# Materialedreven 3d digital formgivning

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# Material-driven 3D digital form giving

## *Experimental use and integration of digital media in the field of ceramics*

**Ph.D. project by Flemming Tvede Hansen, The Danish Design School 2010**

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*Experimental use and integration of digital media in the field of ceramics*
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# About this publication

This publication is a short English version of the Danish written thesis called “Materialedreven 3d digital formgivning. Eksperimenterende brug og integration af det digitale medie i det keramiske fagområde”. The English version consists of a short English summary and four papers presented at international peer reviewed conferences during the project period.

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Flemming Tvede Hansen, June 2010

# Preface

Per Galle // main supervisor

Flemming Tvede Hansen's PhD project as reported here is centred around two research questions: One about how the traditional experience and craft-based skills of the ceramist might be transferred to and utilized in 3D digital form giving; the other about how such a combination of the traditions of the craft with modern technology might be put to use in actual shaping of three-dimensional ceramic artefacts. The exploration of these questions is delimited to the realm of shapes, deliberately disregarding any practical uses or purposes of the artefacts in question. This is why the term "form giving" is sued so frequently throughout the thesis, rather than "design".

Flemming has worked within the emerging paradigm known as "practice-based design resarch". In doing so, he has taken valuable inspiration from my co-supervisor, Dr. Katie Bunnell, and her colleagues in the Autonomatic team at University College Falmouth, who – unlike myself – are experts on experimental form giving of ceramics using information technology. During the three years of work on the project, Flemming has made a contribution of his own to research methodology within that field: what he calls "branching experiments".

Using this experimental method (while developing it), Flemming has produced, documented, and analysed a considerable number of original results in order to answer his two research questions. In doing so, he has frequently engaged in cooperation with students and colleagues, a fruitful strategy, which has obviously contributed to the richness of his results.

At the same time he has developed an elaborate conceptual framework in which to organize the many particular findings generated by the experiments. In other words, he has outlined what might be called *a theory of form giving ceramics by means of IT.* While the experimental results are informative in themselves, this overarching theory raises them to a level of generality that may be useful to other designers who want to transfer his results to their particular area of interest.

Because of this double emphasis on practical and theoretical issues, I believe it is fair to conclude that the outcome of this project is a rather unique combination of basic, and highly applied – or rather applicable – research.

It has been a pleasure to follow the development of this project. Once again it has confirmed my experience that being a supervisor is as much about learning as about teaching.

We must learn to see design algorithms everywhere we look.
Sanford Kwinter (2008)

# English Summary

This thesis is about experimental use and integration of digital media in the shaping process of artefacts in the field of ceramics. The aim of the research is firstly to support the ceramicist in working experimentally and exploratively by means of digital media, and secondly to contribute to an interdisciplinary discourse about the use of digital media within the field of ceramics. The project focuses on 3d form; hence 3d digital graphics and Rapid Prototyping (RP). "RP" is a common term for techniques for transforming 3d digital form into 3d physical form.

The research project is centred on two research questions: One question is about how knowledge and experience about form giving in the field of ceramics can be transferred to and utilized in 3d digital form giving. Another question is about what can be gained with such an approach and use of 3d digital form giving, - and how it can be utilized in a dynamic interplay with actual shaping of three-dimensional ceramic artefacts. The thesis is entitled "Material-driven 3D digital form giving. Experimental use and integration of digital media in the field of ceramics". "Material-driven form giving" is an approach to the process of giving form in the field of ceramics, which is defined and exemplified in the thesis. This approach is based on the idea of the ceramic material as a generative and responding potential in the form giving process, which can contribute unpredictable form solutions. Material-driven form giving is characterized by two levels; a *first level* which is to identify and refine a generative potential in a material; and a *second level* which is to transform and actualize this potential in a representative number of artefacts by interacting with the generative potential of the material. This idea of levels was inspired by Sanford Kvinter (2002), who describes how a virtual component is linked to an actual component by a dynamic and uncertain process. In this context, the virtual component can be seen as the potential of the ceramic material, which can be expressed in a wide range of artefacts.

The method of research was inspired by a PhD work by Dr. Katie Bunnell (2009), who proposed an open and emergent practice-based methodology for exploring the integration of digital technologies into her practice as a ceramic designer-maker. The method is explorative and experimental, which in this study means that the research questions and empirical series of experiments are produced and developed in the process of research. This approach can be seen as an instance of Schön's "reflection in action" (Schön, 1983). Furthermore it is relevant to use the terms "practice based design research" (Biggs, 2002) and "research through design" (Frayling, 1993), which for the present purpose can be defined as an experimental design practice that is part of the design research and contributes empirical data. The method explores how design research that includes experimental design practice, can utilize the researcher's background as a practitioner, and make the practice central to the research.

