductive sensemaking through sketching

A categorization of the dimensions in sketching capacities in design

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Abstract

This paper proposes design sketching as a way to make abductive reasoning manifest and concrete. Through sketching, the abductive sensemaking leaves the domain of abstract logics and becomes part of the researchers or practitioner's reflective practice. This practice is especially evident through incorporating sketching as more than a specific technique, but also as ways of applying design thinking through acting upon the world. The paper presents sketching as an integral part of the design epistemology. Furthermore, a categorization of different dimensions in which sketching can be represented is presented. The main contribution is a discussion of whether this broader view on sketching capacities in design leaves room for further exploration into extended sketching capacities for design.

Introduction

In recent years, the academic field of design research has had an increasing interest in the role of sensemaking in the creative and constructive process of scientific inquiry (Krippendorf 2006, Koskinen et al 2011,). Klein et al. define sensemaking as *"a motivated, continuous effort to understand connections in order to anticipate their trajectories* *and get detailed inquiries into the nature of human culture"* (Klein et al. 2006). The methods and techniques of design-oriented sensemaking varies. However, most seem to be based upon the abductive logic of reasoning (Kolko 2010, Martin 2009). Unlike most other schools of thought, the field of design research applies methods which approach the abductive sensemaking process of adopting new hypothesizes as pursuing 'what if' and 'why' questions to a given problem space (Brown 2009, Nelson & Stolterman 2012 Markussen & Knutz 2013). The designerly epistemology sees the act of 'doing' as the foundation for acquiring knowledge and meaning. This echoes Maitlis and Hernes (2010) perspective on sensemaking as a way of reasoning about the future when confronting, confusing or surprising situations in an organizational praxis.

This paper aims to discuss and categorize the ways designers use sketching to test and challenge assumptions about both current and possible future states of the world. The categorization positions sketching as being broader than a mere set of techniques. The paper examines different expressive dimensions in which designers use sketching to think about and explore problem spaces. Finally it will be argued that the exploration of both existing as well as extended capacities of design sketching can be seen as an integral element for the epistemology of design thinking.

Designerly ways of thinking

In regards to the studies of design Nigel Cross states *"there are things to know, ways of knowing them, and ways of finding out about them, that are specific to the area of design"* (Cross 2007[1]). Cross frames design thinking as a specific way of knowing about- and finding out about matters, creating one of the first framings of design as a specific epistemology. Furthermore, this is supported by an emphasis on Herbert Simon's work on how the ontological domain of design is centered on the artificial 'built environment' (1969). Adding to this framing of design Richard Buchanan made an interpretation of Rittel and Weber's concept of 'wicked problems' into the field of design thinking (Buchanan 1996). Buchanan showed how designers has a special way of approaching the ill-defined, contradicting, and ever-changing problems of design, by embracing the fact that the subject matter of design is by itself designed and framed by the designer. Given its performative nature of its epistemology, design also carries a sort of 'ontological politics' concerning what is being made (Gaver 2012).

With Cross and Buchanan's examinations, design thinking emerges as a distinctive epistemology for creative and solution-focused ways of exploring Simon's 'preferred future states' (Simon 1969). It initiates its inquiry by framing a (often fuzzy) goal for the preferred state, creating a space to be explored instead of a clearly defined problem to be solved.

Jon Kolko (2010) emphasizes the abductive logic as being directly linked to how designers work. The abductive logic relates to Klein et al's (2006) notion of sensemaking as an action oriented process that people automatically go through in order to integrate experiences into their understanding of the world around them. Kolko uses the notion of abductive reasoning to describe how the designer adds new sets of disparate knowledge into the existing parameters of a problem space. Through experimentation with the conditions, the designer explores the basis for claiming that a given idea 'might' be a feasible path to a solution. Unlike deduction or induction, abductive logic allows for the creation of new knowledge and insight through qualified guesses that are not part of the original set of premises, but are added through past experiences with related or intertwined situations.

The abductive logic's role in design thinking sums up the designer's sensemaking process as a phenomenological approach to use past experiences and seemingly unrelated knowledge to ask 'what if?' questions. Kolko describes these experiences as the marks left by the individual designers lived experience in everything designed (Kolko 2010). Furthermore, abductive sensemaking is done only through actually acting upon the world - by making some sort of expression of the 'what if' when we abductively add new set of data to the existing parameters of the problem.

As Cross already noted in 1982, the process of design thinking often happens in the built artificial environment - based upon the creation of artifacts (Cross 2007). However, modern design discourse does not limit itself to the view of design as aimed towards artifacts as an end-goal. With the emergence of disciplines such as interaction design (Moggridge 2007), experience design (Hassenzahl & Tracktinsky 2006) and service design (Stickdorn 2011), modern views of design thinking aim at using the processes of abductive sensemaking in areas where the end-result is not necessarily a 'product'.

But if sensemaking through design thinking is driven by abductive reasoning initiated by exploring and experimenting with the given parameters and constrains of the problem space, it seems reasonable to claim that the multitude of design fields also might adhere to a common way of, in Cross' words, *finding out* about possible solutions to the design problem. This calls for a broader definition of what the role of creating artifacts or expressions has for inferring the best explanations for the preferred future states.

The following section will seek to discuss some of the foundations for using the concept of 'sketching' as this common definition of how the designer applies design thinking in various contexts of doing.

Design thinking through sketching

Traditionally in design, the concept of 'sketching' has been approached and described as either a specific stage in the design process (Simon 1969) or as a specific set of techniques used throughout the design process - mostly represented by pen and paper sketching (Jones 1992). In a more broad perspective Goldschmidt's (1991) studies indicated that we might see sketching as a more integral and inseparable part of design thinking. Goldschmidt argues that sketching is broader than a technique or phase, since it represents the way designers reflect through the act of actually doing concrete visual exploration of a material. Donald Schön (1986) made similar claims in his studies of reflective practice, and lately Bill Buxton (2007) popularized this way of interpreting sketching within the HCI community. Buxton argues for a strategic value in adopting sketching as a mindset for design through both examining what the *right design* might be and *the right way* of designing a solution. Contrary to other approaches like prototyping (ibid) the point of sketching is to make non-committal explorations of both the problem itself, and the possible ways of dealing with this problem, in order to deal with the wickedness of the design problem.

Sketching takes cues from both the pragmatic perspectives of learning through practice (Dewey 1909), and constructivist perspectives of reflective conversation with materials (Schön 1992). Sketching is not concerned with abstractions over the world, but with concrete manifestations of 'what future possible states might be'. This effort of creating manifestations of what might be is what makes design thinking, and sketching as an act of 'doing' in particular, a pragmatic discipline. This is further supported by the constructivist act of iterative reflection-in-action when sketching. If these principles are accepted as part of broadening the concept of sketching, it allows for sketching to be described as being more than a mere technique or phase. Buxton presents eight criteria for sketching that may act as a our focal point: *evocative*, *suggestive*, *explorative*, *questioning, proposing, provoking, tentative* and *non-committal* (Buxton 2007). Derived from these criteria I propose that we might interpret sketching as a mindset through which we apply different techniques, more than being a specific set of techniques by it self. Thus, sketching becomes one of the clearest manifestations of how to think and communicate design. By emphasizing the acts of proposing, provoking, and not committing to one idea, sketching explicitly manifest a speculative sensemaking. Through sketching, sensemaking becomes an abductive inquiry, in which we do not explore what must be or what is, but rather create a reflective practice of speculating, pruning and manipulating the conditions for what might be. Again, this implicates that we must broaden our view of what we actually 'do' when we apply the mindset behind sketching in our inquiry into a problem space.

Here sketching is both the processual way of doing design thinking from Buxton's criteria, but is also the communicative output from which our understanding of the problem evolves and becomes refined. Thus, sketching is a way of both expressing and reading ideas, and through this dialectic relationship, the abductive sensemaking takes place.

We now have the foundation to categorize how sketching manifests itself as an act of applying the abductive logic in practice through a variety of approaches. Thus, in Cross' words, we are able to categorize the *"...ways of finding out"* when applying the epistemology of design through a sketching mindset.

Dimensions of designerly sketching

Buxton's set of criteria indicates that sketching cannot be described as a single technique. Instead, it must be considered in a broader sense as a way of acting upon the world. Through a reflective conversation with both the material at hand, and the context of the design space itself - sketching both has a reflective and communica-

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tive output. In order to categorize the ways of which sketching represents abductive sensemaking we need a new typology for sketching. One that considers the space in which the sketching is applied as well as the enabling mediums or technological praxis. In this regard inspiration has been taken from Gillian Smith's attempts to describe and categorize the essence of interaction design according to its 'dimensions': 1-D, 2-D, 3-D and 4D (Smith in Moggridge 2007). The original typology is oriented towards deconstructing designed products, but the categories are also suitable in a more general view of ways of doing design. In the following, the typology is adapted to the domain of sketching, in order to generate a framework for a more broad view on design sketching.

1-Dimensional Sketching

In the adaption of Smith's original typology, we must first consider how sketching can be considered from a 1-dimensional perspective. In Smith's original typology, 1-D includes the spoken words of language. Applied in the context of sketching this dimension can be used to express the 'what if' questions that characterize the abductive logic, and thus in a sense 'sketch through language'. Not hereby saying that the spoken word is always characterized by the criteria of sketching, just that it can be applied this way. The important thing to consider is that the expressive capacity of words is intrinsically an indirect representation as opposed to a more direct depiction when using spatial dimensions to express an idea. Words are articulated, but has no other expressive capacities than how we might interpret the semantics of the chosen words. Lerdahl (2001) uses the indirectness of language as way to sketch early ideas by proposing 'principal sentences' which drive the fuzzy front end of creative processes as a base sketch of the design space. This base can then be explored further through other sketching capacities. Lerdahl's approach and other attempts to adopt a sketching epistemology through words alone shows that words can in fact be used in a way that fits Buxton's criteria of sketching. Moreover, the lack of depictive qualities does not justify leaping to the conclusion that 1-dimensional sketching is inferior to depictive representations. The abstractions of language, the multitude of meanings, and the sense of wonder and imagination are often better expressed through the indirectness of language. Moreover, in the early stages of design this ambiguity is often exactly what we need to expand the boundaries of the problem space. However, it also seems fair to assume that for the purpose of more concrete and inter-subjective purposes of sketching, a need for more spatial and temporal depictive qualities are needed.

2-Dimensional Sketching

The ambiguity of 1-dimensional sketching is countered by adding a spatial dimension, and move into the 2-dimensional category of sketching. 2-dimensional sketching is the easiest to identify as sketching because it is the space where many of our existing prepositions about sketching as a depictive technique exists. The 2-dimensional space includes the use of typography, diagrams, pictures, icons, and the general ability to visualize what was initially just a word or thought, which enables the feedback loop of reading sketches to be clearer and more concrete. With a 2-dimensional sketch, it is difficult not to interpret and add our own visual experiences of different tropes and metaphors into the reading of the expressed idea (McKim 1973). Furthermore, the enabling mediums of pen and paper, paint and canvas, and later screen-based electronic medias has been well explored and mastered for sketching purposes. This ranges from creating (abductive) synthesis' of form (Alexander 1964), rapid prototyping (Wasserman & Shewmake 1982) or visualizations of information too abstract to capture in 1-dimensional words (Tufte 1997). Thus, 2-dimensional sketching can fittingly be seen as the archetype of sketching, being above the abstract thoughts expressed by words alone, but are also limited to one spatial dimension. This sketching capacity reaches its limits for expressiveness when more complex experiential and dynamic aspects are needed, in order to reflect upon the proposed idea. Thus, we need to add another dimension to the categorization of sketching capacities.

3-Dimensional Sketching

An extra spatial dimension is added when we consider 3-dimensional sketching capacities. In this dimension, the mindset of sketching is applied to manipulating physical form or sketching within a physical space. This type of sketching is composed by situations where the designer applies abductive sensemaking into creating a certain form of expression - a model for an example - as a physical manifestation of the 'what if' question that drives the synthesis. Again the technological practice has enabled us to sketch back and forth between e.g. 1-D and 2-D sketching capacities. As when we imagine and discuss a new concept for a physical product, which we sketch in multiple iterations of paper and digital sketches, and afterwards rapid prototype through technologies like Computer Numerical Control manufacturing (Reintjes 1991) and 3D printing (Hopkinson & Dickens 2006). Other more low fidelity capacities of 3-dimensional include quick mockups of objects or contexts in order to explore the possibilities or consequences of the 'what if' speculation (Ehn & Kyng 1992). This sketching capacity seems quite broad, but the categorization hits a barrier when we consider new forms of 3-dimensional sketching via physical elements such as 'material storytelling' (Jørgensen & Strand 2013). In these cases, the sketching is not just concerned with the output sketch as a static 3-dimensional representation, but is also concerned with the *sequence* as an element of the sketch.

4-Dimensional Sketching

The above is an example of 4-dimensional sketching capacities - where the temporal aspects are considered, manipulated or captured as a transitional part of the design inquiry. This consist of actively sketching aspects of the time through which a given phenomenon is experienced - such as bodily enactments (Oulasvitra et al 2003), sound (Ekman & Rinot 2010), and video (Ylirsku & Buur 2007). Video has had an exceptionally strong influence in this category as a 4-D language for sketching. In twenty seconds, a video clip can tell a complex story understood by almost everyone. Filmmakers have been developing the language of film for more than a century, and with very limited resources, they can express plot, emotion, anticipation, and action over the course of a certain timeframe. These same qualities are shared when the video language is used for video sketching (ibid) - making a visualization over time, speculating how a certain problem space might be handled through the addition of a new set for premises. The 4-D capacity has its strength in not just capturing the different states of an idea, concept or problem space, but also expressing the transition between the different states - the in-between which we might claim is where we actually express the experiential qualities in design.

However, video as a sketching capacity is also somewhat limited in terms of the number of parameters the designer is able to modify. This is due to the limits of video to the spatial conditions of the context of the problem space as it was when it was recorded. Through editing and movie language, we may reach a higher level of expressiveness but we seem to hit a wall in terms of simulating more complex phenomenon that would radically change the existing parameters. Löwgren et al (2010) proposes that we look in the direction of the digital domain and consider exploring design problems via interactive code, enabling a feedback loop in which we may sketch real interactions over time. While this technique is both novel and expressive, sketching via interactive code limits itself to problem spaces, where digital technology is front and center, and does thereby not enable us to apply 4-dimensional sketching beyond either digital problem spaces or the experiential limits of the current context.

Room for extended sketching capacities?

Based on the discussion of the abductive sensemaking through sketching, and the categorization it is suitable to take the adaptation of Smith's description of the 4-dimensional category a bit further. This category has room for expanding the range of approaches to design that we might categorize as 'sketching'.

I propose that we further expand the dimensions of which sketching enables sensemaking by adding 'animation' as the most current extension of the 4-dimensional sketching space. While still in the 4-dimensional sketching space, like bodystorming, video sketching etc., animation differentiates itself by adding more depth to the temporal, spatial and experiential aspects of sketching (Jacob et al. 2008). Stephenson (1973) differentiates animation from classic video with the ability the producer/designer has to claim 'full control' of the transitional material of which the animation consist of. From this point of view, we may frame animation as an extended 4-dimensional sketching capacity, able to simulate and manipulate both the spatial and temporal parameters of the problem space. Adding an animated dimension to sketches can then be seen as a way to express richer transitions in the sketching process, and thus potentially enabling a more clear feedback loop of the sketching process. Thus, animation in sketching is more capable to express the never-thought-depictions that new and novel ideas often require to be understood. This happens while still adhering to the core characteristics of sketching from Buxton.

Since animation remains a largely unexplored area as a sketching capacity in the 4-dimensional category, the question for further research is; *in what ways can animation be appropriated from the traditional animation film to fit the criteria of sketching?* The first criteria to investigate is how to apply 'animation based sketching' without abandoning the rapid and iterative nature that characterizes the criteria of sketching from Buxton. As we have discussed, various sketching approaches can cycle back and forth between the four sketching dimensions - creating hybrid formats. The same might be the case for an extended sketching capacity as animation. The next step would then be to initiate a more elaborate analysis of which capacities from animation we might use to catalyze the sketching processes in different problem spaces, and compare these insights to the more well-described capacities of the 1-D, 2-D, 3-D and 4D sketching capacities. In the end these insights will help further develop the notion of how sketching can be seen as an integral centerpiece of applying the epistemology of design thinking to praxis. This would in turn broaden our insight into how abductive sensemaking can be used to make inquiries by representing and depicting ideas throughout design process.

Perspectives

This paper has discussed abductive reasoning in relation to sensemaking in design. Furthermore, it has proposed that this type of sensemaking is driven mostly by reflective acting upon the world, which can be broadly characterized as different ways of adopting sketching as the centerpiece of a design epistemology. By taking Smith's original typology for interaction, and adapting it to a 1-4D typology for sketching capacities a new frame of reference has been established for further studies into approaches for conducting design sketching. When exercising the sort of speculative sensemaking that design enables, we are faced with multiple choices of which capacities of sketching to apply, and how to combine the languages of each dimension. The typology of sketching dimensions provides a way to compare aspects of these different approaches in regard to which actions the approach actually enables. This is important since few design processes leaves time or budget to explore all sketching capacities when pursuing an idea. Thus, we must facilitate a more clear way of discussing af evaluating which dimensions we need to operate in to explore a given design idea in the most feasible way. Therefore, for further studies we must collaborate and engage with new previously disparate fields into our own abductive inquiry of how design sketching 'might be'. This paper has proposed the capacity of animation as the most apparent and still largely unexplored capacity of sketching to be explored, and thus also a potential field to be included into the broader research into sensemaking in design sketching.

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Note

1 The cited text is the newest edition from 2007, however the original seminal work was first published in 1982

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THE ROLES OF SKETCHING IN DESIGN: MAPPING THE TENSION BETWEEN FUNCTIONS IN DESIGN SKETCHES

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Keywords: Sketching, visualisation, visual thinking, visual communication, design thinking

ABSTRACT

This paper examines how the role of sketching in design process has been disseminated previously through a review of prior perspectives into the field. We identify that the studies of design sketching has been dominated by two perspectives: studies into what is known as 'visual thinking' (Goldschmidt 1991, Schön & Wiggins 1992, Tversky et al. 1999), which examines the designers reflective conversation with the sketch, and a second perspective on sketching as way of 'visual communication' with others in the design process (Lugt 2005, Schütze 2003, Buxton 2010). We raise the question of whether it is reasonable to combine the two different roles of sketching to form a more intertwined relationship - seeing the two as sides of the same coin. Based on the terminology of Olofsson & Sjöflen (2005) four functions are identified as being representative for the different roles sketching can take in the design process: investigative, explorative, communicative, and persuasive. We appropriate these categories into a tension field, reflecting how the role of the same sketch may change over the course of time in the design project, based upon the type of knowledge required to gain from the sketch at a given time.

