Facilitating Consensus in Cooperative Design Processes using animation-based sketching

Vistisen, Peter; Rosenstand, Claus Andreas Foss

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PETER VISTISEN, University of Aalborg
CLAUS ROSENSTAND, University of Aalborg

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.

H.5.1 Multimedia Information Systems (e.g. Animations); H.5.2 User Interfaces (e.g. Prototyping); H.5.3 Group and Organization Interfaces (e.g. Computer-supported cooperative work)

Author Keywords
Sketching; Animation; Consensus; Fuzzy front-end; Cooperative design

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Author's addresses: Peter Vistisen, Office 11.01, Aalborg University, Teglgaardsplads 1, 9000 Aalborg. Claus Rosenstand, Office 11.03, Aalborg University, Teglgaardsplads 1, 9000 Aalborg.

1. 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.

2. 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 2002] 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.

3. 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).

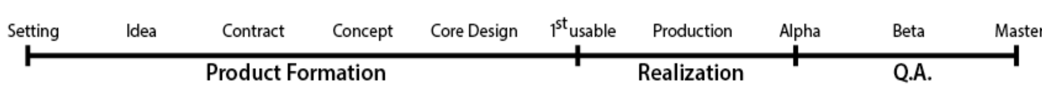

Figure 1: Digital Media Creation Cycle, by Rosenstand & Kyed, with product formation, realization and Q.A. as the major steps, and a range of sub-steps, each indicating a decision point of the design process.

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.

3.1 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.

4. 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.

5. 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.

5.1 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.

5.2 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.

5.3 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)

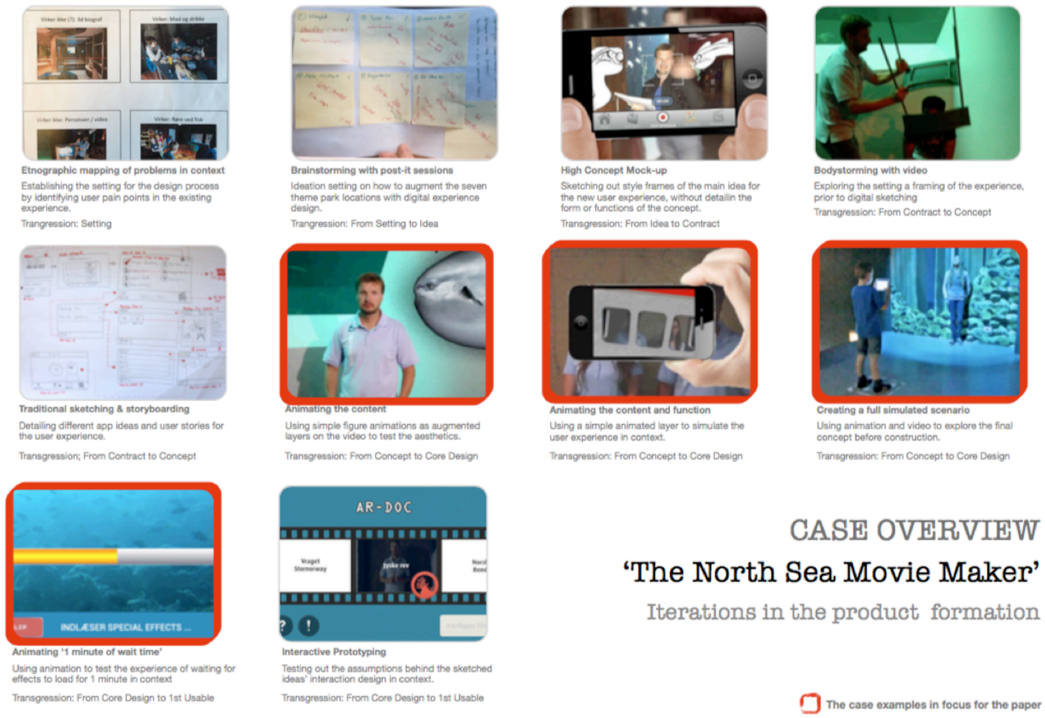

Figure 3: Overview of the iterations in the product formation, emphasizing the design activities and highlighting the four case examples of animation-based sketching described in this paper.

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).

5.4 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.

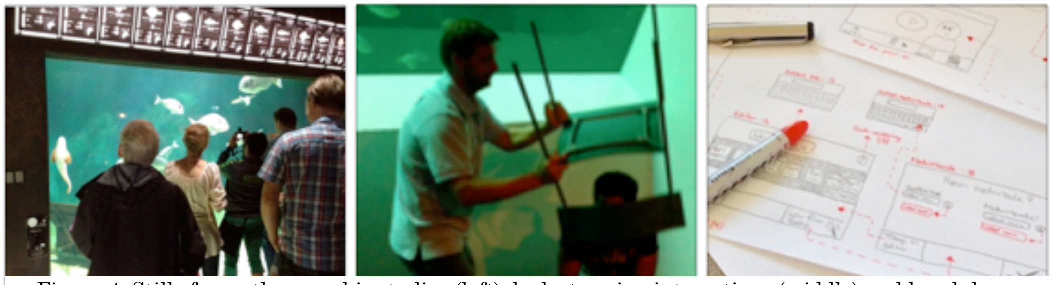

Figure 4: Stills from ethnographic studies (left), bodystorming interactions (middle) and hand-drawn sketching (right)

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.