A method of this kind was developed in the course of the present project, and named *Method of Branching Experiment*. It is characterized by an explorative

approach based on the author's interplay with techniques and materials, and by relying on a cluster of parallel and interdependent experiments within a defined frame – rather than single experiments. The method has shown how the parallel experiments can be seen as a dynamic system in which a number of unpredictable and surprising relationships can emerge and be exemplary for what can be done and how, within the context of the original research questions.

More specifically, the idea of material driven form giving was explored and exemplified by means of the author's own experiments with 3d modelling and simulation software. This led to the concept of material driven 3d digital form giving. The experiments explore how the ceramist can utilize themes such as movement and metamorphosis in his work, by means of 3d digital form giving. The point of departure for these experiments was the use of *dynamics* in the animation program *Real Flow*. In the terminology of such 3d software, "Dynamics" is a common name for a number of digital tools designed for simulation of physical phenomena; e.g. liquids, wind, and gravity.

It is argued that dynamics in this sense can be seen as a generative and responding potential, which is comparable with the role of ceramic material, when used according to the idea of *material-driven form giving*, hence the name *material-driven 3d digital form giving*. Various artefacts were produced during the experiments by transferring digitally defined forms into ceramic materials by means of RP. These artefacts showed a potential to produce "dynamic conflicts". Such conflicts contribute with a fluid boundary between fiction and reality, which reflects the above-mentioned use of techniques and materials.

The preliminary experiments using Real Flow raised new questions and hence new parallel experiments. For example, the use of dynamics in such commercial software can be said to represent an already defined way of thinking and giving form. This issue is discussed in relation to the ideas of Manuel De Landa (2001) and others, regarding how the use of digital media can reflect and emphasize a more personal way of form giving.

The results obtained so far encouraged an experimental development of a 3d digital tool named *digital interactive form giving tool* (DIF) in cooperation with a computer programmer. The experiment explores an interactive 3d digital drawing, which responds visually to the movement of the hand in a virtual 3d space using a wii remote as a device. The movement captured and digitalized by the wii forms the basis for a 3D physical model produced by means of RP, which expresses the movement in physical form. It is argued that such an approach represents a more personal way of material-driven 3D digital form giving, compared to the use of so-called commercial software.

In ceramics it is possible to obtain a very personal way of form giving by developing one's own material and techniques, but the resulting artefact will more or less always exhibit the "signature" of the material given by nature. As a contrast it is argued, that DIF enables an exploration of properties, which are not bound to a material and by laws of physics. For example, the use of 3d digital media enables the designer to explore phenomena such as sound and movement of a hand, and to

develop his own generative and responding dynamic systems. This enables a higher degree of complexity in the form giving process of an artefact.

It requires a thorough knowledge and experience to consider such a generative system and subsequently to transform and realize it in a particular context. It is argued that such an approach to 3d digital media is utilizing the experience that a ceramicist brings from practice, based on the idea of material-driven form giving.

Furthermore, it was explored and discussed how an artefact designed with DIF can contribute in interplay with the ceramic material. The experiment explores the RP produced artefact executed in a specially developed ceramic material. This allows a physical transformation and change of the artefact in the traditional kiln firing. And this, in turn, produces a dynamic interplay between the complexity in the digital form giving, and the complexity of the ceramic material of the artefact.

All in all, the thesis develops an experimental and explorative approach, combining digital media with experience rooted in the field of ceramics. Furthermore, the thesis points out the potential for the ceramicist in interdisciplinary collaboration with designers from fields such as interaction design and programming.

In future research it might be of interest to develop generative and responding systems for 3d form embedding *tactility* as well. Furthermore, the development of RP techniques based on ceramic materials utilizing the chemical transformation in the kiln firing is a topic worth exploring.

The thesis is mainly written in Danish, but during the project period four papers were published in English and presented at international peer reviewed conferences. Each of these papers reflects different aspects and views, which are discussed in the thesis. Two of the papers are focussing on practical experiments in the research project, while the other two papers are focussing on method, which is exemplified by the experiments. The four papers are collected and republished in present volume.

Permission to republish the four papers is gratefully acknowledged. The papers were originally published as follows:

**Paper 1**
Experimental Use of Digital Media within the Field of Ceramics. / Hansen, Flemming Tvede. 2009. 5 s.
Conference: Design Connexity - 8th International Conference of the European Academy of Design, nr. 8,
Aberdeen, Great Britain, 1. April 2009 - 3. April 2009.

**Paper 2**
Epistemic artefacts: The potential of artefacts in design research. / Hansen, Flemming Tvede. 2009. 8 s.
Conference: Communicating (by) Design, Brussels, Sint-Lucas, School of Architecture, Belgium, 15. April 2009 - 17. April 2009.

**Paper 3**
A Search for Unpredictable Relationships. / Hansen, Flemming Tvede. 2009. 16 s.
Conference:
EKSIG, London, Metropolitan University, Great Britain, 19. June 2009 - 19. June 2009.

**Paper 4**
Capturing movements in a 3d interactive dynamic system. / Hansen, Flemming Tvede. 2009. 4 s.
Conference: Engaging artefacts, Nordes, Oslo, Norway, 30. August 2009 - 1. September 2009.