INTRODUCTION

Externalised representations fulfil various functions throughout the design process. They can facilitate a thorough analysis, help generate and evaluate ideas for solutions, and function as a distributed cognition between peers (Hutchins 1995, Römer & Saschse 2000). In fact, external expressions are somewhat near omnipresent throughout the design process. From early freehand sketches on paper to CAD-renderings on a computer monitor (Cross 2000). Löwgren & Stolterman (2004) emphasises the designer's externalisations, as multiple ways of articulating 'the knowledge construct' that is the primary outcome of the thoughtful design process. This frames design as being not primarily concerned with the making of artifacts, but the construction of new knowledge, which may become the basis of further development. This externalised design thinking is carried out by various forms of representation, not necessarily in the form of writing or spoken words, but more often in forms that can be appropriated and assessed more directly.

Sketching is one such way of working with external expressions in the design process. Sketching turns internal thoughts into external expressions, which makes comprehension and inference easier and less abstract than symbolic representations such as written language (Tversky 1999). The term 'sketch' generally has the meaning of a rough or unfinished drawing, and the activity to sketch is to give a brief account or general outline of something (Goldschmidt 2003, Goel 1995). The English word originates from the Italian schizzo, in turn based on the classic Greek term skhedios signifying 'done extempore - spoken or done without preparation' (Dictionary.com). Goel leans on this etymology in his emphasis on the ambiguity of sketches as their essential quality. Tversky adds that the advantage of sketching lies in their public nature - they are out there in the wild and aids the designer by supporting the limited human memory capacity and mental processing for a detailed problem analysis in a reflective conversation with the design situation (Schön 1983). A designer sees then moves and sees again. By working in a given medium the designer sees what is 'there' in the representation of an idea, sketch in relation to it, and sees what has been represented, thereby informing further design moves.

WHAT IS THE ROLE OF SKETCHING IN THE DESIGN PROCESS?

Though the process of sketching has been recognised as the archetypical activity in nearly all disciplines that identify themselves with design (Jones 1970, Krippendorf 2005, Schön & Wiggins 1992), there is still a debate between various research perspectives examining the role of sketching in design. One issue is whether the value of sketching is primarily in terms of its internal or external qualities - in other words who gains value from sketching? One perspective positions sketching as the ability to mediate the sensemaking process between the designer and the design problem that is occurring mostly in the early phases of design. From this perspective sketching is thought of as primarily a tool for 'visual thinking' (Goldschmidt 1994, Goel 1995, Arnheim 1969). The studies into the benefits of how visual thinking enables the designer to 'have a conversation with the drawing' are quite extensive (Suwa & Tversky 1997, Goldschmidt 1998, Bilda & Demirkan 2003), and have gained broad recognition as the primary function of sketching.

The second perspective in sketching studies puts the emphasis on the communicative and inclusive nature of using visual expressions in the design process (Lugt 2005, Schütze et al. 2003, Buxton 2010, Stacy & MacFadzean 1999). Since the design process is strongly influenced by feedback and dialogue, the expressive function of sketching is not only essential to the reflection-in-action by the designer, but is also of great importance by allowing for a broader community of stakeholders to observe, comment on, and revise the ideas in new enactments upon the represented (Frankenberger & Badke-Schaub 1998, Löwgren & Stolterman 2004. This domain of sketching as 'visual communication' has been subjected to fewer studies, but is more commonly ruled out as 'not being sketching' on the argument that it is the process of how the sketches partake in the designer's active reflection, which is of primary relevance (Goldschmidt 1998, Fällman 2003). In other words, the dominant position within sketching studies seems to be a processual focus on 'to sketch' and less focus on the outcome of this process 'the sketch'.

The relationship between the two perspectives leads to the broader question of when is something sketching? In most studies the focus has mainly been on the free-hand sketch, which has been broadly considered the synonym for the term 'sketch' (Goel 1995, Garner 1992, Suwa & Tversky 1997, Cross 1997, Purcell 1998, Tversky 1999, Bilda & Demirkan 2003). Vistisen (2014) made categorisation in which sketching was divided into four expressive dimensions - ranging from 1D (words like metaphors a sketching vehicles), 2D (like traditional sketches), 3D (like mock-ups and physical models) and 4D (like video and animation-based sketches). Vistisen's mapping links to contributions from from Buxton (1996), Löwgren (2004), and Arvola and Artman (2007) who among others have opened the discussion for other sketching modalities, such as video, physical materials, and animations, and made valid points for their validity as being claimed as 'sketces'. However, there is still some unclarity for when something is considered sketching, and when it is some other form of external expression, such as a prototype.

This paper reviews the two dominant perspectives on the role of sketching in the design process, and proposes a tension field of the roles of sketching, which illustrate the different functions sketching can serve over the course of time in the design process. We reviewed a selection of the studies into aspects of sketching in design processes, from the mid 1960's until the beginning of the 2010's with regard to the questions: 1) Is sketching to be defined as being primarily concerned with the reflection in the sketching process or the communicative potential of the sketching output? who gains value from sketching? and 2) Does the role of design sketching change throughout time in design process?

We explore the first question in regard to Schön's notion of the design process as a mix between problem setting and problem solving (Schön 1983) and the importance of viewing these as intertwined activities, unfolded by the reflective conversation with the design situation as well-balanced whole. By placing sketching as the archetypical process of working out this coherence we propose that we must both consider how sketching helps generate and form ideas by representing them via a given technique and medium, and how this representation puts the idea into a community of stakeholders to be tested through interpretation. This lead to our discussion of the second question were we discuss how this intertwined role of sketching is often present in how sketching facilitate different functions throughout the design process over time.

DIFFERENT PERSPECTIVES ON SKETCHING

Due to the near-omnipresence of sketching in the design process a multitude of different research interests have emerged, highlighting different key problem areas to be examined an discussed in order to better understand and reflect upon the role(s) of sketching. Common to most studies conducted from the late 1960's until today is an understanding of the design process as a process of tackling ill-defined wicked problems in practice (Rittel & Webber 1973, Buchanan 1996), and making sense out of sets of often ambiguous and incomplete data (Kolko 2010, Krippendorf 2005). Because of the wicked nature of design problems, there is no definite end to the problem solving activity in design, and the designer therefore needs to iterate upon the definition of the problem, the process, and the potential concepts for solutions in order to progress to a feasible solution. Through the concept of information processing (Simon 1973, Newell & Simon 1972, Hayes 1978), the manipulation of the design problem can be referred to as the exploration of knowledge states in the problem domain and the procedure of decision-making.

Furthermore, the information processing via externalisation constructs the base from which ideas can be evaluated and presented as the representation of new knowledge. Such external representations can be regarded as the concrete performance of designers in the design process. This function of sketching, identified by Fish & Scrivener (1990), is that sketching facilitates the transition from general descriptive knowledge into specific depiction. According to Fish & Scrivener the primary reason for designers to sketch is: "...the need to foresee the results of the synthesis or manipulation of objects without actually executing such operations", which places sketching as a way of externalising knowledge from the design process as a central part of the reflective activity of design (Schön & Wiggins 1992, Goldschmidt 1991). This echoes the emphasis of sketching's visuospatial abilities to add information to reality, and even distort the existing information to generate ideas (Tversky 1999). While we may insert sketching as the principal activity for creating external representations in the design process, its value is regarded differently depending on whether sketching is viewed as primarily concerned with visual thinking or visual communication.

1ST PERSPECTIVE: SKETCHING IS ABOUT VISUAL THINKING

The dominant perspective on sketching studies has been to think of sketching as way of applying visual thinking, which enables the designer to re-interpret the representation from sketching into new knowledge. Various researchers propose models of re-interpretation, each with a slightly different connotation, ranging from a dialectic type of argumentation between modes of seeing (Goldschmidt 1994), moves (Schön & Wiggins 1992), lateral transformation (Goel 1995), and focus shifts (Suwa & Purcell 1998). Though the methods of inquiry and interpretations of concepts differ, all four have suggested that designers are able to see more information in sketches than was invested in their making, labeling it as the cognitive process of 're-interpretation' (Fish & Scrivener 1990, Suwa & Tversky 1997, Purcell & Gero 1998). Re-interpretation refers to the ability to transform, develop and generate new images in the mind while sketching. There is considerable experimental evidence (Goldscmhidt 1991, Suwa & Tversky 1997, Lawson 1980, Menezes & Lawson 2006) that suggest that the generation of ideas in design depends heavily on this interaction between the designer and the external representation.

Goldschmidt's seminal work on the dialectic between designer and sketch comes from an investigation into what she labels 'visual thinking' (Goldschmidt 1994). Visual thinking is separated into three behaviours; seeing, imaging and drawing. Sketching is hence a matter of "…externalising ideas and interpreting external representations as ideas" a process Goldschmidt sees as a dialectic between different modes of 'seeing', between seeing-as and seeing-that. The sketch becomes the middle ground between the designer's idea and how it is realised into a coherent whole - an external representation. The sketch is a reflection of the guiding idea, but with which it is not and cannot be identical to. This interactive imagery form the basis for the material 'talk back' to the designer, which informs the next 'move' in the sketching process - thus echoing the reflective practice of sketching highlighted by Schön & Wiggins (1992). Sketching in this perspective grows to be both the way designers 'work' and 'think'.

One of the most detailed studies of how sketching enables visual thinking was conducted by Goel (1995). He identifies two types of operation occurring between successive sketches in the problem-solving phases; lateral transformations and vertical transformations. In a vertical transformation, movement is from one idea to a more detailed and exacting version of the same idea. In a lateral transformation, movement occurs from one idea to a slightly different idea. Suwa and Tversky (1997) suggest that designers are able to understand different aspects of a design idea, whether it is branches of or iterations of the idea, only through sketching them, and thus being able to shift focus onto different parts of design problem. In his categorisation of active ingredients in idea generation techniques, Smith (1998) presents the use of making graphic representations of the ideas as a 'display stimulation tactic'. He mentions that: "Presumably, when visually depicted, ideas are more able to inspire new ones" (ibid: 125). Sketching enables the designer to ''experiment with reality'', to learn from the experiment and to iterate the solution space in a sequence of seeing-moving-seeing (Schön & Wiggins 1992) in which the re-interpretation aids to extract new information from the expressed sketch. Oxman (1995) makes the important addition to this view of re-interpretation in sketching, that where graphic media such as traditional pen and paper sketches are the medium whereby the design is evolved, the design moves are 'the series of actions' by the designer which result in transformations of a representation. Oxman's notion separates the epistemology of sketching from the mediums of sketching, and opens for a larger scope of sketching mediums ranging from 1-dimensional words to 4-dimensional video sketches. Thus, no single medium can be defined as 'the sketching medium', but rather a range of mediums can facilitate the generation of new interpretations of the problem setting and problem solving.

This transformation makes the circle complete in terms of Löwgren & Stolterman's notion of the importance of viewing design as not being oriented around artifacts, but around knowledge construction, which is generated through applying sketching as a process of visual thinking.

All of these studies have provided considerable value to the understanding of sketching in the design process. Through a multitude of studies and experiments many of the same conclusions have been reached, regarding how the dialectic process of visual thinking aids the designer's reflection in action. While the studies into visual thinking through sketching also mentions external representations used for visual communication, these are often disregarded as not being sketching, but belonging to other rendering styles or fidelities of design representations (Goldschmidt 1994, Fällman 2003). In the next section we shall examine the arguments for viewing this type of representations as equally valid parts of the sketching process.

2ND PERSPECTIVE: SKETCHING IS VISUAL COMMUNICATION

Sketches used for communication differ from sketches used to aid visual thinking in two major areas: the viewer does not entirely know the designers intentions, and does not know the context for the situation that sparked the creation of the sketch (Schön & Wiggins 1992, Scrivener & Clark 1994. However, this ambiguity is what Goel (1995) talks about as the central strength of sketches, which enables the lateral transformation between branches of ideas. Buxton includes ambiguity as a central criterion for what makes an external representation of design ideas a sketch and not a prototype (Buxton 2010). Ambiguity is framed as being of special importance in terms of letting the visual communication "...leave big enough holes for interpretation" (ibid:115). In Buxton and Goel's framing we still see an emphasis on the activity of sketching over the physical object of sketch itself. Nevertheless, there seems to be a difference in the way the activity of sketching is interpreted. While the field of visual thinking sees sketching in the light of Schön's dialogue with the material, Buxton also sees the sketching process as a broader conversation that facilitates others than the designer in obtaining a visceral as well as intellectual understanding of a concept. As a form of communication, Buxton places sketches as shared points of reference against which we can compare other ideas or re-interpretations of the existing. Perspectives from Hutchins (1995) supports this notion by viewing sketches as artifacts which may act as a form of distributed cognition - putting the design ideas 'out there' for debate, critique, and most importantly new interpretations.

Thus, seeing sketching as visual thinking and visual communication seems to be two sides of the same function of sketching - it aids the construction of knowledge in the design process by generating new and more sophisticated information than was put into the sketch in the first place. Whether this knowledge is gained from the dialectic between the designer and the sketch, or by the inter-subjective re-interpretation upon a shared point of reference seem to produce the same value of sketching as an aid to knowledge construction, while not being the desired knowledge output by itself.

As we begin to see, the important discussion might not be as much about whom the value of sketching is for, but more a discussion of when an external expression is used as a sketch and for what purpose? When sketching is considered as visual thinking, we see a often implicit understanding of sketching as being free-hand sketches, as opposed to different types of prototypes and higher fidelity renderings like CAD drawings. When considered from the external perspective the definitions loosen up a bit to encompass a set of other criteria, where speed, ambiguity and the non-committing nature seem to be the most important (Goel 1995, Buxton 2010, Lugt 2005).

When considering tools, materials and techniques other than free-hand sketching Buxton makes the note that "how a technique is used is the ultimate determinant of whether one is sketching." (Buxton 2010: 249). Buxton makes this distinction in contrast to prototypes, but does only vaguely specifies a set of characteristics of the distinction, but no clear semantic divide. In the light of the review of the two sketching positions above we might elaborate on this by further differentiating the difference between when something is a sketch, and when something is a prototype. Following Löwgren & Stolterman's notion of 'knowledge generation' as the driver for the design process we argue that wether something is sketching or prototyping differs in the type of knowledge we seek from the process. When the designer uses sketching it can be seen as the explorative generation of new information. This process adds knowledge through filling out gaps of information about what possible ideas might be feasible, and thus reduces the uncertainty of the design situation. On the other hand, the generated information through sketching also increases the complexity of the design situation, because new information has been added, and the designer has to choose between a series of alternatives as the best fit. Hence prototyping is the process where we reduce complexity by putting the most promising bits information to the test.

Our distinction is akin to Nolte's (2001) suggestion that the important part of design sketching is not the 'sketch' itself. Instead the representation of ideas is the surface structure whereas the meaning of ideas is embedded in a sensemaking activity that is not tied to any particular conceptual tool, but to different ways of articulating and processing information. Sketching, as the process of generating new information to reduce uncertainty, may now be discussed in relation to how the sensemaking activity changes throughout the timeframe of the design process.

A THIRD PERSPECTIVE: A TENSION BETWEEN FUNCTIONS OVER TIME

Nolte's notion of the role of sensemaking in the sketching process suggest and overlap between the reflective practice of visual thinking, and the visual communication of articulating information for others to process. A third perspective on the role of sketching might then be worth considering in terms of not what sketching is, but how sketching supports different activities.

Ferguson (1992) identifies three kinds of sketches, which may be useful for identifying the role of sketches: the thinking sketch, the talking sketch, and the prescriptive sketch. The thinking sketch refers to the perspective of visual thinking, where the sketch is used to "…focus and guide thinking". Talking sketches on the other hand refer to the shared points of reference from the perspective of visual communication, which supports dialogue and peer-feedback. The prescriptive sketch is stated as a more formal rendering of the talking sketch, with which the designer can communicate effectively with stakeholders outside the design process. Ferguson's categorisation is a very concrete way to elaborate upon different types of sketches, and encompasses both the visual thinking and communicative parts. However, the types do not relate much to each other in Ferguson's perspective, but states distinctive types of sketches for distinctive activities in the process of design. Instead, we might examine these sketching genres as functions which the sketch can have a different times. To examine this, it may be beneficial to develop a categorisation that addresses the different kinds of interactions the designer and other stakeholders may have with or through sketching.

Inspired by the same combination of visual thinking and visual communication as Ferguson, Olofsson & Sjöflen (2005) uses a set of four genres as headlines for their work on design sketches: investigation, exploration, explanation and persuasion. The investigative function of sketching is tightly connected to the early phase of the design process. The designer is examining the problem space, thus making this activity belong to the visual thinking perspective of sketching. Explorative sketching is used when proposals of design solutions are expressed in order to be evaluated, and seldom make much sense for others than the people directly involved in the design process. This function belongs somewhere in-between the two perspectives of visual thinking and visual communication. The Explanatory function on the other hand is about communicating a clear message to others than the designer and the team, in contrast to the explorative sketches - in others words relating primarily to the visual communications perspective. These sketches describe and illustrate proposed concepts in a neutral and straightforward manner, to get feedback from users, clients and external experts. The Persuasive function uses sketches in a more rhetorical matter, showing less ambiguity, and more details than the other types. The main purpose with these drawings is to 'sell' the proposed design concept to influential stakeholders, which is why we might criticise the persuasive function for being in conflict with many of discussed characteristics of sketching as a reflective process of ideation, not marketing. The risk of using a sketch in this regard is stated by Houde & Hill's (1997) discussion about the tendency to focus on attributes of the representation itself (i.e. the sketch), and in doing so, the vital dialogue becomes concealed under the sketch itself. But, if the persuasive function is interpreted in line with Do's (1996) notion of the requirement of different visual representations for different stages of design, we may see it as a way of using the sketch to propose a clearly stated argument of the relationship between problem setting and a solution to the problem. By doing so, it seems reasonable to agree with Olofsson and Sjöflen in their addition of this function as possible role of a design sketch since it invites to a conversation about the represented, but one in which clues of the designers intentions are clearly conveyed and expressed.