5.5 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.

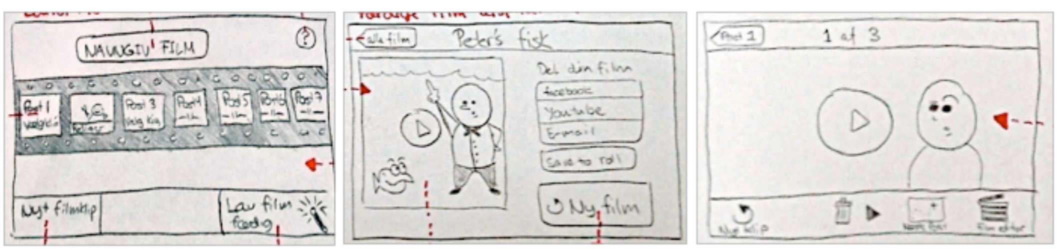

Figure 5: Examples of the hand-drawn initial concept sketches, exploring multiple design alternatives for augmented reality in the zoo context, and recording it as a user-generated special effects movie.

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, 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.

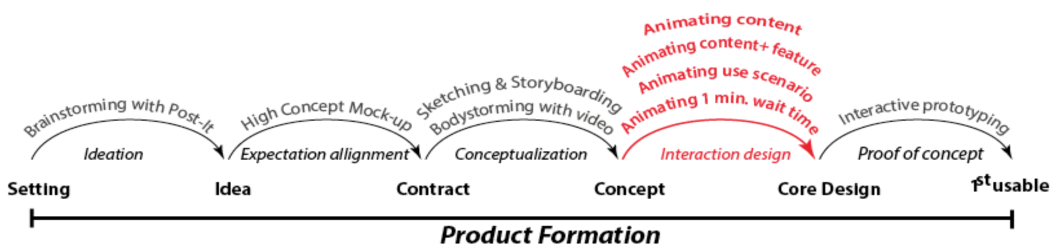

Figure 6: The product formation of the North Sea case. Our focus on facilitating consensus in the transgression between initial concept and core design is highlighted together with the tested animation-based sketches used to facilitate consensus

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].

5.6 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.

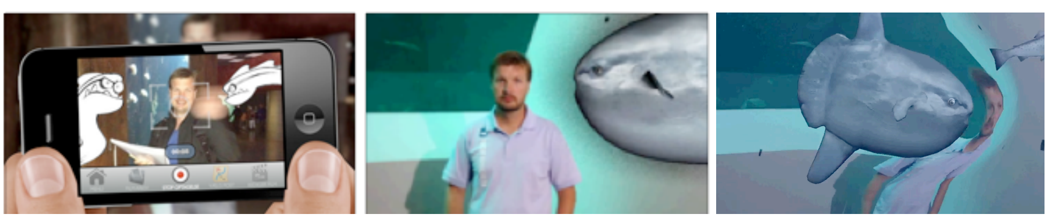

Figure 7: The first stop motion based content sketch (left) with hand-drawn elements animated on top of a still image from the zoo [64]. The second 3D based sketch (middle) in which an animated fish was placed on top of video footage from the zoo [65]. Finally the two content genres were mixed into a 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.

5.7 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.

5.8 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.

5.9 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.

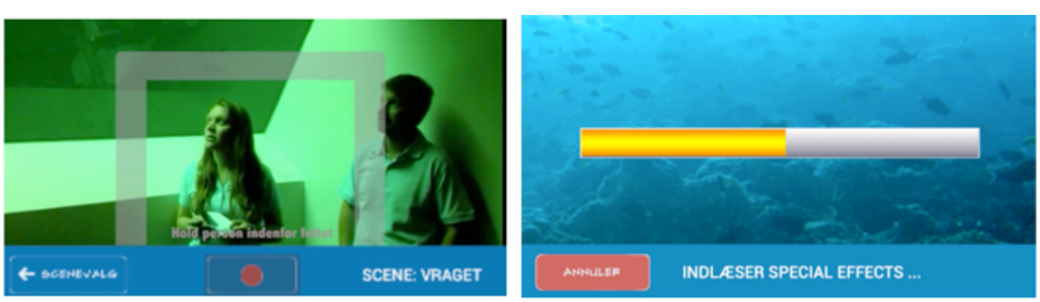

Figure 10: A proposal for the interface of the app's camera viewfinder is animated on top of video footage from the zoo to illustrate how the user records the scene without live effects (left). The scene is followed by a key-frame animated load screen, running for 1 minute before it presents the recorded 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.

6. 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.

6.1 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.

6.2 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.

7. 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.

ELECTRONIC APPENDIX

The electronic appendix for this article can be accessed in the ACM Digital Library.

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