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# Paper 1 //
# Experimental Use of Digital Media within the Field of Ceramics

Experimental Use of Digital Media within the Field of Ceramics. / Hansen, Flemming Tvede. 2009. 5 s.
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Aberdeen, Scotland, 1. April 2009 - 3. April 2009.

# EXPERIMENTAL USE OF DIGITAL MEDIA WITHIN THE FIELD OF CERAMICS

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**ABSTRACT**

This paper reflects an ongoing Ph.D. project about experimental use of digital media within the field of ceramics and refers to the theme about design boundary in the conference; in this case between traditional techniques in the field of ceramics and the use of digital media.

The paper presents an example of own experimental design practice, about how digital media can be integrated in a way that takes advantage of the approach a ceramic artist has to designing, and in a way which produce synergy in the interaction between the use of digital media and traditional techniques with natural materials. The paper discusses what this interaction can add in an artistic qualitative sense in a ceramic product and emphasizes a potential for the digital media to create fictitious narratives about the ceramic material in which it is embodied. Furthermore synergy emerged from a fluid boundary between fiction and reality, which reflects the above-mentioned use of techniques and materials, is emphasized.

The focus in the field of ceramics is motivated by the author's background as a ceramic artist, but the project is about a general issue about integration of digital media in related fields such as textile and furniture design. These fields are characterized by a long tradition of craftsmanship using material and craft with great importance for both the process of designing and the finished product.

*Keywords: digital media and analogue techniques, fiction and reality, Rapid Prototyping and 3d form.*

## 1 INTRODUCTION

This paper reflects an ongoing Ph.D. project about experimental use of digital media within the field of ceramics and refers to the theme about design boundary in the conference; in this case between traditional techniques in the field of ceramic and the use of digital media. The Ph.D. project comprises the author's experimental practice and the paper is presenting one of these experiments.

My overall research question regarding the issue is how the digital media can be integrated in a way that takes advantage of the approach a ceramic artist has to designing and in a way which can produce synergy in the interaction between the digital media and traditional techniques with natural materials. And by that, what the use of digital media can add in an artistic qualitative sense to a product of ceramics.

The project focuses on 3d design; more specifically 3d digital graphics and Rapid Prototyping (RP). RP is a common term for techniques to transform 3d digital form into 3d physical form.

Since the technique in RP is not developed to a satisfactory degree to transform the digital form to the ceramic material, this project focuses on the RP-produced models used in combination with traditional techniques. Furthermore the study is focussing on the stage of sketching, - more precisely the stage when form appears as physical form. In that sense the project does not operate with practical functional solutions.

Regarding this research question a lot of experimental work has already been done by artists and researchers. An example of such an artist is Geoffrey Mann (http://www.mrmann.co.uk). Using video recording, he has built up a 3d digital form capturing the movement of a bird over time. Still pictures of the silhouette of the bird have been used as templates for the extrusion of a 3d digital form. The artefact in figure 0 is the result of the transformation of the 3d digital form into a physical form of glass. This has been realized with the help of Rapid Prototyping (SLS technique).

Figure 0

Figure 1

An example of researchers relevant to the issue under consideration is the research cluster at Falmouth College University "Autonomatic" (http://www.autonomatic.org.uk/), which among others includes Katie Bunnell, Justin Marshal, Drummond Masterton and Tavs Jørgensen. The creation of the artefact, which can be seen in Figure 1, will form the basis of this paper and is a result of my own ongoing process of experimentation and reflections on the possible interaction between digital and analogue techniques and materials. The artefact is made of porcelain and the size is 40x30x12 (h) cm. It has a significant, organic growing and detailed formation in the middle and is limited by a soft curved edge, which is determined by the liquid material from which it is produced. In the following I will introduce my method of research, after that I will present my experiment and in the end I will discuss and conclude.

## 2 METHOD OF RESEARCH

In the case of my approach to research it is relevant to use the term "research through design" (Frayling 1993), which for our purpose can be defined as an experimental design practice that is part of the design research and contributes empirical data. The method is explorative and experimental, which in this study means that the research questions and empirical series of experiments are produced and developed in the process of research. This approach can be seen as a "reflection in practice" similar to Schön's ideas (Schön 1983). The method begins with a definition of a frame for carrying out experiments, which is inspired by Exemplary Design Research (Binder and Redström 2006).

*Quotation: With the notion of "exemplary design research driven by programs, experiments and interventions", we refer to research based on the explicit formulation of design programs that act as a frame and foundation for carrying out series of design experiments and interventions. It is 'exemplary' in the sense that it enables critical dissemination primarily by creating examples of what could be done and how, i.e. examples that both express the possibilities of the design program as well as more general suggestions about a (change to) design practice. (Binder and Redström 2006).*

My intention with this paper is to give an insight into one of these experiments in this frame and the potential it may exhibit. It is only relevant to talk about an insight, because the number of examples in this paper is not representative for the overall research question.