A FRAMEWORK FOR EVALUATING THE FUNCTIONS OF SKETCHES IN DESIGN PROCESSES

In Olofsson & Sjöflen four functions we identify a possibility to map the two research perspectives on design sketching: visual thinking as primarily related to investigative and explorative functions, and visual communication as primarily related to explanatory and persuasive functions of sketches. The four genres were originally not intended to this type of scrutiny but were meant as way to index the chapters of the author's book publication. However, we propose that the four genres could be further suspended into a tension field, which would enable us to better illustrate how different sketching activities and techniques are used to support different aspects of the knowledge generation in the design process. The first 'sketch' of this tension field would look something like the following:

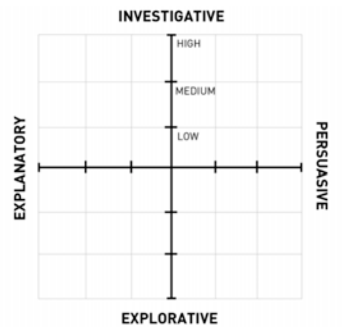

Figure 1: The four functions are framed as being suspended in a tension field, and uses the values of 'low', 'medium' and 'high' to depict in which degree a given function is present.

Evident in the model is the arbitrary notation of using 'low-high' as the label for how mapping different sketching activities would be done, which in turn makes the evaluation seemingly qualitative and subjective. However if this qualitative mapping is done to evaluate the role of sketching through the same design process, the notations will at least be based on the same ground, and become more comparable. Consider the example below, where the digital sketching of a new social web site as case (right side):

Figure 2: The digital representation made in the digital sketching software 'Balsamiq' (www.balsamiq.com)

When sketching the first concept for the web site, the designer engaged in a reflective conversation with the sketch and the design tool, making investigations into the problem setting based upon the re-interpretation of the sketching output, while also continuously getting feedback by involving other design peers in the exploration of possible solutions within the problem space. This activity can be mapped in the framework as being mostly investigative, with a supporting explorative function:

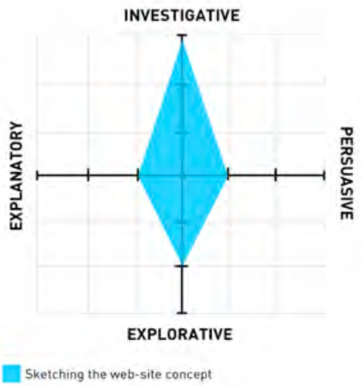

Figure 3: The visual thinking process, combined with the visual communication with the design teams, mapped into the framework.

Later when the same sketch was used to gather feedback and communicate the initial idea to the potential users of the site the sketching functions in the activity combined explanation, persuasion and further exploration:

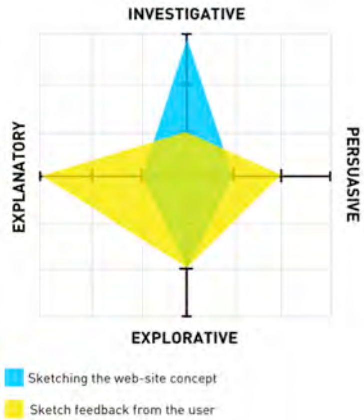

Figure 4: The feedback activity with the users mapped into the framework

When the same visual representation was used to create a shared point of reference with the potential user of the site, the functions of the re-interpretations changed into a mix. The sketch as an explanatory vehicle, a persuasive statement of the designers intention with the idea, and finally a partially new explorative activity of getting the users to further explore what the desirable outcome of the design process ought to be.

The epistemological foundations for sketching remained present throughout both activities: working in a external medium were the designer and peers sees what is 'there' in some representation of the idea, sketches in response to it, and sees what has been represented, thereby informing further re-interpretation - adding to the knowledge generating process. What however changed during the two activities were the functions of sketching, and the relationship between the functions in play. The framework's use of Olofsson and Sjöflen's genres potentially add a more detailed view of the often intertwined tension between the perspectives of sketching as visual thinking, and as visual communication, and how this relationship changes during the course time in the design process.

FURTHER PERSPECTIVES

In this paper, we have presented a review of the two most common perspectives on the roles of sketching in design processes. From determining that the position of examining sketching as primarily valued by its ability to aid visual thinking, to the less studied position of how sketching supports communications and dialogue between the designer and other stakeholders in the design process. In extension to the two positions we raised the question of when something is sketching. We proposed to separate sketching from prototyping based on which type of knowledge the activities generate in the design process. Having this more precise characteristic of sketching in place, we proposed that the two position of sketching epistemologies in praxis are intertwined and in a tension between different ways sketching can generate new information and help reduce uncertainty in the design process. To reflect this, four genres of sketching by Olofsson & Sjöflen were appropriated into a new tension field framework in a new framework, which maps the tension between the different functions of sketching, and how different activities correlate to these functions.

The framework is currently in a preliminary state, in which the importance is to define its relevance based upon the current state of sketching studies into the role of sketching in design. Further studies are needed based on this first step, where different sketching techniques might be evaluated in terms of their supporting role for the different functions mapped in framework. Especially sketching techniques that differ from the classic free-hand sketching, or the digital metaphor of free-hand sketching as we used in our example, would be of special interest to analyse further in order to map the relationship between different ways of articulating design knowledge with how they support the different functions in the framework, and how the tension of the sketch's knowledge generation changes over time.

The conclusion is therefore tentative in our proposition of studying sketching further in an integrated perspective of how different sketching activities and techniques support different functions of sketching in the knowledge generation of design.

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Investigating User Experiences through Animation-based Sketching

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Abstract

This paper discusses the use of animation-based sketching as an approach to explore diegetic designs in the fuzzy front-end ideation of the design process. We present the results from a design workshop with more than 200 participating design students, and 16 companies. The participants used motion graphics and animation to sketch design ideas into diegetic design solutions. Through a deep-dive into two cases we discuss how animation-based sketching techniques supports the investigation of user experience aspects in design scenarios, and wether the expression is dependent on the visual fidelity or on how animation is applied to support a design narrative anchoring to the context.

Keywords: *Sketching, Design, Animation, Diegetic Prototypes.*

Introduction & Previous Work

This paper details the use of animated motion graphics as externalisations in design processes. Externalisations has for centuries been a key competence for designers regardless of the subject matter being designed (te Duits 2003). Externalised representations fulfil various functions throughout the design process. They can serve as aids for a thorough analysis, help generate and evaluate ideas for solutions, and function as a distributed cognition between peers (Arnheim 1969). The ability to externalise thoughts in order to create a more operational image of an idea echoes the praxis-based epistemology from Schön (1983) in which externalisations enable us to engage in reflexive conversations with the situation. Traditionally externalisations has been done through various forms of sketching or prototypes - sketching being concerned with reducing the uncertainty of 'the right design' and prototypes dealing with reducing the complexity of how 'to get the design right'.

In this paper we focus on the development and investigation of new ideas through sketching. Traditional sketching approaches in 2D (e.g. paper) and 3D (e.g. mock-ups) are suitable for investigating spatial concepts, but often lack the expressive capacity of illustrating how an idea manifest its temporal perspectives or in interactions with other actors or artifacts. Thus, 4-dimensional forms of expression like video has also been explored as sketching mediums. Video has been experimented with as a sketching medium to a degree of representation where they replace the need for functional prototypes early on in the design process (Ylirisku & Buur 2007). According to Pasman (2012) video, with its ability to capture the richness of life as it unfolds, is a feasible medium to register the world as it is now and visualise the world as it could be. The mediums ability to showcase experiences through time and in context is pointed out by Raijmakers (2009) *"film is definitely the most powerful tool to an emotional understanding of the user"*. Empathy for the user is a central objective for any user-centered design process, and here video can meaningfully be perceived as intermediate artefacts during design, and as means of persuasion and engage people in the design process (Veland & Andresen, 2007). Finally video can be applied as a change agent, functioning *"...as persuasion to present complex ideas in a concentrated and exciting way for influencing research directions and decisions,"* (Chow 1989).

Despite its advantages, video as a sketching medium is by default limited to capturing *the world of what is*, and is only able to illustrate *the world as it might be* when the scenario is representational through existing artifacts. Though methods exist to improvise artifacts and services through e.g. props (Brandt 2007) or the body (Oulasvirta et al 2003) the ability to simulate new technologies or contexts are still somewhat limited due to limited simulative ability of the video medium by itself - thus also limiting it's sketching capacities.

An interest has been aimed at animation and motion graphics as sketching approaches to augment the temporal and simulative perspectives of sketching traditional video. These approaches all leverages the qualities of animation, described by Stephenson (1973) as how animation contrary to classic film is able to give 'full control' of the transitional material of which the animation, and thereby also potential sketch, consist of. Löwgren (2004) proposed to use motion graphic elements to create animated use cases to gather feedback, and to explore the fuzzy front end of design ideas. Similar is three workshop accounts in Fallman et al (2012), Fallman & Moussette (2011) and Bonanni & Ishii (2009) in which stop motion animation is applied to early explorations of interaction design and architectural processes.

A second perspective focus on augmenting traditional video sketching with animated motion graphics effects (Mackay 1988, Vertelney 1989, Bardram et al 2002, Tikkanen & Cabrera 2008). This is the most common approach of sketching studies to include animation as part of the sketching vocabulary, even though the animation techniques themselves are not examined in detail.

A third area of interest focusing on the enabling technologies of animation has been taken by Fernández & Martens (2013), Davis et al (2008) and Sohn & Choy (2010). Here the goal is not to explore a specific animation technique, but to develop tools to lower the participatory threshold of making animations for design sketching.

How does animation support simulating user experiences?

Even though earlier contributions has shown the potential in using animation for sketching purposes in design, a clear argument about when and how animation techniques are suitable as tools for sketching is still missing. While the previous body of knowledge is an inspiring point of venture, we argue that it is of value to compare how different means of animation and motion graphic elements can be appropriated for design sketching. In doing so, a more clear understanding of the potentials and limits of animation as a sketching approach might be development, in contrast to existing discourse which mainly provides assessments of a single technique in a single case. We hypothesise that the sequential and simulative quality of animations enables the designers create a more clear representation of the scenario in which a given design proposal might work, and thus foster a better foundation for reflecting upon the qualities of the idea. We assess the quality of such representations by evaluating how clear a sketch represents aspects of the potential user experience (UX) of a design idea.

In this study, we focus on the use of animation-based sketching as a tool in the fuzzy front end (Khurana & Rosenthal 1997). In this phase the 'right design' (Buxton 2010) has yet to be established, and the aim is to explore many alternative future solutions, and evaluate its potential UX. It is not our aim to diminish the importance and relevance of traditional pen and paper sketching, but rather to add to the discussion about how animation and motion graphics may be used to sketch representations of the simulative and temporal aspects of a design idea. In doing so, we focus our research on the sketches as design outcome, and not on the designers sketching process.

Research approach

Empirical observations were conducted in 2014 during a three-week workshop called U-CrAc; the abbreviation of 'User Driven Creative Academy' (Poulsen & Rosenstand 2009). The workshops contains four phases; research, analysis, synthesis and realisation. The research phase concerned unfolding the given case by exploring its dimensions in its context and collecting relevant ethnographic data on video. The analysis phase was directed towards translating the collected video data into information and knowledge by applying the Video Card Game (Ylirisku & Buur 2007), object theatre (Strand 2014) and through creating design fiction scenarios (Sterling 2009). Based on these insights early concepts were generated through video sketches, before the final phase, realisation, where a final concept was formed and presented through animation-based video sketches.

The aim of the workshop was to create a multitude of design scenarios about possible futures for the companies, and help the companies understand their users, and the potential UX of the near future better. In doing so, the participants were instructed to use various animation techniques to sketch out their ideas, representing their designs as diegetic elements in a short video scenario. The diegetic element draws inspiration from Kirby's (2010) analysis of the use of 'diegetic prototypes' in films and narratives to showcase the potential of new technologies. "Diegetic" is from film and theatre studies (Elam 1980). A movie has a story, but it also has all the inherent scene-setting, props, sets and gizmos to support that story, which is called diegetic elements. Diegetic elements in design differ from speculative sci-fi which uses cinema effects to seem plausible, but which ontological rules differ from our reality. The diegetic designs exist to illustrate that a given design could exist in the real world, and has a rhetoric aimed at getting traction - both culturally in the imagination of potential users, and strategically in the plans of business stakeholders.

We examined how these diegetic design elements could be designed through different motion graphics elements and animation techniques, ranging from simple animatics to higher fidelity special effects videos. The evaluative criteria for the assessment of the sketches was based on the notion of how a 'product' can be broadly understood as the combination of three factors: the aesthetic (desirability), the usefulness (utility), and it's user friendliness (usability) (Buchanan 2001). Since the UX of a product is also highly depended on the use context (Hassensahl & Tractinsky 2006) we choose to also add the contextual integration and representation of the users touch points to the evaluative criteria for the sketches.

To record the sketches we used a participant-generated web-platform (www.urac.dk) as a modified type of a technology probe (Hutchinson et al 2003) to gather the participants' sketches at different stages of the workshop. This resulted in 158 animation-based sketches in total, divided throughout multiple rough process sketches, and one final polished sketch for each group (Web 1).

Thus, a categorisation was made consisting of the UX factors on the one side, and the applied animation and motion graphics techniques on the other (Web 1). From a first comparison of the produced sketches we identified that no clear link could be seen between the choice of animation technique, and the resulting expression of the UX of the diegetic design elements. Rather it was evident that the assertion should be based on how a given animation technique was used to express one or more aspects of the UX in the design scenario - investigating the design through the use of some sort of narrative. We were able to identify that the sketches which successfully explored multiple aspects of the UX criteria often used many different animation techniques, and not just techniques with a high visual fidelity. From illustrating an entire scenario in simple stop motion sketches, to using motion graphics overlays on top of video sketches each sketch featured different ways the techniques could be used for sketching design ideas.

In the next section we will further detail how the techniques enabled the creation of diegetic design elements, by detailing two of the cases from the workshop in a qualitative comparison. This deep dive in two of the 36 cases helps to illustrate the observed difference in applied techniques, and helps us narrow down the decisive factors of how animation supported the expression of the UX criteria, through simulating diegetic design elements in context.

Two cases featuring animation-based sketching of the user experience

The two chosen cases from the workshop included a total of 10 sketches, which depicted the process from early ideation sketches to a more refined conceptual sketches.

We describe two of these sketches in accordance to which animation techniques they use, and how the chosen technique support the expression of the UX in the depicted design scenario.

Case 1: "Wayfinding in the hospitals of the future"

The group collaborated with the danish wayfinding company 'AskCody' (Case 1, web) in exploring how the hospitals of the near future could reduce wait time, and help their patients navigate through their treatment process. A total of five animation-based sketches were generated by the group. The first three sketches used very simple stop motion animation of rough drawings (figure 1) to ideate different patient service ideas in small use case scenarios.

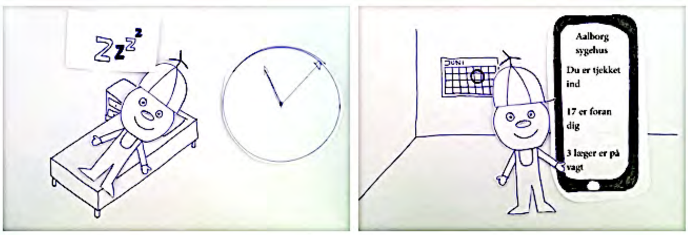

Figure 1: The rough stop motion animation of the user journey in the proposed scenario

In the fourth sketch stop motion was also applied, but zoomed in to animate the interaction design of the interface of a mobile app interface to control the different service options from the scenarios (figure 2).

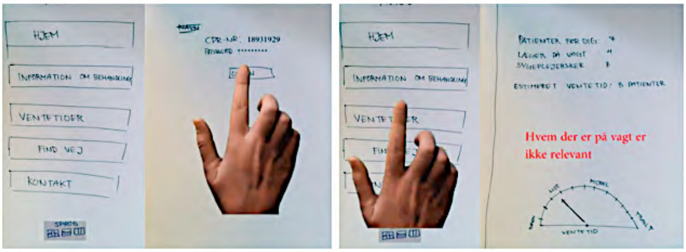

Figure 2: Sketches of the app interface augmented through stop motion animation

Finally the fifth sketch used the ideas and interfaces from the first four sketches and iterates on them in a video sketch with animated motion graphics in layers on top of the real actors enactment of the scenario (figure 3).

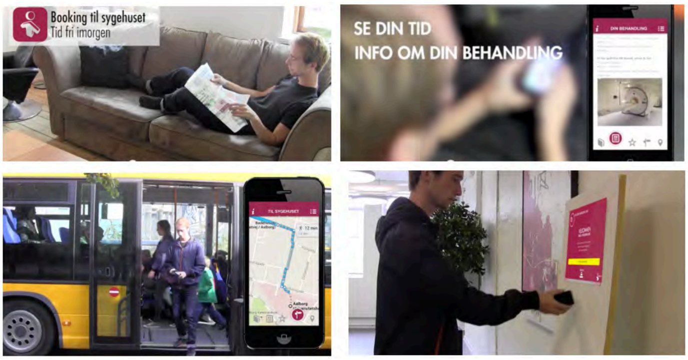

Figure 3: Stills from the final video scenario where animated motion graphics elements were applied on top of the video to illustrate service touch points, interactions, and interfaces in the final concept.

What is interesting to note is how the five sketches express different aspects of the UX. The first three sketches rely mainly on illustrating the idea as a user journey and uses the stop motion animation to tell the story of the user in a simplified context which mainly acts as a scene to illustrate the utility dimension of the UX. The fourth sketch uses the same animation techniques, but disregards the user journeys context in favour for detailing the usability dimension in detail through the first interface ideas. The final sketch builds upon the insights generated through the other videos and iterates upon them in a more clear user story, with focus on both the utility of the service, the usability and aesthetics of the touch points, and how the multiple touch-points are tied together through the concept. The visual finish in the motion graphics elements paired with the real video footage certainly add to a higher fidelity feel of the sketch.

This led us to ask whether the finalised concept's expression of the UX was so clear due to the fidelity of the animations and graphics, or if it was rather how seamlessly these elements were fitted into the narrative of the use case? The next case (Case 2, web) helps to bring clarity to the fidelity vs. narrative integration issue mention above.

Case 2: "The city of Lønstrup - a city on the edge"

In this case we saw sort of a reverse process compared to the AskCody case. The group collaborated with the municipality of Hjørring to create new digitally supported services for the area around the city of Lønstrup. A total of five animation-based sketches were produced to explore different service ideas. However, in contrast to the previous case the first two sketches used higher fidelity renderings of the motion graphic elements than the ones following after. The first sketch used interface and video elements in an animatic sequence, whereas the second elaborated on the interaction with the digital service in a keyframe animated sequence with rather high fidelity graphical elements (figure 4). The later two sketches took a step back and used LEGO and hand drawn props respectively in a stop motion sequence of the user scenario (figure 4).