## 3 THE EXPERIMENT

The experiment has its starting point in the use of the 3d animation software called Real Flow, by which I have produced the data for a 3d RP produced digital model. The 3d model has formed the link for interaction between the digital media and the traditional techniques in the field of ceramics. In this case the use of slip casting with porcelain.

### 3.1 Digital Media

Regarding the issue I have explored the use of Dynamics in 3d digital graphic software packages as a design tool. Dynamics cover a range of tools in 3d digital graphic software to simulate transient phenomena and effects related to reality such as wind, gravity, liquids etc. Instead of capturing transient phenomena from the physical world, Dynamics allows you to simulate the transient phenomena in

question, making it possible to work with representations of them. In that sense it is suitable for exploration, since these 3d geometries in such software have the ability to respond if exposed to a force. Dynamics are found in large software packages such as 3d studio max and Cinema 4D, but can also be found in smaller and more targeted packages like Real Flow, which is used in this case. Real Flow is animation based software; hence it is based on film sequences. A fascinating point is that it is also possible to have these effects - such as a collided water surface, which delivers a water splash – produced as a 3D physical model by the use of Rapid Prototyping. In this case with a three-dimensional print in ABS plastic produced by a 3D printer from Stratasys Dimension. Figure 2 shows some snapshots from the animation used in this case. Using Real Flow it is even possible to be beyond gravity, specific gravity and the liquid surface. It is possible to regulate the speed and outcome of the event, which can then be an impact in a cup of coffee or in a liquid acid-sea on Venus. We are not bound by the laws of physics and can even freeze a moment in the film sequence at any time and the resulting model can be enlarged or reduced.

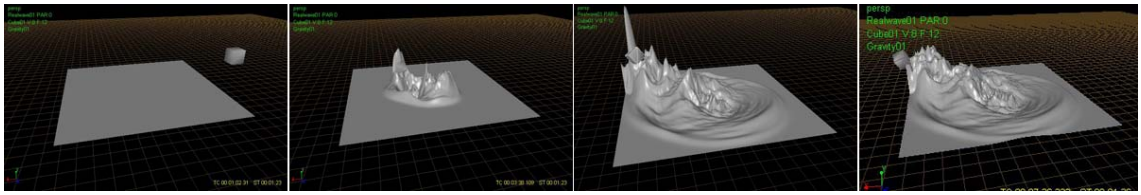

*Figure 2*

Figure 3 shows the physical model of a snapshot in the sequence produced by the 3D printer from Stratasys Dimension.

Figure 3

Figure 4

### 3.2 The artefact is created

The artefact in figure 1 was finally produced by slip casting in porcelain, which involves liquid aqueous clay. The liquid porcelain is poured onto a plaster mould made on the basis of the RP model. As the liquid material flows across the plaster, the water is drained out of the porcelain, whereby it slowly stiffens in its action and dries. The dry porcelain can subsequently be dismantled from the plaster mould, which now has made an imprint in the porcelain. The plaster mould used in this case can be seen in figure 4. It shows the imprint of the three-dimensional print in figure 3. First the depression was filled. Subsequently the liquid has found its way beyond the depression and at a stage is has been captured in a drying moment. The way the porcelain has been flowing is unique and determined by the way I poured it. This process is clearly reflected in the contours of the artefact, as a consequence of what *actually happened in reality*. By contrast, the irregular formation in the middle of the artefact was made by a digital simulation mimicking a liquid, which is hit by an object. The event has been frozen at the exact moment where the

reaction of the collision has reached its climax. The formation is not created as a caricature, but with an intention to be a naturalistic representation of an event, - but one that *never happened in reality.*
But what difference does it make if the event *actually happens in physical reality* or it is a simulation? The answer is to be found in the synergy that occurs between the digital media and the analogue techniques and materials in the field of ceramics.

### 3.3 Synergy

If we separately reflect on the formation and the contour of the artefact, respectively, we will find the expressions fundamentally different. The formation describes and pictures a phenomenon about liquid. It is naturalistic but fictitious. It has never been a floating liquid itself and refers to a phenomenon which differs from its own creation, similar to the notion of a figure, model etc. On the other hand, the contour of the artefact rather refers to itself and its creation. It simply just looks like what it is. It has never been the intention for it to be anything but the flowing porcelain, which has stiffened. Thus the two expressions differ and integrated in one and the same artefact they create ambiguity and visual dynamic conflicts, which I will go into details about.
Because the formation is an integral part of the artefact along with its contour it is at first sight interpreted as a splash generated by the original liquid porcelain and as part or result of the creation. But on closer inspection it becomes clear that the formation seen in this context reflects a splash at an entirely different scale. As if it was a meteorite impact in a big ocean. This difference in scale is emphasized by the organic complexity of the formation reflected in a naturalistic miniature with photographic accuracy. It produces what I call a *"conflict of scale"*. In general a scale-conflict is easily achieved e.g. a juxtaposition of model cars in different scales. But what makes this particular conflict of scale interesting is the imitation of material as such in the formation. The imitation makes the scale-conflict hard to point out at first sight and only gives a hint about something wrong.
Another important aspect is the character of the formation which seems to be a frozen movement. This reminds the observer of the ability of photography to capture a moment. This also points to the fact, that the formation was not a part or result of the creation. The liquid material, from which the artefact is produced, would not stiffen that quickly in motion, but rather have a less dramatic and calmer nature, as can be seen at the contour of the artefact. This difference in behaviour in one and the same object produces what I call a *"conflict of material*". In this experiment it is a conflict between the fictitious digital material and the ceramic material.
These conflicts are intriguing. On one hand we have an undramatic narrative about the creation of the artefact expressed through the behaviour of the material in which it is created. On the other hand, we have the much more dramatic narrative; the naturalistic, but fictitious and dynamic story about liquid "told" by the formation. In the juxtaposition of the two narratives in one and the same object synergy is created. On one hand, the powerful and condensed expression in the fictive narrative becomes plausible and tangible, when used in the context of real physical materials and analogue techniques. On the other hand, the event expressed in the contour of the artefact has the possibility to be interpreted as part of the fictive narrative and become something else than a sign of the nature of the material itself. As observers of the artefact, we will alternate between fiction and reality, but also between representation and material as such. Synergy emerges from these fluid and tricky boundaries presented in one and the same artefact.

## 4 CONCLUSION

In this paper I have attempted to present an example of how digital media can be integrated in a way that takes advantage of the approach a ceramic artist has to designing and in a way which can produce synergy in the interaction between the digital media and traditional techniques (and natural materials).
Furthermore, I have discussed what this interaction can add in an artistic qualitative sense to a product of ceramics. Regarding this issue I will emphasize the possibility for the digital media to paraphrase or to produce a fictitious narrative about the material in which it is embodied. Furthermore the fluid boundary between the artistic expression through the material itself and the representation of phenomena in a different material should be emphasized. This is setting the stage for further reflection and discussion about the potential on fluid boundaries and further similar experiments in the meeting between clay and digital media.

The “hands on” explorative use of the digital media has raised some new issues to explore. E.g. regarding the use of the software Real Flow I find a lack of interaction between the user and the dynamics. The event simulation is defined in advance with the possibility to change parameters and orientation, but with no possibility for interaction by the user while the simulation is executed. This differs considerably from the approach of the ceramist relevant in this research, which I have mentioned earlier, and appeals more to a calculated and rational approach. Regarding the use of the RP produced 3d model within the traditional techniques for slip casting, I find some limitations in how complex the 3d model can be, if it is to be transformed into the ceramic material. These issues call for further research which, I am sure, will show further potentials in an artistic qualitative sense.

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**Websites:**

Geoffrey Mann, http://www.mrmann.co.uk/

Autonomatic, http://www.autonomatic.org.uk/

**List of illustrations:**

Figure 0: Geoffrey Mann, “Flight” 2005, photo: Sylvain Deleu.
Figure 1: Flemming Tvede Hansen, “Splash” 2008, photo: Dorte Krogh.
Figure 2: Flemming Tvede Hansen, snapshots from the software Real Flow.
Figure 3: Flemming Tvede Hansen, 3d print by a Stratasys Dimension, photo: Flemming Tvede Hansen.
Figure 4: Flemming Tvede Hansen, plaster mould, photo: Flemming Tvede Hansen.

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# Paper 2 //
# Epistemic artefacts: The potential of artefacts in design research

Epistemic artefacts: The potential of artefacts in design research. / Hansen, Flemming Tvede. 2009. 8 s.
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# Epistemic artifacts

*The potential of artifacts in design research*

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**Abstract.** An epistemic artefact is characterised by having the sole purpose to be a tool to develop theory in interplay with a verbal reflection and discussion in the context of practice-based design research. It offers the design researcher the advantage to deviate from the design context and turn the design practice in which the he or she is trained, into an integral part of the design research. Hence, the design research can focus solely on the experimental and exploratory aspect of the design practice through the use of materials and techniques. These advantages are discussed and exemplified by the author's own experiments with experimental use of digital media within the field of ceramics. The paper is based on an ongoing PhD project.

**Keywords.** Epistemic artifact; practice-based design research; digital media; Rapid prototyping, ceramics.

## 1. Introduction

This paper reflects on an ongoing Ph.D. project titled "Experimental use of digital media within the field of ceramics". In this research it is relevant to use terms like "research through design"(Frayling 1993) or "practice-based design research", which for this purpose can be defined as an experimental design practice that is part of the design research and contributes empirical data.

The paper is about research method. As a PhD. student with a background in design practice I have been occupied with how design research, which includes own experimental design practice, can utilize the researcher's background as a practitioner and make the practice central for the research.

This issue is also about how design research and design practice can be seen not as two separate and parallel tracks in practice based design research, but as a single track and as an integrated whole.