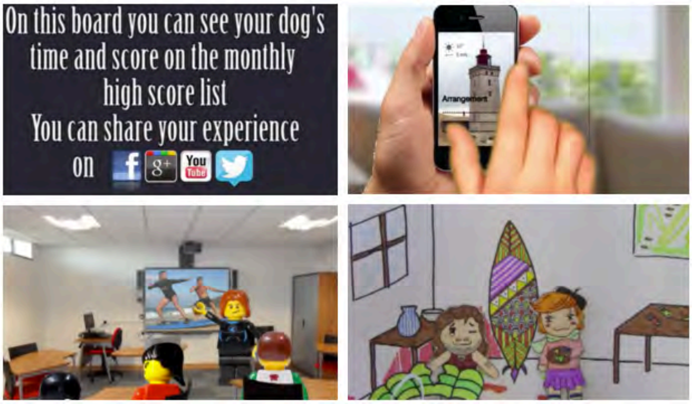

Figure 4: Stills from the four initial sketches. Animatic still image of the interface (top left). Keyframe animated motion graphics of interaction with the interface (top right). Stop motion animation scenario with LEGO's (bottom left). Stop motion animation with hand drawn elements (bottom right)

The emphasis in the first two sketches was centered more around the diegetic designed artifacts than the later two stop motion sketches which changed the focus to the sequentiality of the service. Thus, different aspects of the UX is emphasized in the different concept sketches - from a focus on utility, usability and rough aesthetics in the first two, to a more constrained focus on utility shown in a clear context with aesthetics altered to match the hand-drawn rendering in the latter. The interesting aspect was that the lower fidelity technique of hand-drawn stop motion elements ended up being chosen as the visual format for merging different aspects of the four initial sketches together into the finished iteration of the concept (figure 5).

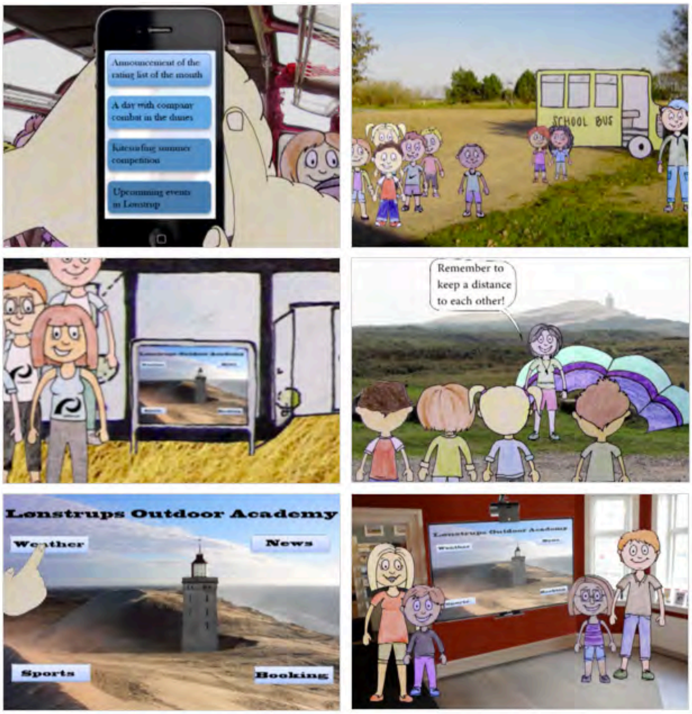

Figure 5: Stills from the final concept sketch of the user scenario, which primarily uses hand drawn stop motion elements combined with a few animated motion graphics.

The visual fidelity of the final animation-based sketch is clearly lower than the final sketch in the AskCody case. Despite this, the Lønstrup sketch still manages to address more or less all UX aspects of our evaluative criteria. The sketch shows a clear representation of the usability of the interaction with the diegetic design elements (a mobile app, the rental service, and the digital kiosks at each tourist facility), and further investigates a scenario in which the diegetic elements provide utility for the users. The aesthetics are elaborated to a degree where it is fairly easy to perceive the relation and relevance to the context and users - even though the fidelity is evidently not the final look and feel. The context is easy recognizable as well, through using still footage from Lønstrup as backdrop for the hand-drawn animations. In this way, the UX in the fifth sketch is expressed at a comparable high level to the more realistic animations and motion graphics in the AskCody sketch. In the next section we will discuss this revealed tension between visual fidelity and the ability to illustrate the UX.

Discussion: visual fidelity vs. telling a story about the user experience

In our evaluative criteria for the sketches produced in the U-CrAc workshop we regarded the expression of UX as a synthesis of usability, utility, aesthetics and context. A sketch investigating what is useful takes us to the question of which functions and features the concept consist of, and how they help solve a problem or create positive feedback from the user. Usability addresses the fact that functionality is not enough, it has to fit into the users abilities and motives at the right time. The fit between user and product is however ultimately also shaped by the aesthetic dimension of how the concept helps the user identify one self with values and intentions behind the product. In the use context the three issues come to together in the investigation of the complex lived experience through time and space - together forming the user experience.

In the two presented cases we have seen two quite different ways of investigating these four UX criteria. The AskCody case iterated from low fidelity animations investigating only a few UX factors in each sketch before combining the insights into a video sketch using animated motion graphic with high visual fidelity. The Lønstrup City case took a different approach by starting in a higher visual fidelity than the final concept sketch, which used primarily hand drawn stop motion graphics. Thus, no clear connection between the visual fidelity of the chosen animation technique, motion graphic elements, or other visual effects can be made. In terms of expressing aspects of the UX, the hand drawn stop motion showed to be equally effective at conveying the idea compared to the visual richer and more 'real' expression of video augmented with animated motion graphics.

The main difference is evident in the way the two cases address the aesthetic aspect of the UX. Both cases clearly investigate the utility, and usability of the final concept sketches, and also places them in a clear representation of the use context. On the aesthetic front however, the two cases differs greatly in both 'finish' and in how clear the visual vocabulary of the users identification with the product is portrayed. The final AskCody sketch leaves no doubt about the choices of the aesthetics, while the Lønstrup sketch leaves holes to fill out by the viewer. This echoes traditional sketching guidelines about leaving room for re-interpreting the sketch in a reflective feedback-loop (Buxton 2010), and also feeds into a discussion of how much information we are able to 'fill in' by our selves when seeing something represented - wether or not it is represented in high fidelity or not. In this sense, the AskCody sketch might show a visual fidelity, which is to high for reflecting upon the intended aspects of the idea because it almost looks to real to still qualify as being a design sketch - the focus is not about the overall structure of the idea, but more about the finer details which are more concerned with iterative prototyping.

Instead of a full investigation of the aesthetics alongside the other UX factors as being the explanation for what still makes both cases work, we might turn to the narrative of the scenario. When considering the narrative aspect we see that the higher fidelity in the AskCody sketch helps integrate the elements into a clearly understood narrative, and thus enable reflections upon the use-case of the concept. Thus, by it's integration in a narrative the reflective quality of a sketch is preserved by moving foucs from the product in itself into it being a diegetic element in a broader scenario. The same goes for the stop motion sketch in the Lønstrup case, where the unfinished aesthetic support the perception of the video as focused on telling an animated story, starring both users and the diegetic touch points of the new digital service.

By comparing the sketches in the two cases we might now reframe the discussion. Instead of focusing on how animation and motion graphic elements can express the UX aspects as much as possible, we should discuss how $the techniques help express an appropriate amount of UX aspects to enable reflection, and more importantly, integrate them into a narrative. The anchoring in a narrative points towards a broader issue of using sequential mediums like video and animation to express ideas, but also shows why the illustration of the context showed to be just as an important aspect to illustrate as the more product-oriented aspects of utility, usability, and aesthetics.

Because of this, the aforementioned comparison between the aesthetics of the two sketches makes sense. As long as the aesthetic UX dimension is used to support the connection to a narrative it becomes a strength, but when aesthetics alone are represented to create a high visual fidelity of the diegetic products appearance, without supporting the narratives anchoring to the context, it may become a limiting factor for reflections upon the sketched use case for the product.

Finally, the examples from the two sketches show traces of a larger trend in the totality of our categorized sketches from the workshop (appendix 1). The sketches, which successfully convey the potential UX of the proposed concept, also has a clear representation of context, and is set in clearly articulated narrative. As we have seen in the comparison of the two cases there is a variety of ways this contextual and narrative anchoring might be achieved. In this regard, the common dominator seems to be way the application of animation and motion graphic elements augment the simulation of the diegetic design elements of the scenario. Whether animation is also used to express other aspects such as characters and effects, or are used to portray more realistic renderings on top of traditional video the result is the same: The sketch makes a more or less clear representation of the proposed UX when the animation techniques are used to connect the simulated diegetic elements to the context, and integrate them into the narrative of the use case. Furthermore, it is important to note, that the use of animation to express an idea does not merit anything about whether the UX is good or bad, but expresses the proposal in a manner for the quality of the UX to be evaluated by the stakeholders.

Thus, the results from the comparison, and the categorization as a whole, indicates that a broad range of animation techniques can support the evaluation of the potential user experience of diegetic designs in video sketches. However, as we have argued the principal strength of animation as a sketching tool is the ability to simulate not yet existing designs in a sequential and narrative contextual setting.

Conclusion

In this paper we have presented a review of the current research into using animation and motion graphics as tools for design sketching. We contributed to the existing knowledge in this domain by experimenting with the relationship between animation techniques and their ability to investigate user experience aspects in diegetic design concepts. From our initial categorization of the sketches in the U-CrAc workshop we saw that no clear link could be made between the visual fidelity of the chosen animation technique, and their ability to illustrate the user experience. Instead, by detailing two very different cases from the workshop, we saw that the core quality is how the use of animation and motion graphics enable the designers to simulate a scenario with diegetic design elements which does not yet exist, and use a narrative to anchor them to the use context. In this way the full potential of animation and motion graphics in design sketching is not only in it's ability to investigate a product in itself, but rather to support the creation of an easy perceived narrative in which the proposed design stars as a main component. This realization points towards further studies into the narrative structures of the animation-based sketches to investigate wether a set of narrative mechanics can be identified as being especially suitable to be represented through animation based sketching. Finally, our contribution is to argue that the scope of animation-based sketching needs to be broadened. From a focus on assessing wether high vs. low visual fidelity is appropriate, to how the different fidelities support the evaluation of the potential user experiences to come within a certain use context - supported by animations ability to portray sequential narratives.

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Animating the ethical demand – exploring user dispositions in industry innovation cases through animation-based sketching

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ABSTRACT
This paper addresses the challenge of attaining ethical user stances during the design process of products and services and proposes animation-based sketching as a design method, which supports elaborating and examining different ethical stances towards the user. The discussion is qualified by an empirical study of Responsible Research and Innovation (RRI) in a Triple Helix constellation. Using a three-week long innovation workshop, U-CrAc, involving 16 Danish companies and organisations and 142 students as empirical data, we discuss how animation-based sketching can explore not yet existing user dispositions, as well as create an incentive for ethical conduct in development and innovation processes. The ethical fulcrum evolves around Løgstrup's Ethical Demand and his notion of spontaneous life manifestations. From this, three ethical stances are developed; apathy, sympathy and empathy. By exploring both apathetic and sympathetic views, the ethical reflections are more nuanced as a result of actually seeing the user experience simulated through different user dispositions. Exploring the three ethical stances by visualising real use cases with the technologies simulated as already being implemented makes the life manifestations of the users in context visible. We present and discuss how animation-based sketching can support the elaboration and examination of different ethical stances towards the user in the product and service development process. Finally we present a framework for creating narrative representations of emerging technology use cases, which invite to reflection upon the ethics of the user experience.

Categories and Subject Descriptors
H.5.2. [**User Interfaces**]: Evaluation/methodology, Prototyping, User-centered Design.

K.4.1 [**Public Policy Issues**]: Ethics

General Terms
Design, Experimentation, Human Factors

Keywords
Animation, sketching, user experience design, ethics, RRI, scenarios, design thinking, løgstrup

1. INTRODUCTION
This paper discusses how animation can be applied to simulate future applications of the designs to elaborate and examine different ethical stances towards the users in the product- and service development process through an empirical study of Responsible Research and Innovation (RRI) in industry cases. The challenge of every design and innovation process is to designate as well as reflect upon what this particular innovation will bring into the world; how it will change practices, perceptions, and relationships [1]. The common dissection between invention and innovation is that the latter not only creates something new, but in fact changes the way people live [2]. And with this change comes responsibility and ethical challenges for the designer. In the wake of these challenges the need for responsible research and innovation enters the picture.

The authors recognise RRI as a transparent, interactive process by which societal actors and innovators become mutually responsive to each other with a view on the (ethical) acceptability, sustainability and societal desirability of the innovation process and its marketable products in order to allow a proper embedding of scientific and technological advances in our society [3]. RRI has mostly been used to determine methods and frameworks for inclusion in publicly funded research programmes across Europe. However, in industry, there are few active incentives for companies to innovate responsibly, and even fewer methods by which such incentives might be implemented. This is emphasised by the recent call for new knowledge to create this link between research into responsible innovation, and methods for the industry [4] [5].

This need for industry incentive contrasts the movement within the field of design thinking. Throughout the last decade, design and designerly ways of thinking about and acting upon the world, has gained widespread popularity [6] [7]. The movement towards a user-centred design approach, pioneered in the late 1980's and 1990's [8] [9] [10] has given rise to later years emphasis on the concept of 'user experience' [11] as the common denominator for the end-goal of all user-centred design processes. User experience design as an industry-oriented praxis details the need for understanding and testing the user's experiential quality, when developing new products and services [11].

Until recently however, the user experience design discourse lacked a discussion of the ethical dimension underlying its approach. At an earlier ETHICOMP conference, Vistisen & Jensen [12] presented a framework discussing the notion of user experience design from an ethical point of view. Showing how the notion of 'user experience design' creates an underlying responsibility for the designer. Designers claiming to be user-centred or to be designing in the context of the user experience also implicitly commit to shape and form certain aspects of the experience of a group of human beings (ibid) - thereby adopting part of the responsibility for these experiences and their consequences. This experience can both be a small flutter in the user's way of performing a simple task enhanced by a given design, or it can be a life changing experience, brought about by an all-encompassing design strategy which catapults the user out of his everyday life [11].

With Løgstrup's [13] 'ethical demand' as their fulcrum [12], the user becomes 'the other person' to the designer in the design process. Categorising different ethical stances towards the user, they create a framework consisting of: apathy - the strict adherence to rationalism, sympathy - the reaction to an effect, and finally, empathy - the reaction to a cause. While the framework gave rise to intriguing discussions, no aim was given at the time as to which empirical domains this framework could be applied, neither which methods might enable the user-centred designer to actually explore the different user stances in real world settings.

Pairing RRI with Vistisen & Jensen's ethical perspective on user experience design creates a fitting industry oriented framing of how actors might form co-responsible relationships. While RRI first and foremost asks what kind of future we want innovation to bring into the world, ethical user experience design challenges us to discuss the underlying user dispositions during these innovation processes. In this paper we narrow the discussion down to focus on a certain design approach, animation-based sketching, by raising the question: how can animation-based sketching support the examination of ethical stances towards the user in the product and service development process? The next section will elaborate the ethical framework used in the exploration of the different user stances.

2. THE ETHICAL DEMAND

Løgstrup's ethical demand [13] differs greatly from other normative ethics [14] through its ontological and situational approach to ethics. Thus, a framework for a design process based on the ethical demand will always have to be user centred and situated. The core concept of Løgstrup's ethics depend on the dyadic meeting, where the 'I' (the designer) is responsible for acknowledging the unspoken ethical demand posed by 'the other person'. In the design process, and whenever a design is used, the 'I' will be the designer, while 'the other person' will be the end-user of the design. The design itself is mediating the dyadic meeting. The unspoken demand itself consists of the so-called life manifestations like mercy, trust, a plea for non-violence, and the openness of speech, among others [15] [16]. In Løgstrup's thinking, the 'I' has a responsibility to bring out the full potential of 'the other person's' being by acknowledging and respecting the unspoken ethical demand in their meeting [17].

Not only does the demand pose a considerable responsibility on the designer, but on the design process and the design itself. The dilemma of the unspoken ethical demand becomes apparent when it is turned *"(...) into an outward, manageable principle that is supposed to be able to operate as a magical principle and solve all problems. The result is that the demand becomes nothing but a cliché."* [13] It turns into a cliché, because the 'I', as the designer, will be the one who solely articulates and sets the conditions for the meeting, taking his knowledge and the existing rules and systems into account, without acknowledging the life world of the user, 'the other person'. This is, what Vistisen and Jensen [12] call the apathetic ethical stance toward the user. The user is just a means of input for the intended end, the final design.

To avoid this, Løgstrup emphasises the need for doubt and uncertainty on the side of the 'I', the designer in our case, since "(t)hinking and imagination become equally superfluous. Everything can be carried out quite mechanically; all that is needed is a purely technical calculation. There is no trace of the thinking and imagination which are triggered only by uncertainty and doubt." [13] Only by constantly questioning oneself, the designer can ensure a certain, needed openness toward the design process as well as the users involved.

Still, the designer needs to acknowledge his ethical responsibility as a designer. Meaning, it is important for the designer to make necessary choices in the design, to not only sympathise with the user, giving him whatever he demands. Instead, an empathetic design approach needs a deep understanding of the life world, which comprises not only of the tacit, but also of the systemic knowledge. In this, the three ethical approaches to design should be regarded as steps in the design process, especially when paired with a flexible and changeable method like animation-based sketching. As our case analysis will show, the design team uses all three ethical stances to accomplish a design concept, which takes the life world of the end user as well as the given task and the systemic needs into account.

3. RESEARCH METHOD

Experimenting with the pairing of RRI and ethical user experience design, we facilitated a three-week-long innovation workshop called U-CrAc, an abbreviation of User-driven Creative Academy. This workshop format originates from the LUDINNO research project, which was founded by The Nordic Research Council [18]. The objective of LUDINNO was to establish collaboration among participating companies and consultants with students and researcher through playful user-oriented laboratories or learning labs. From the perspective of the university this was an initiative to engage in the role of the civic university as there within the associated academics was a fundamental interest in knowledge application within the surrounding society. However the intention was not to take a subservient role, but instead engage as an influential actor and equal partner in a Triple Helix constellation with industry and government. The Triple Helix constellation builds on the idea of synergy between involved partners as; *"Industry operates in the Triple Helix as the locus of production; government as the source of contractual relations that guarantee stable interactions and exchange; the university as a source of new knowledge and technology, the generative principle of knowledge-based economies"* [19].

U-CrAc, has undergone several changes, as the workshop design itself is an iterative process in which we, the educators and researchers, seek to explore new methods and techniques. U-CrAc builds on the pedagogy of Problem-based Learning, and each of the 22 groups was given an assignment with an elaborated problem. These assignments had a combination of IT, experience and health dimensions and was provided by both local companies and public organisations, which in the following will be entitled clients. Throughout the workshop there is an on-going collaboration between the students and the associated client.