My overall research question is about how the digital media can be integrated in the field of ceramics in a way that takes advantage of the approach a ceramic artist has to designing and in a way which can produce synergy in the interaction between the digital media and traditional techniques with natural materials. And by that, what the use of digital media can add in an artistic qualitative sense to a product of ceramics. The aim of the research is to support the ceramic artist to work experimentally and exploratively in themes such as movement, transience and metamorphosis by the use of digital media within the field of ceramic.

The project focuses on 3d design and by that 3d digital graphics and Rapid Prototyping (RP). RP is a common term for a range of techniques to transform 3d digital form into 3d physical form.

The overall research question does not reflect the design process as a whole from identifying user problem to finding the right way of production, but focus solely on the experimental and exploratory stage of the shaping process through the use of materials and technique (design practice). See Figure 1.

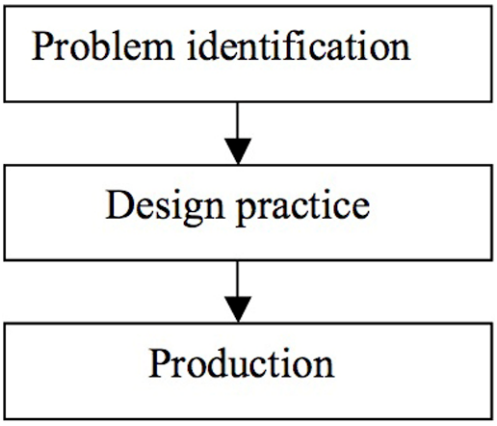


*figure 1, Design Process*

Thus the research question is solely concentrating on the relationship between the designer(s) and form, material and technique. This has the advantage of disengaging the research process from the design context and turns the design practice in which the design researcher is trained, into an integral part of the design research. Below I will show how that the creation of an artefact and the artefact itself in the context of design research can have the sole purpose to be a tool to develop theory in the context of practice-based design research. I shall call such an artefact an epistemic artifact, and I shall argue that such artefacts offer certain advantages for the design researcher to do with practice, method and communication of the outcome in practice-based design research.

In the next section I will clarify my method of research. Subsequently I will clarify the difference between the role of practice and artefact in the context of design and design research, respectively, and how this contributes to and influences my research method, which I will exemplify by my own experiments. Finally, I will draw a parallel to a similar use of artefacts in Participatory Design Approaches from the concept of Make Tools (Sanders, 1999) and Critical Design, which use artefacts with a purpose to stimulate discussion and debate (Dunne, 2001)

## 2. The method in this design research

The method begins with a definition of a frame for carrying out experiments, which is inspired by Exemplary Design Research: With the notion of “exemplary design research driven by programs, experiments and interventions”, we refer to research based on the explicit formulation of design programs that act as a frame and foundation for carrying out series of design experiments and interventions. It is ‘exemplary’ in the sense that it enables critical dissemination primarily by creating examples of what could be done and how, i.e. examples that both express the possibilities of the design program as well as more general suggestions about a (change to) design practice (Binder and Redström, 2006).

My intention with this section is to give an insight into the operational aspect of this frame and the potential it may exhibit. The frame is defined by the overall research question.

The approach to design research is explorative and experimental, which in this study means that the research questions and empirical series of experiments are produced and developed in the process of research. This approach can be seen as a “reflection-in-action” (Schön, 1983).

One experiment has formed the starting point in the research, which has given rise to new questions and experiments. Subsequently the research has comprised parallel

experiments which influence one another through verbal discussion and reflection. The verbal discussion and reflection is based on parallel studies of relevant literature and similar experimental work in the field. The frame and series of parallel and interdependent experiments are illustrated in figure 2.

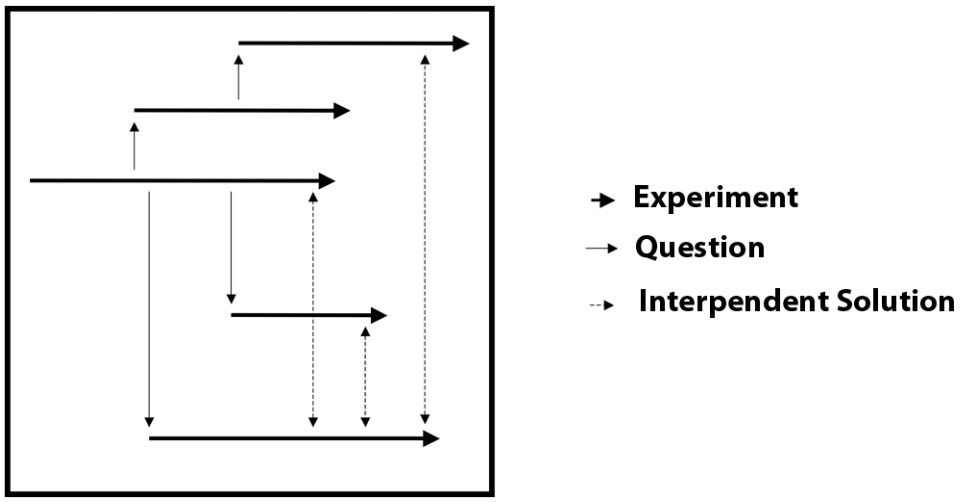


*Figure 2, Series of parallel and interdependent experiments*

### 3. The difference between the role of the artefact in design and design research

In this section I will clarify the difference between the role of practice and artefact in design and design research and how this gives some advantages for the design researcher, which has to do with practice, method and communication of the outcome in practice-based design.