The workshop is divided into three phases; Fieldwork, Ideation and Concept development. Each phase had a dedicated week: the students performed ethnographic user studies in the first week and interpreted the observations into what we phrase *innovation tracks.* These innovation tracks became the starting point for the following idea and concept development process, which is the empirical focus of this paper. In these phases, Ideation and Concept development, the design students goal was to both explore new ideas as well as anticipate how these new ideas might affect the user experience. Furthermore the students were tasked with exploring their ideas in different animation-based sketching formats, which opened up for different types of ethical reflections.

The students were instructed to use various forms of animation-based tools to help the companies simulate and reflect upon how different ethical stances towards their users could potentially affect the user experience of their product or service proposition. Through the workshop we examined how these methods could be used as a foundation for the participating companies to explore and experiment with the desirability and feasibility of their upcoming pipeline. Establishing an ethical point of reflection early in the process might affect the users final experience. Later in this paper we will take a deep dive into one of these innovation cases, deconstructing how animation-based sketching was used to explore multiple user-dispositions, and assess their ethical stances in regard to apathy, sympathy, and empathy.

3.1 Using animation as tool to sketch ideas

A method was required for the design students to express and externalise the different ethical stances towards the users in their ideas. Previously film scenarios has been used to externalise experiences through time, and in context as pointed out by Raijmakers [20] *"film is definitely the most powerful tool to an emotional understanding of the user"*. Furthermore, the linearity of video creates a constrained narrative, which may become an agent for change, functioning *"...as persuasion to present complex ideas in a concentrated and exciting way for influencing research directions and decisions,"* [21].

Despite its previous uses in design, and innovation processes, video as a sketching medium is by default limited to capturing the world of what is, and is only able to illustrate the world as it might be when the scenario is representational through existing artefacts. But, when concerned with expressing challenges regarding emerging technologies, and anticipate and reflect upon the possible user dispositions around these technologies, video simply lacks expressiveness. Our hypothesis was that exploring possible user dispositions in new and innovative contexts required a design material in which the designers would have a larger degree of control of the simulated use case for an idea. Such a potential was found in *"...the full transitional control of the subject matter"* in animation [22]. Animation can be defined as "the process of generating a series of frames containing an object or objects so that each frame appears as an alteration of the previous frame in order to show motion" [23]. Further, animation represents an abstraction of reality [24], and as a temporal 4-dimensional medium [25], it is able to simulate qualities such as movement, flows, transitions and timing from not-yet existing artefacts [26].

The use of animation as a tool to explore new design possibilities has previously been explored by creating animated use cases to gather feedback, and to explore the fuzzy front end of design ideas [27]. Similar studies were accounted for in Fallman et al [28], Fallman & Moussette [26] and Bonanni & Ishii [29] who used stop motion animation in early digital and architectural design processes. Others have used animation to augment traditional film [30] [31] [32] [33]. Despite being widely used, this approach in general does not address which qualities of animation actually makes it suitable in the design process. The techniques themselves are not examined in detail. Vistisen & Poulsen [34] investigate this dilemma in greater detail and assess that the simulative nature of animation enables the designers to create strong narratives, in which new technologies can be integrated into a believable use-context. The use of animation in this paper echoes this approach, by not emphasising the specifics of the animation techniques themselves, but rather by experimenting with animation as the enabling technology of exploring user dispositions in RRI cases. However the goal is not to create specialised tools either, as is the case with recent contributions [35] [36] [37]. Instead we place animation as a broad set of techniques, with a broad set of existing tools, that may be feasible to apply in the exploration of designs that does now yet exist - or in other words, to address the 'what if...' questions of RRI [38].

3.2 Selection of workshop case for analysis

To record the design students animation-based sketches we used a participant-generated web-platform [39] as a modified type of a technology probe [40]. The web-platform provided a common frame of reference for the facilitating researchers, the participating companies, and the design students to discuss, and reflect upon the different stages of the ideas, and ultimately the different user-dispositions inherent in each of the ideas.

From examining the sketches a general insight was how the multitude of animation-based sketching methods all seemed to enable the creation of sketches, which explored ethical user stances from the Løgstrup-based framework. Furthermore the explorations in general adhered to the primary concerns of RRI described by Stilgoe et al [41] as anticipating technological emergence, reflecting upon it's consequences, inclusion of stakeholders, and responsiveness towards the next step. However, dependent on the industry case, it was also evident that some of the produced sketches explored a broader range of ethical user stances than others. While the RRI perspectives can be identified as a higher meta-level aim to shape, develop and align existing and future technological innovation in the process [42], the three ethical user stances from Vistisen & Jensen are more evident in the details of the sketches. Thus, to further assess how animation-based sketching enables us to explore user dispositions in RRI cases, we selected one of the cases which explored aspects of all three ethical user stances for a further case study.

The selected case was a collaboration between the retirement home 'Plejecenter Lykkevang' and the Danish health care innovation center 'Copenhagen Living Lab'. The case challenged the students to explore how to engage and empower elderly residents in smart retirement homes. The students' ethnographic field studies were captured as a series of four video segments showcasing the limited focus on creating activities for the still-active residents at todays retirement homes. The video material produced helped the design students to map the current apathetic situation, and provided a basis for the students initial statement of the 'right design' [43]: *how can we support the activities of the elderly by creating scalable social experiences which motivate both physical and social activity?*

From the mapping of the current state of the retirement homes the design students began their ideation process, and sketched their ideas into scenarios [44]. Through video enactments and by applying animation techniques and effects these scenarios became visualised as a series of animation-based video sketches. The next section presents the produced sketches, and reflects upon the user dispositions the sketches portrayed.

4. CASE ANALYSIS

A total of three initial animation-based video sketches were made before the design students arrived at the final concept of the 'PlejePad'.

4.1 The interactive experience room

The first concept generated was the interactive experience room with projected visualisations on the walls, aimed at creating an immersive environment for the elderly to experience without having to travel to other locations other than a designated area of the retirement home [45]. In the sketch, we see the caretakers help the residents into the experience room followed by a series of different content types, the elderly would be able to experience inside the room (Figure 1). The sketch uses green screen video recordings with animated motion graphics overlays to simulate the digital walls of the experience room.

While the simulated interactive environment would seem to solve parts of the design problem of creating a social experience it is evident in the use case how the concept actually shows an apathetic user stance. The elderly are placed inside the experience room by the caretakers, and are then left for themselves to experience the content. While this may create an experience in by terms from [11], the experience really does not in any way solve the underlying problem of the elderly needing more social and active interactions in their daily routines. Instead, the elderly are treated as a component in a procedure of being placed inside an installation, receiving a designated dose of stimulus, and are then left to their normal routines again. Thus, the scenario helps to clarify how the use of digital design does not necessarily result in a solution which actually solves the problem, but might as well become an extension of the existing apathetic situation in the system of the retirement home.

4.2 Digital games in the common area tables

The second concept seeks to create a social and active experience for the elderly through digital games integrated in the common room tables [46]. The simulated use case illustrates how two residents activate the table after dining together, before choosing between a range of classic board games in a digital format (figure 1). The scenario is made by animating a series of timed keyframe animations on top of the table to simulate the digital interface and games.

Figure 1. The interactive experience room (top) and the digital table games (bottom).

In the scenario we see how the elderly are able to interact via gestures in order to navigate the digital interface of the game table. Furthermore we see how the table mediated the social interaction between the two participants. However, the scenario also showcases a user disposition in which 'the need for a social and active experience' is literally translated into playing a game together. While the idea of an interactive dining table is novel, the scenario does not show how the technology helps the elderly become better suited to engage in active and social activities. Neither does the solution empower the elderly to take control of the experiences, besides giving them the opportunity to sit and play predesignated games. In this regard, the scenario explores a 'sympathetic' user stance by showing how a seemingly novel solution to the problem actually only treats the symptoms and not the cause for the problems with lacking social and active daily routines at the retirement home. Thus, the technology is paired with the person, but not recognising the contextual setting or underlying motivations for the problem faced in the context.

4.3 Social touch screen in the living room

Following the first two sketches exploring possible apathetic and sympathetic user experiences at the retirement home, the students were able to reframe the problem into: *how the activities of the elderly can be supported by integrating social and active experiences into their existing daily routines?*

Through this reframing, the third animation-based sketch explored the use of a social touch screen system in the individual apartments of the retirement home [47]. The sketch shows a scenario with a resident establishing a video chat with another resident, arranging a social activity in the common rooms (figure 2). The interaction with the touch screen is simulated through simple stop motion animations.

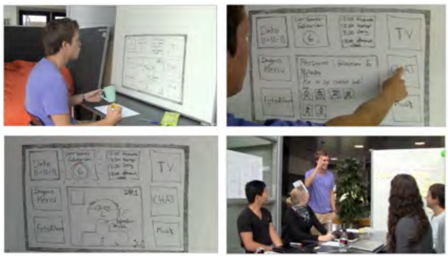

Figure 2. The early vision behind PlejePad, depicted as a social touch screen system in the living room.

Through this scenario the design students explored how to establish a more empathetic user stance towards enabling the elderly to actively view and manage the social activities through a device located in the context of the apartment. The empathetic disposition is evident in the idea's focus on taking the current living situations of the elderly as the starting point of concept, further elaborating how the new device can tap into the daily routines, and make it easier to communicate and participate in activities at the retirement home.

Through making the sketch the design students realised that even though the general aspects of the idea addresses the cause for the problem of inactivity and lack of social interactions, the touch screen solution might not fit the digital literacy of the majority of the elderly residents, they had met during their field work. The touch screen was a product of the design students current understanding of the technological landscape, and did not accommodate the same level of empathy as the overall idea about using a screen in the apartment to mediate the social activities for the elderly. This reflection upon the ethical stance towards the literacy and social fit of the concept, led to the reframing towards the final idea of 'Plejepad' (english: NursingPad).

4.4 The PlejePad concept

The final animation-based video sketch makes use of a range of animation techniques to simulate the screen-based 'PlejePad' [48]. The concept is a smart TV system, which is controlled through a traditional remote control, adhering to the technological literacy of a medium and interaction device most of the elderly are familiar with. Furthermore, the use of animation is used to integrate the prior insights about the apathetic user disposition of the situation as it is at the retirement home. By animating a clock in the top left corner, and running a fast-forward time lapse of the daily routines of the elderly persona, it is illustrated how the elderly often is confined to be sitting alone in the apartment, often in front of the TV (figure 3).

Figure 3. The apathetic situation of the current daily routines of the elderly, depicted via animated annotations.

The apathetic user disposition is illustrated in a quick and straight-forward manner by using easy to understand visuals to emphasise the narrative setting and context of the problem. This helps to establish a clear connection between the apathetic status quo, and the following sequence in which the empathetic user stance is explored through the new concepts, integrating the exact same context and routines, but altered by the system's social mediation. The sketch makes use of keyframed interface animation to showcase how the elderly persona interacts with the system (figure 4).

The sketch shows how the proposed concepts acknowledges the cause of the problem, and circumvents it by making the TV the main hub for arranging and controlling social activities. The concepts thus takes an empathetic user stance in showcasing how a new emerging technology (smart TV systems) may be appropriated into a specific context (apartment in a retirement home) fitting the routines and literacies of the user. To explore the potential user experience of this empathetic stance towards the elderly persona in the sketch, the design students set up a concrete user scenario through a narrative of the persona 'Ole' interacting with his friend 'Helge' through the PlejePad system, arranging to participate at a social activity at the retirement home (figure 4).

The scenario illustrates how Ole communicates with Helge through the voice and voice-to-text messaging service ind the system, coordinating to participate in an activity shown in the 'Daily overview' function in the system. After agreeing upon the activity, Ole goes back to his daily routines in the apartment, until the TV system gives him a reminder about his appointment with Helge. When pointing the remote at the reminder, Ole sees which residents are present in the common areas for the activity, and makes ready to leave the apartment to meet up with Helge. The empathetic user stance is again evident in how the design students explored the integration of technologies such as peer-to-peer communication, online scheduling, indoor wayfinding, and intelligent assistants. The technologies integration into the context presents a way to solve the cause for the in-activity problem, while staying true to the literacies and routines of the person, and further empowers him to reach out and connect - augmenting the social sphere of the entire retirement home.

Throughout the final part of the animation-based video sketch, the design students explore how the system might adhere to the anticipatory function deemed important by the RRI discourse [41]. We see how the caretakers can customise and edit which apps and functions are available to the individual smart TV, which shows how responsibility can be delegated between the industry stakeholder (retirement home) and the end-user (the elderly).

Figure 4. The Plejepad system in the living room (top), the personas interacting with the system (middle), and the back end customisation features (bottom).

The animation-based video sketch takes the viewer through a narrative in which we get to explore the apathetic status-quo of the present situation, and is guided through a story of the elderly persona, as the sketch builds up its case for how an empathetic user experience can be achieved. Through its narrative structure the division of touch points between the elderly, the caretakers, and the context of the retirement home are explored, and the inherent responsibilities are made visible. In tandem the sketches, exploring apathetic, sympathetic, and empathetic user stances towards integrating digital technologies into the problem domain, invites the viewer to reflect upon both the application of a certain technology, as wells as the implications it may have for the user experience of the involved stakeholders. The narrative format, and the use of animation to simulate the emerging technology, and modify the context helps to include a broad range of stakeholders in the reflective process of evaluating both the technical concept as well as the underlying ethical user dispositions. Thus, animation-based video sketches becomes more of a reflective tool, than a communicative tool, as would normally be the case for animated narratives [22]. In the next section we will gather the insights from the case analysis, and present a possible framework for exploring user experiences with interactive technologies in animation-based video narratives.

5. A NARRATIVE FRAMEWORK

As we have seen in the case above, the exploration of ethical user stances is not necessarily a process of choosing one user stance, but more a flexible process of reaching an empathetic user experience as the end goal. By exploring both apathetic and sympathetic views, the ethical reflections of the stakeholders become more nuanced due to the process of actually seeing the user experience simulated through different user dispositions.

Figure 5: Framework for creating linear animation-based video sketches which explores new technologies from an ethical user perspective.

Exploring the three ethical stances by visualising real use cases with the technologies simulated as already being implemented makes the life manifestations of the users in context visible and relevant. Thus, through animation the scenarios are able to simulate how the ethical demand is applied in a given setup of users, industry stakeholders, and newly developed technologies. This offers a strong incentive for reflecting upon critical issues of how to create responsible innovations, since the user dispositions are explored in an easily comprehended format. Furthermore using animation shows to be a flexible set of techniques, which enables a broad range of cases to be simulated and communicated.

Systemising the functional components in the animation-based video sketches we get a framework through which an interactive technology is placed inside a linear scenario. Hereby a user persona acts as characters in a story, which takes place in a given context. The plot of this story revolves around any issues to which the interactive technology is presented as a possible solution. From the scenarios exploration a reference is drawn back towards the persona, illustrating which ethical stance the technology takes upon the persona in the given context and use case. The framework may be illustrated as figure 5.

Through the process of applying animation in a narrative format, which is not aimed solely at storytelling, but rather at creating ethical reflections, we get a framework for the construction of such animation-based video sketches. Using persona stand-ins for the real observed users [49] and placing them in a real world scenario [44] and by establishing a clear point of reference to how the technology affects the life world of the persona. Thus, the user disposition is made visible and inclusive for others to reflect and comment upon.

Concerning the practical feasibility of using animation to explore ethical user dispositions one might ask whether the techniques and framework are generically applicable. Considering the RRI discourse's emphasis on anticipation, reflectivity, and inclusion we argue that this question depends on the technological issue at hand. If we deal with more or less normative issues, like designing with existing technologies, and with existing design patterns [50] we might be less inclined to simulate the user experience in an animation-based video sketch. On the other end of the spectrum, fields like design fiction [51] [52] and critical design [53] recently have been proponents for speculating in future scenarios for both problems and contexts that are still unknown. Here, simulating and speculative prototyping is the only possible tool available. This critical domain of design has no normative qualities, but is quite often concerned with the speculative futurism, rather than the present world 'as it is'. Inside this spectrum, between the purely normative, and the purely speculative, we might place animation-based video sketching of ethical user dispositions as 'the middle ground'. Maintaining a critical perspective on new technologies and their applications, but with a clearly strategic aim to explore how the relationship between users, industry an R&D should be established to reach the 'right impact' [41].

Once you work in a narrative setting, focus is taken away from the design itself. Instead, context and world building, the conflict, and characters become important and present. A narrative is open for interpretation, enabling a discussion which surpasses mere functionality and the design as such. A narrative opens for possibilities, and engages the reader, viewer, listener. And with engagement comes participation and empathy. A deeper understanding of the design and its purpose and possibilities within the world. This exploration is not based on some far-future utopia or dystopia, but on how we make the most responsible user experiences in the near-future. Being able to simulate, and clearly articulate multiple user dispositions in such near-future scenarios is the main contribution of animation-based video sketching for RRI.

6. CONCLUSION

Through the research question of this paper we explored how animation-based sketching can support the elaboration and examination of different ethical stances towards the user in the product and service development process. By using the ontological ethics of Løgstrup as a framework for the design process we tested how the life world of the end-users could be taken into account, as well as how the designer could explore multiple user dispositions towards establishing an empathetic user experience.

As argued, working with the uncertainty prescribed by Løgstrup demands flexibility from the designer and the design methods put to use. Animation-based video sketching is a set of tools, which enable the designer to create simulated narratives of the near-future, to promote reflection upon the desirability and relevance of the user experience depicted. By exploring both the apathetic, sympathetic, and empathetic sides of the design problem, a more nuanced reflection can be achieved. By creating more operative deliverables for ethical reflection, the examination of the responsibilities between an innovation project's stakeholders may also become more inclusive.

We have presented animation-based sketching as a viable tool to create such operative images for ethical reflection upon the user dispositions when designing new interactive products. We contribute to the existing discourse by showcasing how animation can be used to simulate the near-future use of new emerging technologies, and make their ethical user stances visible to both the viewer and the designer. Thus, the set of techniques, and the framework for their application in narratives as our contribution to the developing RRI toolkit.

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Facilitating consensus in cooperative design processes using animation-based sketching

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1. ABSTRACT

In the following paper we show how animation can be used as a digital sketching tool to facilitate cooperative work processes when exploring the application of non-idiomatic digital technologies. Focus is on the early stages of the design process, framed as 'product formation'. Based on the results from a action research case study at the North Sea Oceanarium we show that animation can act as a tool to create clear representations of the quality criteria at hand, and thus enable a richer feedback loop between the different stakeholders in the design process. The main contribution is an examination of how animation can be applied as a cooperative temporal sketching tool for establishing representations of different aspects of a design, and how it can facilitate consensus between stakeholders in the design project. We propose a set of guidelines for choosing animation-based sketching in cooperative design processes, and detail how the techniques differs from other representational options in the early design process.