Arguably the purpose of design research is to produce knowledge expressed in terms of theory. The Danish design researcher Per Galle (2009) defines research, knowledge and theory like this:

Research [a process]: Disciplined acquisition of new non-trivial knowledge and documentation of it by means of theory.

Knowledge: Familiarity with concepts, states-of-affaires, or courses of action.

Theory [a product]: A description (often detailed, argumentative, explanatory) of concepts, states-of-affaires, or courses of action.

In the present project, the resolution of the overall research question relies on a series of experiments which contributes empirical data. In that sense the creation of the artefact and the artefact itself can be seen as tools or means to develop theory in interplay with a verbal reflection and discussion.

In comparison the purpose of design is to enable the production of artefacts, accordingly Per Galle, who defines design like this:

Design [a process]: Creatively develop and express an idea so as to enable yourself or someone else to produce an artifact that you will recognize according to the idea.

Following Hilpinen (2004), he takes an artefact to be something deliberately made for a certain purpose; and Per Galle elaborates:

For example, an artefact may accomplish its purpose by being useful in a certain manner, by arousing particular emotions, by signaling its owner’s social status, by mediating an artistic expression, and so forth.

In the ordinary context of design the role of the artefact can be said to be a product and a statement by itself, useful and understandable for a consumer, and it will usually stand alone without a verbal description to accompany it.

As table 1 shows, the purpose, role and product depend on whether it is situated in research or in the practice of art or design.

| | **The purpose is to develop** | **Role of artefact is to be a** | **The product is** |
|---|---|---|---|
| **Design Research** | Knowledge | Tool /means | Theory |
| **Design** | Artefacts | Product | Artefacts |

*table 1*

This gives some advantages for the practice-based design researcher, which has to do with the role of practice, method and communication of the outcome in practice-based design research.

Because in the research situation, the artefact is developed specifically and solely for the sake of the experiment and does not have to make sense outside the experimental setting, it can be characterised as an epistemic artefact. This is possible because the epistemic artefact does not stand alone in the context of design research, but will be accompanied with a verbal reflection and discussion.

This is an advantage because the design research can focus solely on the experimental and exploratory aspect of the design practice through the use of materials and technique. It enables the design researcher to ignore the design context, which usually is about the relationship between the artefact and the user. The epistemic artefact is relieved from its usual obligation to fulfil a purpose e.g. of everyday use, such as the purpose of a vase to contain water for flowers. The design research can focus on the overall research question that is to support the ceramic artist to work experimentally and exploratively and express the possibilities within the frame and general suggestions about design practice. In that sense the epistemic artefact, that is the object of the experiment, can be seen as a tool or a means to develop theory in interplay with a verbal reflection and discussion and by that an integral part of the research practice. This turns the design practice in which the design researcher is trained, into a tool for research. This is an advantage. Thus the research becomes relevant and accessible for the target group of design researchers and designers, who are meant to make use of the developed theory in practice. Furthermore, the epistemic artefact does not have to make sense outside the experimental setting. It can be interpreted in the context of several applications, without having served to serve the purposes of an ordinary artefact such as a plate or a cup.

The notion of epistemic artefact encourages a mode of research that involves a series of parallel and interdependent experiments. The answer to the overall research question expressed by theory can be said to be a primary activity, while the production of the epistemic artefact is secondary. It is more important to clarify the overall research question of what can be done and how by interventions and new questions and experiments, than to design an artifact in its own right. This is an advantage. Firstly because it enables the design researcher continuously to put each single experiment into perspective by which the potential is clarified. Secondly and most importantly, because it create solutions based on unpredictable relationships.

## 4. Exemplifications of advantages

I this section I will exemplify the above-mentioned advantages by some experiment of my own.

I will show how one experiment has formed the starting point in the research and how epistemic artefacts can express the possibility of what can be done. Below I will consider how a new solution based on unpredictable relationships was created.

### *4.1 An epistemic artifact*

The first experiment, which formed the starting point, is about the use of “Dynamics” in 3d digital software programs, in this case Real Flow. The aim of the experiment was to explore themes such as capturing transient phenomena and synergy in the interaction between the digital media and traditional techniques with natural materials. Dynamics cover a range of tools in 3d digital graphic software to simulate effects related to reality such as wind, gravity, liquids etc. Instead of capturing transient phenomena from the physical world, the use of Dynamics allows you to simulate the transient phenomena, making it possible to work with physical representations of these. Dynamics is typical used for the film industry and thus animation based. Through the use of Real Flow, I am not bound by the laws of physics and can even freeze a moment in the film sequence at any time, which can be enlarged or made smaller. An attractive point is that it is also possible to have these effects – in this case a collided water surface, which delivers a water splash (figure 3) – produced as a 3D physical model by the use of Rapid Protyping (figure 4).