Author Keywords
Sketching; Animation; Consensus; Fuzzy front-end; Cooperative design

2. INTRODUCTION

The landscape of emerging ubiquitous devices with e.g. multi-touch screens, accelerometers, gyros, compass, barometer, and camera has made it more challenging than ever for designers to rely on known repertoires of design idioms [Lindel 2012, Löwgren 1996]. The area of interest covers design processes where the subject matter can be described through non-idiomatic characteristic. Until the point of cultural establishment of generally accepted idioms or design patterns, a design process in which an emerging non-idiomatic technology is in use either as a technological need or as a plausible technology for meeting a specific goal will be a process of immense uncertainty in the front-end of the design process - making the initial setting 'fuzzy' [Reid & Brentani 2004].

When the technology does not have any or only few established conventions or at its best remains challenged to clearly define how the future user experience might be. Furthermore, since the technology or the technological praxis is lacking conventions, the design team rarely has standardised prototyping tools - like wireframing tools for web-design or level-editors for game-design to help create operative images for the team to focus the discussion upon. The lack of applicable CASE technologies (Computer Aided Software Engineering) [Mathiassen & Sørensen 1996] and hence the possibility of using Software

Factory Methodology [Aaen et al. 1997], means the team must often rely on traditional static sketching, which provides value through its fast explorative nature, but lacks in expressive capacity for communicating ideas in temporal and spatial ways, and is therefore not suitable as a communication tool for all matters. This technical challenge is made even more complex when considering the social praxis of the design context. When multiple stakeholders from different knowledge domains are part of the design project, multiple optics exist for what is considered important, and what the desired user experience of the final design should be. However, when dealing with non-idiomatic technologies, the situation is innovative thus the level of uncertainty rises when selecting, prioritizing, and combining the optics [Rosenstand 2012]. This establishes the need for better cooperative tools to facilitate consensus in the fuzzy front-end.

The paper examines animation as a possible cooperative tool through the research question: *How can animation-based sketching be applied as a cooperative temporal sketching tool to reduce uncertainty about the core design of design projects?* We evaluate the method's capability as a tool to support cooperative design processes with regard to how it supported consensus-making in the design team. Thus, the main contribution is examination of animation-based sketching as a computer supported cooperative tool to bridge between different decision points throughout the early phases of design processes concerning non-idiomatic technologies. We position this contribution in regard to the common computer supported cooperative work) concern of *"how collaborative activities and their coordination can be supported by the means of computer systems"* [Carstensen & Schmidt 1999]. Animation-based sketching as a cooperative tool is evaluated as a digital sketching approach, which can support the process of designing new digital products. To this end, the contribution is not a 'system', but a broad set of temporal digital sketching techniques, which enable us to simulate and illustrate design ideas in a manner suitable for collaboration and group-based decision-making.

3. RESEARCH METHOD

The empirical data was collected through an action research study, based on the methods of collaborative practice studies in which we evaluate praxis by seeking to change it [8], and the constructive process of research-through-design [Koskinen et al 2011, Zimmerman et al 2007]. We follow the notion from Gaver [2012] about research through design as a unique research paradigm with slightly different conditions than traditional action research or case studies. Design often addresses wicked problems [Buchanan 2001] in which no correct solutions exist a priori - the formulating of the design problem is integral to addressing it. Furthermore, design involves many different decisions, dealing with different and often independent factors of the final production - situated within the specific use context. Finally, by addressing wicked problems, and being contextual, research through design is productive by changing the context through it's own design activities. In this way the theories we may gain from research through design is theory by necessity and is thereby nearly always unfalsifiable [Gaver 2012]. This is true for both when we base our design activity on borrowed theory from other fields, as we do with applying animation and group-based decision making, or when we observe the world and specific design examples within it. As such our study contrast the ambition of the traditional scientific method were theories converge to describe a single independent world, where one account of the same physical domain must be better than the other. In contrast, when doing research through design we do not describe the world as it is, but more generatively investigate how it could be, or as Zimmerman et al [2007] how to make the right things. Thus, the criteria for 'better' in theories derived from research through design is aligned with pragmatism [Langergaard et al 2006] in which the practical use and value of the knowledge outcome is deemed as important as the ideal of objectivity and formulation of universal theoretical principles. To this end, our study generates knowledge through the constructive activity of design, and systemises this in regard to how the applied animation-based sketching techniques supported the praxis of the design context. This echoes the annotated portfolios of Gaver [2012] in which the designs of each iteration are annotated with our theoretical and methodical reflections upon the used sketching techniques. We applied a similar technique in this study, by carefully separating the design process in iterations within a broader section of the design process called 'the product formation'. The design output from each of these iterations was afterwards annotated with our reflections and the reasoning behind constructing the specific design outputs.

The study was conducted in collaboration with the aqua zoo *The North Sea Oceanarium*, and concerned the development of new digital mobile experiences for visitors, and thus focus on one specific case, concerning the design of a mobile augmented reality application. Mobile augmented reality, where a digital layer is put on top of the real world through a mobile medium, is in this regard considered an example of a non-idiomatic technology, which has not yet seen full commercialisation [Höllerer 2004] and still lacks well-established user experience idioms [Mekni & Lemieux 2014, Kloss 2012]. The sketches, prototypes, and documentation from the design iterations of the product formation are the main empirical data, and the author's reflections and observations from participating in the action research process provides reflection-on-action to support the examination of data.

Before diving into the findings from the empirical study, the next sections provide the background state of art by detailing the technical and social challenges in the fuzzy front-end of digital design projects. Afterwards, an overview of how animation can be seen as an extended sketching capacity is provided. Thereafter animation-based sketching as method is assessed/evaluated through a series of key moments from the empirical study. Finally, a conclusion is given which reflects upon the feasibility of using animation to facilitate consensus and framing the cooperative decision making in a non-idiomatic design project.

4. PRODUCT FORMATION OF DIGITAL DESIGN

Various design methods, development models, and frameworks has been proposed and tested in an attempt to tackle the fuzzy front end of digital design projects. Stuart Pugh [1990] together with later contributions from Buxton [2010] uses a funnel metaphor to show how the design process constantly converges, but with iterative divergent loops for each phase in the process. The ISO 13407 standard [1999] together with life cycle models like Boehm's [2000] emphasise these iterations, and how knowledge is generated through each step to guide the process forward or to go back and change the previous steps. Kim & Wilemon [2002] points out that major conceptual iterations can be attained easily and abundantly in the fuzzy front-end phase because rejecting a proposal comes at a relatively small cost, while the later development phase emphasizes iterations that mainly scale or adjust already established concept details.

In continuation of Kim & Wilemon, Rosenstand & Kyed [2013] has detailed this distinction between fuzzy front-end and production phases further towards the design of digital media technologies. They detail fuzzy front-end as a major iterative movement from the project setting to 1st usable. This is framed as product formation of the digital media creation cycle (figure 1).

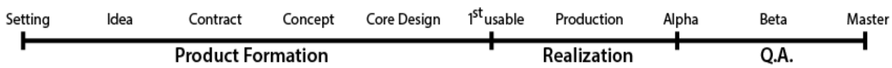

Figure 1: Digital Media Creation Cycle, by Rosenstand & Kyed, with product formation, realization and Q.A. as the major steps, and a range of sub-steps, each indicating a decision point of the design process.

While the digital media creation cycle is generic and comparable to other design cycle models, it is chosen as the organising framework for our contribution due to its emphasis on decisions regarding the transgressions between each step of the design process. The cycle illustrates a range of sub-decisions between the major phases, each qualifying the transgression to next sub-decision. We see these sub-decisions as crucial consensus points in the early design process, where it is important to mediate a clear consensus for whether to transgress to the next decision or iterate further on the current step. We understand consensus through Kacprzyk & Fedrizzi's [1988] soft definition as a dynamic and iterative group discussion process, coordinated by a moderator, who helps the experts to make their opinions closer. This definition can be further elaborated as a process of cooperative based decision-making about *"...finding the best alternative(s) from a set of feasible alternatives according to the preferences of a group of experts"* [Herrera-Viedma et al 2007]. In a digital design project this consensus making can be understood as the process of generating a range of possible design alternatives, and evaluating their feasibility among stakeholders in the project. As such, consensus is the cooperative decision-making between the stakeholders in the design project.

Especially the decision points in the product formation step make up a suitable framework to understand the intersection between technical and social challenges of the cooperative design process with non-idiomatic technologies. For the remainder of this paper we use the terminology from the product formation as representative for fuzzy front-end. We focus on the product formation as a frame of reference to discuss how to mediate the transgression between its different sub-decisions. Because of this focus, we will not detail the process after the product formation, since the methods of *realisation* and *QA* are rather well understood in systems development literature like Cadle & Yates [2008]. Thus, the aim is not to further develop on the methodology, but rather to explore new tools and methods to facilitate consensus in the early phases of a design project.

4.1 Sub-decisions of product formation in detail

Product formation is constituted by decision points regarding *setting*, *idea*, *contract*, *concept*, *core design*, and *1st usable*. The *setting* defines the conditions and constrains for the project. It is within this setting the idea is generated as the basis for a project vision, which might be formulated and illustrated in different ways. However, the vision is not fully transcendent before the actual product is finished – if the vision is achieved. The *contract* is an agreement of the qualities of the product and how and when deliverables should be delivered. The *concept* is the criteria of the design. The *core design* constitutes the essential design principles. The core design step is especially interesting when the design makes use of non-idiomatic technology, since no experience-based knowledge exists, which can generate a clear idea of how the interactivity should be enabled - where interactivity is defined as *"...a measure of a media's potential ability to let the user exert an influence on the content and/or the form of the mediated communication"* [Jensen 1998]. Upon establishment of consensus about these principles, a *1st usable* version can be produced.

Normally a multitude of deliverables are generated in these early steps to generate knowledge about the high amount of uncertainty, which exists before the core design. This uncertainty can be technical, visual and/or mechanical, and organisational.
Based on Simon's theory of *bounded rationality* [1979] and others further works [Mintzberg 1989, Mathiassen & Stage 1992, Rosenstand 2002] *uncertainty* is understood as a negative measure for available project information – lack of information. This is opposed to complexity, which is a positive measure for available project information – information at hand. Thus, methods in the creation cycle until core design reduce uncertainty by generating new project information; and methods hereafter mostly reduce complexity.

In transgressing between 'Idea' and 'Contract' we typically see quick renderings in words or mocked up by existing visual elements. The transgression from 'Contract' to 'Concept' is typically the domain of traditional hand drawn sketching in which many low detail renderings are made to explore possible concepts that meet the criteria set during the contract phase. Transgressing from 'Concept' to 'Core Design' often consist of more detailed sketches and prototypes, which enables an exploration of possible design principles and their application in the design. Finally, the decisions of the core design qualifies the transgression to 1st usable which must represent a fully functional part of the product.

When dealing with non-idiomatic technologies the team is challenged with designing without known patterns or best-practices for a given technology, or the ability to use existing sketching techniques or prototyping tools to explore and evaluate both features and content. The team's dilemma becomes an issue of exploring the design of a concept or technology that has no clear prerequisite and no feasible standardised tools to create that specific type of technology within.
In the next section it is discussed how externalisations such as sketches are traditionally used in digital design, and we search to identify a sketching format which can accommodate the exploration, and communication of design in a non-idiomatic design processes to facilitate consensus in project teams cooperative decision-making.

5. WORKING WITH SKETCHES IN DESIGN

Externalised representations fulfil various functions during a design process: they can serve as an aide for analysis, idea generation, evaluation, communication, and as external storage [Romer & Sachse 2000]. Sketches, for example, support the limited human memory capacity and mental processing for a detailed ideation and visual problem analysis [Suwa et al 1998, Goldschmidt 1998]. The term 'sketch' generally has the meaning of something rough or unfinished, and the activity 'sketching' is to give a brief account or general outline of something [Goldschmidt 2003, Goel 2003]. The communicative strength lies in the public nature of sketches - they are out there in the wild and aid/assists the designer by supporting the limited human memory capacity and mental processing for a detailed problem analysis in a reflective conversation with the design situation [Schön 1983].

Fish & Scrivener [1990] describes how sketching facilitates the transition from general descriptive knowledge into specific depiction. In this regard, the primary reason for designers to sketch is: *"...the need to foresee the results of the synthesis or manipulation of objects without actually executing such operations",* which places sketching as a way of externalising knowledge from the design process as a central part of the reflective activity of design [Schön & Wiggons 1992]. This emphasis of sketching's visuospatial ability to add information to reality, and even distort the existing information to generate ideas echoes that of both [Tversky 2006].

Most studies have focused on free-hand sketches [Suwa et al 1998, Goldschmidt 2003, Goel 2003, Tversky 2006, Bilda & Demirkan 2003, Garner 1992, Purcel & Gero 1998]. However, later contributions from Buxton [2010] illustrated that it is rather how a given tool is used that defines if it is sketching, rather than the tool itself. In continuation of this Vistisen [2014] made a categorization in which sketching was divided into four expressive dimensions - ranging from 1D (words like metaphors used as sketching vehicles), 2D (like traditional hand drawn sketches), 3D (like mock-ups and physical models) and 4D (like video and animation-based sketches). In the same line of thinking Olofsson & Sjöflen [2005] presented four genres of sketching: *investigative, explorative,* *communicative,* and *persuasive*, which illustrates how sketches can serve different functions in the design process. Vistisen elaborated on these four genres, showcasing how the same sketch, might actually change throughout the course of time. A sketch starting as an investigative internal sketch might be used in combination with other externalizations as a persuasive sales pitch later in the design project.

With sketches seen as a tool-independent process, digital and computer-aided conceptual sketching has been an issue of some scrutiny [Frankenberger & Badke-Schaub 1998, Dijk 1995]. In past, studies compared differences between computer aided sketches and pen and paper sketches in idea development. Because the digital tools cannot properly express the explorative and non-commitment nature of sketches in idea development, the majority of researcher's report that pen and paper is better than digitalised environment in concept development. In light of this, it has been considered more important whether the digital tools could reproduce the characteristics of traditional pen and paper sketches or not [Liu 1996].

Buxton [2010] argued against this fallacy through his seminal work on sketching within the Human-Computer Interaction. Buxton argues that instead of talking about low-fi and high-fi rendering styles in design deliverables, we rather should be talking about which renderings styles that have the 'right fidelity' for the decisions we need to make at a given time. The notion of 'right fidelity' frames the issue to deal with questions regarding the desired feedback from the sketch, rather than focus on the inherent aesthetics or techniques applied in the sketch itself. Thus, in terms of supporting consensus and decision-making in a cooperative work context, sketching is a flexible method of establishing points of reference to reduce the uncertainty early on. Buxton here echoes McCloud's notion of the sketch's ability to offer 'amplification through simplification' [1994] by creating a less detailed rendering of reality, but with close enough resemblance to actually communicate the essence. Following this train of thought, the fidelity of a sketch can potentially be higher than reality - in terms of showing or exploring the future user experience before anything has actually been build. Considering Ehrlenspiel's [1995] still relevant results which showed that 70–80% of production costs within digital development are determined in the early pre-production, the value of having sketching formats that enable us to explore non-idiomatic technologies where there exist no clear conventions becomes even more clear.

To this end, the importance of sketching in product formation is not as much a question of low vs. high fidelity in terms of expressiveness, as it is a question of which method provides the most valuable information to facilitate and frame the discussion among the team members towards the most relevant issues at the given sub-step.

When designing a digital product that is presented relatively static on a screen, traditional representation techniques such as pen & paper sketches, storyboards and prototypes in program code work well as clarifying points of reference to discuss the concept. However, complications occur when the design depend on highly interactive and complex behaviour, which are costly or difficult to express in conventional representation techniques [Arvola & Artman 2006]. In design settings like these, the need arises for more temporal and narrative representation capabilities in the enabling technologies of the cooperative process of exploring and reaching consensus about the design.

In the next section we discuss animation as a possible technology to enable sketch representations of temporal designs, and illustrate it in a manner which provides the 'right fidelity' feedback needed to reach consensus about early design ideas.

6. ANIMATION AS A SKETCHING TOOL

The static and material limitations of sketching has previously been dealt with through using CAD tools to sketch digitally, but thus also making the sketch look more like a finished design schematic. Others such as Lindell [2012] proposed that we skip traditional sketching in the product formation altogether and instead jump to code, but maintain the sketching mind-set. Buxton [2010] is not fixed on any specific medium as tool for sketching, but rather emphasises the characteristics of what makes a sketch a sketch as: *evocative, suggestive, explorative, questioning, proposal, provoking, tentative* and *non-committal* as opposed to prototyping which is: *didactic, descriptive, refining, answering, testing, resolving,* and *specific* These criteria creates an inspiring point of reference for sketching, but also highlights a certain ambiguity when addressing the issue in terms of decision making processes.

6.1 Reducing uncertainty vs. reducing complexity

In continuation of Buxton's characteristics, we propose a focus on the nature of the knowledge that each type of representation technique enables. This illustrates how sketches and prototypes can be can be separated in regard to the information they add to the decision making process. We argue that sketching can be seen as an *explorative generation of new information*. This process adds knowledge through filling out gaps of information about what possible design alternatives might be feasible, and thus *reduces uncertainty*. This is especially true in regard to Buxton's characteristics of sketches as 'proposing' and 'explorative'. On the other hand, the generated information also *increases complexity* of the design situation, because new information is generated, and the designer now has to choose between a series of alternatives as the best fit. Hence prototyping is the process, where we reduce complexity by putting the most promising bits information to the test. This again adheres to Buxton's characteristic as prototypes' character as 'testing' and 'refining'. This information-based distinction makes it easier to see how product formation mainly is constituted of sketching activities. In the front-end, no design alternatives exist (e.g. no project relevant information to choose from), and thus there is no foundation for the design team to discuss and establish consensus - *an uncertain situation*. When design alternatives has been generated the team has new project information to choose between, creating the need to choose between the different alternatives - *complexity has to be reduced.* In relation to the previous discussion about sketching mediums, the distinction between uncertainty and complexity further underpins why the same medium might be used both for sketching and prototyping. When the aim is to reduce uncertainty about 'what we are going to make' we are sketching, and when we reduce the complexity about 'which of the possible ways to realise the design is the best' we are prototyping.

6.2 Animation-based sketching

As one of several examples of enabling technologies which could fall under this uncertainty reduction definition of sketching, is the use of animation. We understand animation as the illusion of motion which artificially created rather than recorded [Furniss 2008]. Furniss' concept of animation is based on a continuum between the purely mimetic of real time film, and the purely abstract motions of decontextualized animated shapes. Within this spectrum we propose animation may also be utilized as sketching medium – hypothesizing that rough and unfinished animation may convey enable clearer decision making about temporal and simulative aspects of the digital design. This genre of animation-based sketching has to some degree been proposed earlier. Löwgren [2004] has presented an inspiring case on using 'animated use sketches' in which he assessed the quality of using animated scenarios to establish 'operative images' to guide the product formation towards more detailed specifications for the realisation of the digital artefact. Similar accounts about the use of animation in sketching processes are found in other works in which stop motion animation is applied to early explorations of interaction design and architectural processes [Zarin et al 2012, Fallman & Moussette 2011, Bonanni & Hiroshi 2009]. Common is the way animation is seen different as a sketching tool from using conventional video, as promoted by among other [Vertelney 1989, Mackay et al 2000, Ylirisky & Buur 2007] since the realness of video tend to communicate and persuade rather than merely illustrate. However, the previous studies has not followed through on the entire fuzzy front end of the design process, but have manly focused narrowly on isolated elements of the process. We propose the potential of the animation-based sketch is be wider, and can generate project relevant information throughout the entire fuzzy front end of the product formation.

In its essence, animation-based sketching is an attempt to use moving-image storytelling in design not only for entertainment or persuasion but for constructive communication with enough abstraction to still be a sketch. To this end, animation is preferable to video since it has a higher simulative quality than video - given the designer full control of the expressive medium [Stephenson 1973, Furniss 2008]. By simulating 'what could be' instead of testing 'what is' animation is in many ways a fitting temporal equivalent to the characteristics of sketching derived from Buxton and McCloud.
Design becomes more complex when we combine multiple materials and contexts that each has specific qualities. Furthermore, it becomes difficult when this is a

composition of both technical and social actors. The challenge is to design the social components together with the technical components as a systemic whole, and still be able to differentiate the issues to be dealt with each. Such situations simultaneously challenge our design ability and design tools through their high complexity as well as the freedom to simulate both spatial and temporal dimension with animation has its potential strength. The animated material invites others into a discussion about content, features and context, even though it is not available as a real object, and illustrating how different contexts and social practices may be affected by the proposed concept. This level of shareability, paired with the availability of easy to use digital tools to actually compose simple animations speaks in favour for seeing animation as a feasible technique to facilitate cooperative design processes about reaching consensus in product formation of non-idiomatic design projects.

The next section of the paper presents how the authors experimented with different techniques of animation as a sketching tool in product formation of the North Sea Oceanarium case.

6.3 THE NORTH SEA CASE STUDY

The North Sea Oceanarium is a state-recognised zoo with an annual subsidy from the Danish Ministry of Culture supported with income from ticket sale and other activities. The aim of the zoo is to inform visitors about the North Sea through edutainment activities [2015]. Topics range from underwater nature and animal life to sustainable exploitation of the seas alongside a display of a wide selection of creatures and plants from the North Sea.

As part of the organisations 2020 strategy, a focus on creating digital extensions of the physical experience at the zoo was set in motion in 2012. The authors were involved as researchers in this initiative. The case examples cover the cooperative design process behind the social mobile augmented reality application *North Sea Movie Maker* [Huge Lawn 2013]. The finalized app makes use of a novel approach to marker-less augmented reality platform in which the user records live footage during their visit to the zoo. The footage becomes real-time manipulated by the app, while special effects are put on top of the video, generating a scene where fish and other actors interact with the filmed guests. The video is saved live onto the smartphone, and the app afterwards cut seven small video bits into one coherent movie with special effects (figure 2).

Figure 2: Stills from the 'North Sea Movie Maker' iOS app, depicting the interface (left), and two of the augmented reality scenes with effects from the app (middle & right).

The application was launched on the iOS App Store in October 2013 and afterwards gained award-winning recognition for its innovative blend of new technology and user experience [AAU 2015a]. To give and overview of the production formation, in which the concept and interaction design was explored we mapped out the iterations with an emphasis on the method used, and the sub-decisions made in the transgression in the iteration (figure 3)

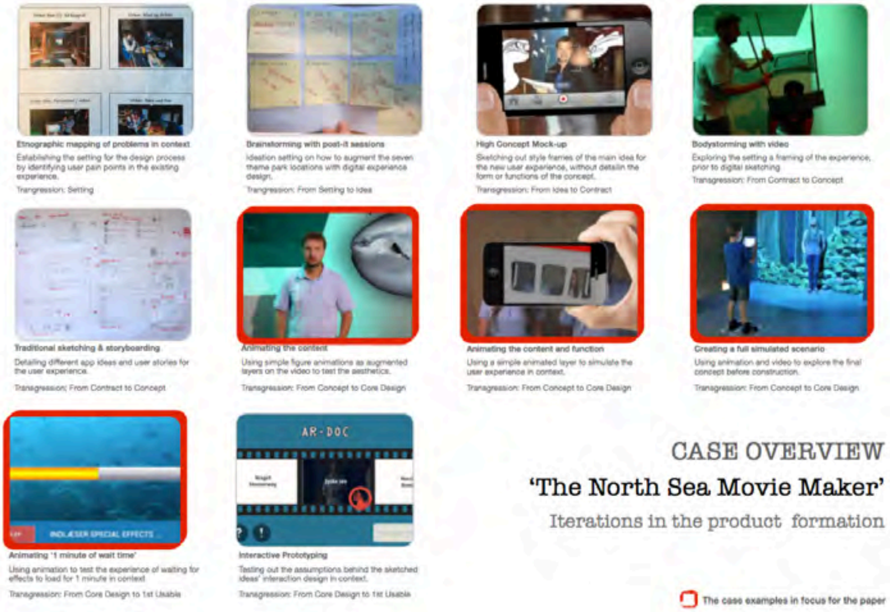

Figure 3: Overview of the iterations in the product formation, emphasizing the design activities and highlighting the four case examples of animation-based sketching described in this paper.

The following case study describes the sub-decisions in the product formation step, which used animation-based sketching to facilitate the group-based decision-making behind the finished app (marked with read outlines in the case overview below).

6.4 Establishing the initial Augmented Reality concept

The design teams consisted of a heterogeneous group of multi-disciplinary stakeholders - ranging from digital designers, developers, zoo keepers, biologist, and marketing personal. The process started through an ethnographic field study of the visitor's use of the existing exhibition, and was used as basis establishing a setting for the further design process. This setting of the design context provided the basis for ideation of desirable design(s) to support the existing experience. After using a range of best-practice studies and conceptual mock-ups to align expectations for desired user experience, initial ideas where generated and recorded through videotaped bodystorming, hand drawn sketches, and storyboards (figure 4). These deliverables helped facilitate the transgressions from the 'setting', 'Idea', 'Contract' and 'Concept' sub-decisions.

Figure 4: Stills from ethnographic studies (left), bodystorming interactions (middle) and hand-drawn sketching (right)

The majority of ideas surrounded the use of some sort of *mobile augmented reality* [9] - using digital overlays on top of the physical zoo to augment the experience. Augmented reality as a technology at the time did not yet have many established design patterns or user conventions, and even smaller knowledge among the common user [Carmigniani et al 2011, Krevelen & Poelman 2010]. Even though prototyping software such as 'Layar' [2015] existed, none of the tools evaluated provided enough expressive freedom to illustrate all the issues at hand, and generate enough information to foster a consensus about which direction the design project should go. Thus, augmented reality as potential enabler for a new mobile user experience at the North Sea Oceanarium became an interesting case for experimenting with how to design for a technology, which was still largely non-idiomatic from an end-user point of view.

6.5 Facilitating consensus with animation-based sketching

The initially generated pen and paper sketches of the augmented reality concepts (figure 5) illustrated many different aspects of the design: From content possibilities, to specific interaction modalities for which the users would be able to interact with the design within the zoo context.

Figure 5: Examples of the hand-drawn initial concept sketches, exploring multiple design alternatives for augmented reality in the zoo context, and recording it as a user-generated special effects movie.

What became evident was that even though sketches provided a clear consensus about the initial concept among the members of the design team, it was harder to establish a common ground about the design principles for how the concept should actually work. The author of one sketch obviously understood the depictions more clearly than the rest of the team, seeing more information than was actually depicted. This was in particular an issue for the members of the team who had other backgrounds than design and HCI, like the biologists and zoo keepers. This presented a problem, since these specific team members had invaluable contextual knowledge about the zoo, and how to guide the guest in the best manner. When discussing this matter in regard to a particular situation about the flow between the future users activation of the application and the identification of spots in the zoo to capture a movie, we realised that the problem arose every time something happened 'in-between' the depicted states in sketches. The team initially tried to overcome this by using more descriptive and narrative scenarios [Caroll 2000], but with the same issues arriving when having to imagine the augmented reality actually at play in the zoo. This gave an indication of the issue with reflecting upon non-idiomatic technologies when having no clear design idioms to build an understanding uon. As such, we learned that though we could generate information about possible design alternatives through traditional hand-drawn sketches, the quality of information was not high enough to actually reduce the uncertainty about the temporal issues with the concept. Thus, we needed another sketching tool, in order to facilitate transgression between the concept, and the more specific core design.

To enable this transgression a series of animation techniques were used as experimental tools for sketching. Four distinct examples of animation-based sketching were; *1) Animating the content 2) Animating features + content 3) Animating a full use scenario 4) Animating the consequence of using different mobile platforms.*

At different decision points, these animation-based sketches were used to reduce the uncertainty of how augmented reality could be realised in the context of the zoo - establishing an operative image for the multi-disciplinary design team to evaluate and discuss the potential, and establish consensus about the most feasible decision. Following Kacprzyk & Fedrizzi's [1988] consensus definition, animation-based sketching here took the role of the facilitating medium, which helped the stakeholders express design alternatives and challenge opinions about the design, and to frame the discussion towards the decisions needed to be made. This mediating role of the animations would further be the basis for creating the first functional prototypes for the 1st usable, where the complexity of 'how to realise the design most efficiently' was reduced. In total, the production formation for the augmented reality development is depicted in figure 6.

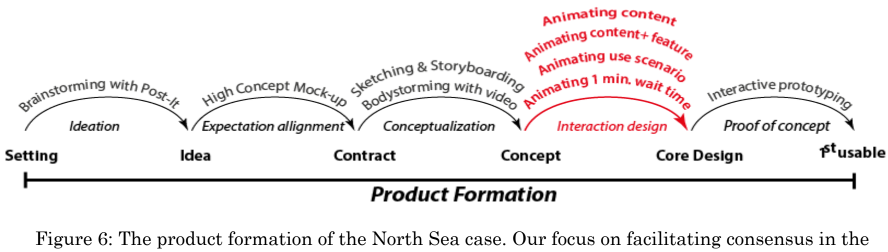

Figure 6: The product formation of the North Sea case. Our focus on facilitating consensus in the transgression between initial concept and core design is highlighted together with the tested animation-based sketches used to facilitate consensus

The next section presents four examples of animation-based techniques used in transgression between concept and core design. We describe the applied animation technique, and how it enabled the group decision making process in order to reach consensus about the issues at hand. The animated sketches can be examined by viewing the video link in the corresponding references for each sketch [AAU 2015b, 2015c, 2015d, 2015e, 2015f].

6.6 Animating content

Several of the augmented reality concepts for the mobile experience took shape around the idea of giving the visitors the possibility to shoot special effects movies during their visit. This required an initial establishment of the content of interactive elements in the digital design. The issue was raised by the zoo keepers on the design team. For the app to function as an extension of the physical experience at the zoo, the zoo keepers argued that we needed to know exactly how much 'over top' we could go with content, before it would become a parody on the living creatures in the zoo. Thus, the design problem was to establish design alternatives about whether to go in a 'slap stick' direction, or a more realistic style which resembled real sea animals. Two issues here needed to be dealt with: the overall look and feel of the content, and the interactive behaviour of the content. This design problem was something that we could not explore in a feasible fidelity via hand-drawn sketches, since the discussion about the existing sketches became to detailed on the look of the specific sketch, rather than on the general aesthetic genres and its temporalities. It became clear that we had to mix both aesthetics and interactive behaviour in a single sketch in order to create a point of reference for all team members to reflect about the totality of the content choices we had to make.

We created two animation-based sketches at this step [AAU 2015b & 2015c]. The first explored a slap stick aesthetic via simple stop-motion animation where drawn elements where moved on top of a still image of a smartphone aimed at a guest in the zoo (Figure 7). The stop motion effects were animated through a simple off the shelf software 'iStopMotion' from the Apple Appstore. Each graphical element was placed in the scene, and moved accordingly frame by frame, and was smoothed out by adding motion blur when processing the final sketch. The second sketch explored a more realistic aesthetic by animating the animals in 3D Studio Max, combining basic 3D shapes with textures to copy the look of the animals. These animated objects were placed in a video layer in Adobe Premiere Pro on top of live footage filmed on location in the zoo. Thus the sketch consisted of mimetic video with animated overlays in 3D. The combinations of aesthetic content and interactive features in context could then be evaluated without having to code a functional prototype, which would have been considerately more costly in resources.

Figure 7: The first stop motion based content sketch (left) with hand-drawn elements animated on top of a still image from the zoo [64]. The second 3D based sketch (middle) in which an animated fish was placed on top of video footage from the zoo [65]. Finally the two content genres were mixed into a third sketch with slap stick humor effects with realistic looking content (right).

Through the animations the team got the ability to actually see a temporal representation of how the two aesthetically genres might impact the future users in the context of the zoo. The information generated provided basis for discussing important issues of 'what' the future user could experience. From seeing the sketches a zoo keeper and biologist argued strongly in favour for the realistic aesthetic, while the user experience designer and the zoo's marketing manager argued for the more over the top slap stick approach. One side argued on behalf of the fact-based learning objectives of zoo, and the other on behalf of the experiential and thrill seeking side of the experience at a zoo. This illustrated a typical consensus issue, in which two experts with different optics favoured different design alternatives, which would plot widely different courses for the core design. However, we observed how the ability to mix both the aesthetic and interactive behaviour of the content via animation-based sketching here had a mediating effect. From watching the animated sketches we proposed a mix between the realistic aesthetic, and the slap stick behaviour - a combination of the optics resulting in a compromise, which constituted a third design alternative. The two opposing sides on the team agreed on trying this approach since their major concerns were being accounted for. From this point, it only took a few hours for the team to mix the elements from the two sketches together, and get a new animation-based sketch, in which the realistic looking animals interacted in slap stick comedic ways with the users in front of the camera. This sketch created the needed information for the team to agree on the content criteria for the core design.

6.7 Animating content + features

Having animated a range of sketches to inform which types of interactions would potentially work in the context of the zoo, the team had to assess how the features of the digital content could be interacted with - both in terms of user interface design, as well as the broader set of interaction modalities available on the mobile medium. These questions concerned some of the non-idiomatic aspects of using augmented reality; were we to use fixed markers or marker-less? Should the user be able to interact with the augmented overlays? Which elements should be affected by the overlays? None of these issues was able to be discussed in a meaningful manner from the initial hand-drawn sketches, since they all dealt with highly interactive aspects, which had few best practices or patterns to lean on. Generating information to qualify a decision about these questions would furthermore have been both costly and complex to do with coded

prototypes from the estimation of the two programmers in the team. Since existing augmented reality sandbox tools like Layar could not create a suitable representation of the desired concept, animation was again used as sketching technology to reduce uncertainty of a feasible interaction design [AAU 2015d].
Using the existing animated content from the previous animation-based sketches the team created a series of sketches in which the content could be evaluated in different interaction designs (figure 8). We used key-frame animation in Adobe After Effects, in which the software animates movements between two or more designated key positions. We animated still images of a transparent smartphone, on top of footage from the zoo, and used the content sketches in tandem to illustrate how different types of augmented reality could be controlled and experienced by users.

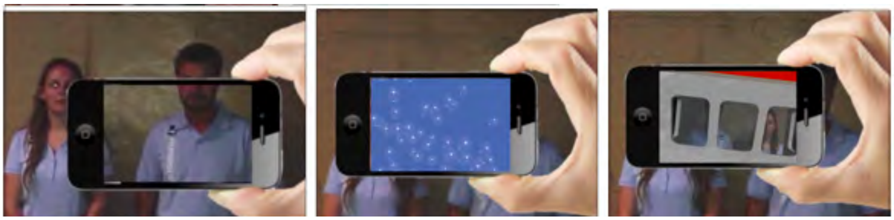

Figure 8: Sequence from one of the sketches, exploring how the augmented reality effects would become activated on the mobile medium. A still image of a hand holding a smart phone is animated on top of video footage from the zoo, with the animated content sketches placed on top to simulate the augmented reality when the interaction occurs.

The main benefit from creating the animated sketches of the interaction design was the broad range of concepts the team was able to explore in a short amount of time. Despite its non-interactive nature, temporal sketching through animation provided viable insights in the interaction possibilities and possible breakdowns, with the non-idiomatic technology of augmented reality. While not being able to try out the interaction design, the animations were assessed as 'real enough' to perceive how the given design might work. It was clear that through watching the animation, different elements were noticed by different team members, based on their respective disciplines. The zoo personnel noticed how the combination of having the guest standing in front of a camera at specific places in the zoo might affect the rush hour traffic of guest at the zoo, and potentially disturb both the users of the app as well as the other guests. The HCI members of team on other hand saw how the augmented reality might present usability issues of visibility and feedback if no physical constraints were made to the context of the app. Though the observations were different, all were directed against the same sketches as the backdrop, making it easy to gather the inputs and prioritise them as a group with the animated sketch as a constant point of reference. This created the basis for discussing 'what would happen if we do this' instead of going straight to more usability oriented assessments of 'why does this happen when I do this?'. Especially the team members not responsible for the technical development saw this as a way of 'watching and discussing a movie about the attraction' instead of having to understand all the technical constraints in detail. In this regard, the non-interactive aspect of the animation actually helped to maintain the focus on being explorative instead of becoming didactic - a sketch rather than a prototype.

The re-use of elements from the content sketches showed another quality of using digital animation as an enabling tool to support the cooperative work - speeding up the process. The existing animated elements became easy to cut together with new material - creating a fast pipeline of creating new animated sketches when the need came for new information to guide decision making. This was evident when the team had to decide how make it intuitive for the user to know where to stand when being filmed. By editing the key-frames in the animated sketch, and shifting between content placeholders, we were able to get a fast feedback on, where on the screen it would seem most logical for content to be viewed, without having to create entirely new sketches each time. In this way, using time on animating one content sketch proved to have long-term benefits by being able to create a backlog of re-usable sketching elements. In return this resulted in a possibility of generating more design alternatives, and thus reduce uncertainty by seeing possible interaction designs simulated via animations.

6.8 Animating user scenario

A critical aspect of designing augmented reality is the arrangement of the physical context in which the digital layers will be in use [Carmigniani et al 2011, Höllerer 2004]. This was an area of intense debate between the design team members, making the stakeholder relationship between the zoo personal and the developers very clear. The developers and HCI members proposed to design visible guiding posters, light spots on the floor to indicate where the user could use the app, and create a movie scenography as context for the app use. The zoo personal on the other hand wanted to maintain the physical settings as authentic as possible without posters and other elements taking focus from the zoo context. From the initial sketches of the proposed scenography, we could not get sufficient information to reduce uncertainty about the most feasible road to take. We realised that we needed to sketch on top of 'the real context' in order to gain the information we needed.

We used a technique similar to Löwgren's [2004] animated use sketches to focus more on the user story than on the digital design itself [AAU 2015e]. However, we did not follow Löwgren's example of creating a fully animated sketch, but made a more depictive representation by mixing the modalities of stop-motion, key-frame animation and live video footage. Stop motion was first used to create a quick animation of an interface for the augmented reality app, animating how the users input would make the application respond. Once again we then used the previously made 3D content animations to key-frame the augmented reality effects in the scenario. Finally, we recorded a live video session of two children visiting the zoo and bodystorming how to use the app. The use of live footage from the zoo was important in order to generate information about how much the design elements would affect the context of the zoo. To this end we captured pictures of the aquariums, and made them into scenography backdrops, mounted a flashlight as spot light, and used a series of printed icons as guiding signs. The final video scenarios consisted of a small narratives of the children visiting the

North Sea Oceanarium, and different ways of being notified about the application, and ways of using it in the zoo context. (figure 9).

Figure 9: The user scenario sketch, combining video footage, mocked up scenography and interface elements, to sketch how the physical context of the zoo could be integrated with the digital design.

The sketch ended up as a short relatable narrative set in a context that all the team members had become well acquainted with through the design process. As such, focus could be directed at the new elements in the narrative - the scenography and the use of the app in the context. The uncertainty about how much the addition of scenography would affect the look and feel could now be addressed through very concrete reference to an animation-based sketch. The zoo personal agreed that some background scenography might be a good addition - as long as it would be based on pictures from the actual aquariums. The developers also compromised upon seeing how much their proposed posters and light spots would stand out from the more natural looking setting of the rest of the zoo. Thus it was decided to minimise the guiding signs to a signpost at the entrance of the zoo, and indicate the augmented reality spots with subtle footprints painted onto the floor.

Again, the temporal quality, combined with the ability to simulate the digital content provided a basis for framing the discussion in the group in a consensus-seeking direction, where all team members committed to some compromises.

6.9 Animating 1 minute of wait time

A late decision in the product formation was whether different mobile platforms should be able to accommodate the design principles the sketches had helped to qualify. While many of the design criteria and principles had been explored and were more or less established at this late point in the product formation, it was still uncertain whether how the user experience would differ between Apple's iOS and Google's Android platforms. Through an analysis of the technological prowess of each platform the team learned that while real-time rendering of the digital overlays was possible on iOS, a rendering time of approximately 1 minute was needed for the same to be applied on the majority of Android devices. Among the team members no clear consensus could be reached about the feasibility of this. The zoo personal was backed by the zoo managers to provide equal support in order to get as many potential users as possible. The developers and HCI team members leaned towards focusing on not creating a potentially frustrating wait time for some users, and prioritise the resources on polishing the iOS edition of the app.

To help facilitate the decision making, we chose to simulate how 1 minute of wait time would feel when using the app [AAU 2015f]. Again, the same tools and techniques from before were applied – but this time with a different goal. A live action video filmed in context. The video was combined with a key-frame animation of one of the augmented reality scenes. This scene was followed by a new key-frame animated interface of a load screen, running for one full minute before showing the footage with the augmented reality content (figure 10). A side note to the sketch is this specific animation-based sketch by far was the fastest for the team to create, taking no more than 10 minutes of production time, due the already established pipeline of live-video material, 3D objects ect. from the project – once again underpinning the efficiency of animation when integrated into the iterative process.

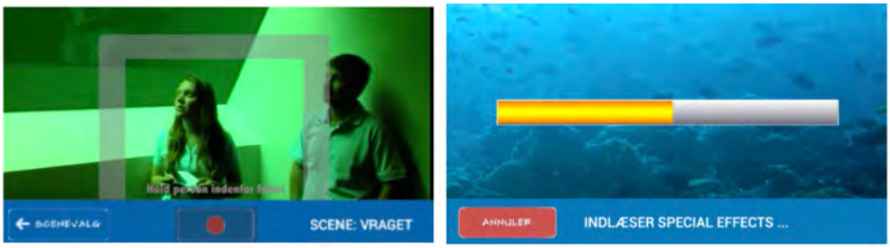

Figure 10: A proposal for the interface of the app's camera viewfinder is animated on top of video footage from the zoo to illustrate how the user records the scene without live effects (left). The scene is followed by a key-frame animated load screen, running for 1 minute before it presents the recorded scene with the augmented reality special effects (right).

This use of animation stood in sort of a middle ground between functioning as sketch and prototype. On one hand the knowledge output was still clearly aimed at reducing uncertainty, providing information about the difference between the two platforms. On the other hand, the animated format also allowed for the team to actually put the animated sketch onto a phone and test the wait time in context. This enabled them to test the hypothesis that many users would become frustrated by waiting a full minute, and quickly become distracted by other potential experiences in zoo. This showed to be exactly what happened when visitors to the zoo were exposed to animation-based sketch in the zoo. To this end, the role of animation-based sketch changed to that of prototype, by reducing the complexity of how to realise the app design most efficiently.

Through the insight from being able to compare the two platforms, and test it, consensus was established for postponing Android support in the first version of the design. The decision freed up resources which provided space in the budget for the zoo to acquire a set of iOS devices to borrow to the guest who did not have an iOS device of their own. Had the team been forced to create a 1st usable coded prototype of both the live-view iOS edition and the one minute load time Android edition before realising the non-desirable outcome, the resources used to acquire the borrowing units would not have been available.

Thus, the animation functioned as both explorative sketch to explore 'what will 1 minute of wait time look and feel like in this context?', and as didactic prototype to test the hypothesis that 'users would become frustrated of having to wait!' at the same time. As a mediator of consensus the sketch functioned as both a way to express one preferences among the team members, as well as facilitate how the view of the other team members could be realised through making the decision to postpone the Android version, and use the resource to still provide access to the app for the guests.

7. DISCUSSION

Throughout the transgression from concept to the more specific core design we learned how the decision-making about non-idiomatic technologies differs from more established design domains, due to the constant challenge of addressing the temporal aspects as well as simulating a technology without established conventions. In this section we will discuss the feasibility of using animation as a tool to cooperate about reaching consensus about this type of decisions.

7.1 Animation based sketching as a cooperative tool

Evaluating animation-based sketching as a viable design tool is dependent on how we assess the nature of the cooperative design processes, and the tool's ability to support these compared to other approaches. In our case we have seen a range of design situations were a multi-disciplinary team had to reach consensus about issues which were difficult to frame through conventional hand-drawn sketching or prototyping platforms. Compared to other temporal methods Arvola & Artman's [2006] use of bodystorming and enactments proved useful in order to explore interactivity, but the methods lacked the ability to simulate the digital materiality. This is also the case for video sketching as presented by Ylirisku & Buur [2007], which proved useful for showing narratives and the temporality of use cases, but it is not able to illustrate digital material on its own terms. To this end, the use of animation to reduce uncertainty of temporal aspects of digital interaction design provides the necessary expressive qualities to both illustrate use over time, as well as simulating digital artefacts which do not yet exist. Thus, animation can reasonably be regarded as a supportive tool to cooperative design processes, when there is a need to both explore the temporal aspects, as well as simulate non-idiomatic digital technologies. Animation joins the toolkit for design teams, and as we have seen in the cases above, also works in tandem with other techniques to create design alternatives that may reduce uncertainty in decision-making.

7.2 A viable sketching tool?

Proposing animation as a sketching tool, also means that it has to be viable compared to both the quicker method of hand-drawn sketching, and the more sophisticated approach of coding a fully working piece of the designed software. We see this as a distinction between time-saving and the quality of the generated information. When choosing to animate a sketch instead of using hand-drawn sketches it increases the time used to create the sketch. On the other hand, the expressive quality of the generated sketch becomes higher, and provides basis for a more informed decision about the temporal and simulative aspects of the design problem. When choosing to animate instead of making a coded version it is (most often) time-saving. Here the assessment is based on how to save time compared to coded prototypes, in order to sketch more design alternatives to reflect upon - thus reducing the uncertainty about design possibilities in decision making during the fuzziness of the product formation.

In the case analysis we saw the choice of animation over hand-drawn sketches in the first three sketches. From the initially generated hand-drawn sketches it was clear that the quality of the information was not high enough to help the team reach consensus about the issues at hand. When introducing the animation-based sketches, more time was used, but the information from the sketches qualified the basis for reaching the needed compromises to reach consensus.

The animation over coded version was evident in the third and fourth case example. Here the needed information regarded issues which might also have been explored through prototyping techniques and coded iterations of the design. However, since the degree of uncertainty at these steps was still high it was more feasible to be able to explore the issues faster than coding. Furthermore, the quality of the information was not dependent on being able to actually interact with the app, rendering a functional coded version unnecessary in the decision making at that point in the process.

The above discussion does also have en underlying premise for 'what kind of animation' we speak of, when we deal with animation-based sketching. Looking back to the initial inclusion of Furniss' notion af spectrum between the purely mimetic and purely abstract representations when dealing with temporal means of expression we may illustrate, how animation-based sketching is different from what we traditionally associate with animation. The traditional animated film as a mean of expression stories seeks to balance between the mimetic representation of reality, while using the classic animation principles to express the exaggerated reality of the animated film [Johnston & Thomas 1995]. To achieve this, a certain level of visual fidelity is needed to create this 'illusion of life' for the film audience, and to establish a feeling of the animation as a completed artwork in motion. This requires immense amounts of time being used to refine the graphical material, and fine tune their movements to a point at which the suspension of disbelief can be achieved. Animation applied in design sketching distances itself from this approach to animation, by adopting the sketching mind-set of creating quick, and disposable representations, which are not meant to stand as final expressions of the design, but to rather generate just enough relevant information to push the decision making forward. In Furniss spectrum of animation, animation-based sketching might therefore take a more abstract representation, or simply combine abstract unfinished representations with mimetic film to achieve the needed output. To this end, what we propose as being labelled as animation-based sketching is the type of animation which remain fast, unfinished and rough, opposed to the traditional polished and refined artwork of the animated film. Thus, we propose that animation-based sketching has the role for non-idiomatic design processes, as rough pre-visualizations has for special effects driven film production – to provide information about conceptual feasibility prior to the following resource heavy steps of the process.

Finally based on the case analysis we may synthesise animation-based sketching as a middle ground between hand-drawn sketches, and coded versions. In the product formation step of the digital design cycle we learned that animation becomes suitable as a sketching medium when transgression from initial concept to the more specific core design. In retrospect this seems logical, since the sub-decisions of this transgression in the cycle deals with the interaction design – a temporal aspect of the design. Derived from the study, we propose three guiding principles for using animation as a sketching tool in cooperative design cases:

1. *When choosing animation-based sketching over traditional hand-drawn sketching, the production time increases, but so does the quality of the information generated. Viable when needing temporal and simulative information in order to make a decision about the design problem.*

2. *When choosing animation-based sketching over coded versions of the design, the quality of the information generated is lower, but the production time is faster. Viable to reduce the time to get information about issues, which does not require direct interaction with the design.*

3. *The animation must not become 'the product'. Regardless of which situation animation is chosen as a sketching tool it must be applied with a contrast to traditional animated film – keeping it fast, rough, and abstract enough to enable reflection upon the design problem, and thus guide the decision making.*

Our study is not exhaustive in terms of tested animation techniques or the potential design situations where animation might be used as a facilitative design tool. Even so, we contribute to the existing attempts of using temporal sketching tools as enabling technology for cooperative design processes. We provided a more detailed inquiry into which qualities can be harnessed from animation to inform important decisions at critical points during product formation - showing the scope of animation-based sketching. In this regard, we argue that animation can be assessed as a powerful cooperative tool to support decision making of a design team when dealing with design cases, which require exploration of non-idiomatic technologies and temporal dimensions.

8. CONCLUSION

The research question was: How can animation-based sketching be applied as a cooperative temporal sketching tool to reduce uncertainty about core design of design projects? We have evaluated this animation-based sketching as an enabling medium for facilitating consensus between stakeholders in product formation of digital design projects dealing with non-idiomatic technologies. Through the case study from the author's research through design study with the design of a mobile augmented reality application a range of examples of how animation informed the decision making was featured. From this we conclude that despite its non-interactive nature, temporal sketching through animations can provide viable information, and thus reduce uncertainty about the design alternatives and create the basis for consensus in a multi-disciplinary design setting. Animation does this by being able to simulate temporal, material and interactive aspects of the design, without writing code. This is important when having to explore and inform decisions about technologies without established conventions or design patterns, since the lack of best-practices would require a lot of development time potentially used better elsewhere. While it also takes time to create an animation, the time used on each animation-based sketch in our case where considerately shorter than the system development time in the later phases of the design project - especially when setting up a pipeline of animation assets to be reused in different sketches throughout the iterations of the product formation.

As a tool for cooperative design processes we assess that the animation-based sketching cannot stand alone. Instead animation-based sketching must be viewed as an addition to the design toolkit – suitable for situations when in need of reducing uncertainty about temporal aspects of digital interaction design. From this we derived three guiding principles for when to choose animation-based sketching over traditional hand-drawn sketching or coding a functional version. The first two principles emphasis the distinction between the quality of needed information, and the time spent on generating information. The third principle emphasises ontological meaning of 'animation' when considered in a design sketching perspective – reframed from a focus on creating high fidelity visuals, to creating a rough realisation of the temporal issues of design space. The last principle is of special importance to our contribution to understanding animation-based sketching since it illustrates why the two first principles are valid, and further why their distinction is not a trivial matter. When choosing to apply animation-based sketching as a cooperative design tool, one must reflect both on which methods we choose between, and upon the mindset behind the method. This is to avoid spending to much time on refining the animation, and thus freeing up time for engaging in the cooperative process of decision making, facilitated by the animation-based sketch.

In the end, we assess that animation is a valuable cooperative design tool on its own - a tool to dynamically explore digital design possibilities before the design actually becomes interactive. We provided further details to the existing discourse and featured an analysis of how different critical decision points of the product formation could be informed through animation-based sketching.

With the focus on animation as a sketching tool, it is easy to lose sight of the fact that it represents only part of a much richer ecology of rendering types. In this regard, data and insights made during this case study cannot conclude animation-based sketching as being superior to other possible sketching or prototyping approaches. However, we provide empirical testing of a variety of ways to apply animation in a cooperative design, and experienced the benefits they provided for the group based decision making. This finally calls for several more studies to be carried out regarding cooperative design situations in fuzzy front end setups to further explore animation-based sketching as a method, and compare its suitability towards other tools.

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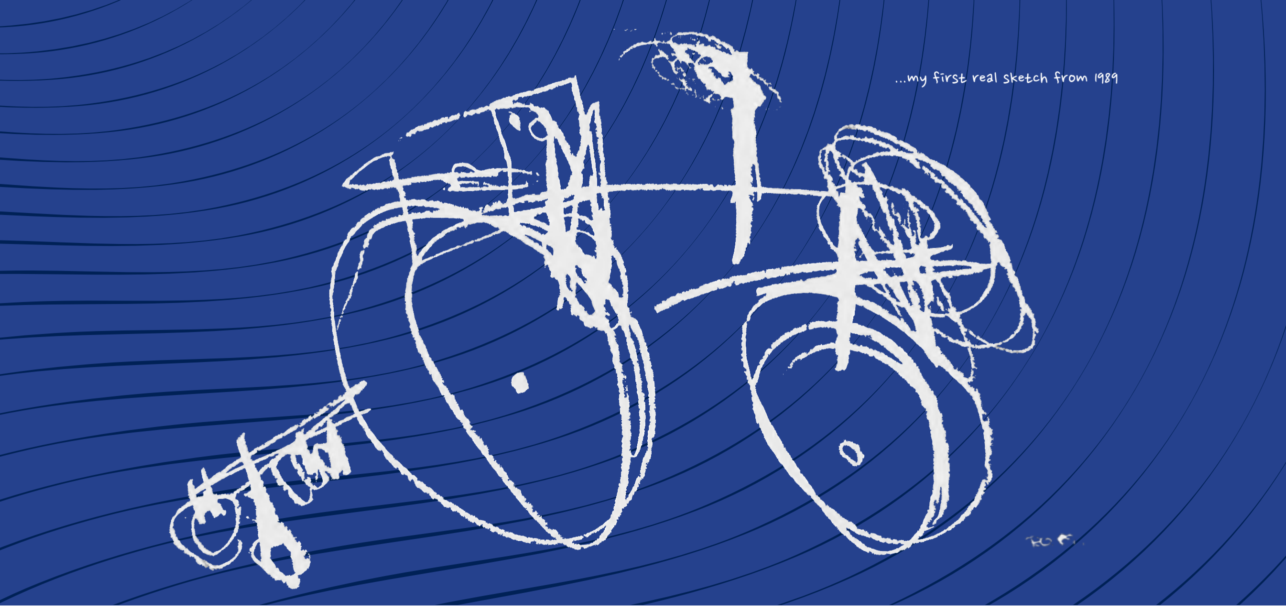

SUMMARY

This thesis is based on the results of a three-year long PhD-study at the Department of Communication and Psychology at Aalborg University. The thesis consist of five original papers, a book manuscript, as well as a linking text with the thesis' research questions, research design, and summary of contributions.

In the produced work, I expand upon animation as a sketching approach to communicate, and explore interaction and user experience design concepts that are hard to grasp via traditional means of sketching. I propose that the sequential, temporal, material and narrative qualities of animation may sufficiently be considered an extended capacity of sketching. The subject matter for merging these perspectives is supporting exploration of the viability and feasibility of new user experiences with a proposed technology, before functional versions are build. A series of constructive design research experiments has been carried out, applying animation-based sketching in various contexts and at varying points in the design process. In the studies, I evaluate the viability of the approach, the practical integration into the design process, and map how consensus between stakeholders in design can be established through animation-based sketches. Thus, the scope of this project is practice-inclined, towards qualifying animation as an approach for design sketching in practice.

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