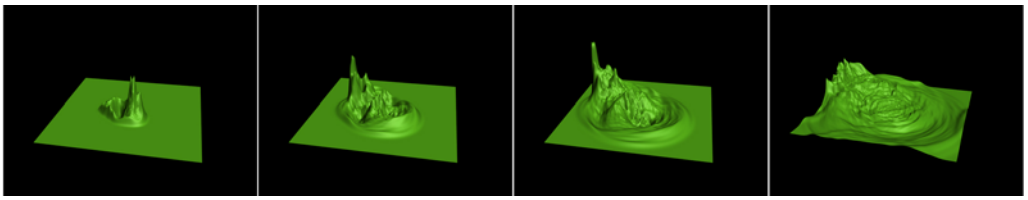

*Figure 3*

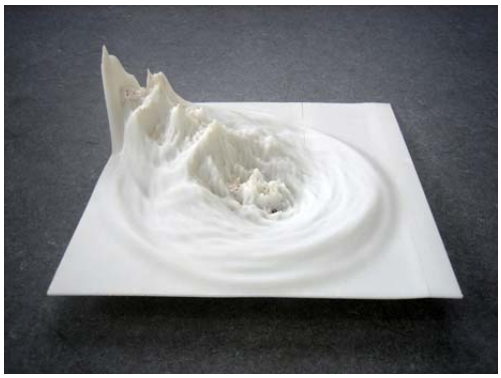

*Figure 4*

*Figure 5*

During the experiments, an artefact was produced in porcelain by the use of a hundred-year-old and refined technique, slip casting. The technique transforms the three-dimensional print figure 4 into plaster (figure 5).

The resulting artifact, which can be seen in figure 6, has a conspicuous, organically growing and detailed formation in the middle, produced by the use of digital media. However it is bounded by a soft curved edge, which was determined by the liquid material, in which it is produced by the traditional techniques.

*Figure 6*

To exemplify how such epistemic artefacts may work in the research context, I will emphasize the possibility for the digital media to paraphrase or to produce a fictitious narrative about the material in which it is embodied and produce what I call a “scale conflict”. At first sight the formation is interpreted as part or result of the creation, but on closer inspection it becomes clear that the formation seen in this context reflects a splash at a scale entirely att odds with the scale of the curved edge. As if the splash was caused by a meteorite impact in a big ocean.

Furthermore the fluid boundary between the liquid material expressed through the material itself and the representation of the liquid material should be emphasized. On one hand we have a narrative about the creation of the artefact expressed through the behaviour of the liquid material in which it is created. This is emphasized by the contour of the artefact, which is a sign of my pouring of liquid material, something which *actually happened in reality*. On the other hand, we have the naturalistic, yet fictitious and very dynamic narrative, expressed in the central formation, which suggest a dramatic event that *never happened in reality*. This narrative relates to a liquid material as such, rather than the actual material in which it was created.

*4.2 Unpredictable relationships*

The experiment has raised some new questions and issues to explore.
Examples of questions are:

1. Since the technique of Rapid Prototyping (RP) is not developed to a satisfactory degree to transform the digital produced form to the ceramic material, this project focuses on the RP-produced models used in combination with traditional techniques. However the use of traditional techniques involves some limitations to the degree of complexity allowed in the 3d model. Can this be improved?

2. The formation developed in Real Flow was not created as a caricature, but with an intention to be a naturalistic representation of a transient phenomenon captured at a dramatic stage. Is it possible to execute such an experiment and achieve similar effects in reality e.g. with physical materials?

The latter question was explored using plaster. Plaster has the quality of a crystallizing process which enables us to capture a movement of the material in a process from fluid to stable. This was explored in several ways including the use of gravity, as shown in figure 7.

*Figure 7*

Since the overall research question in this project is focusing on ceramic, the issue of transformation into the ceramic material is paramount. Apparently by accident I was introduced by Karen Harsbo, associated professor at the School of Architecture in Copenhagen, Fine Art department and head of the Ceramic Lab, to her collaboration with Neil Brownsword, PhD from United Kingdom and their experiments with a mixture of plaster and liquid porcelain. This particular mixture constitutes a material with the quality of plaster as well the quality of a textural ceramic material meant for firing. This material was utilized in the experiments.

Subsequently, I explored the mixed material in relation to the first mentioned question about the limitations of traditional techniques. The material was found very suitable for improving the degree of complexity, when transforming the digitally produced form to the ceramic material, used in traditional techniques with moulds of silicone. This solution is now explored in relation to more complex geometry developed in Real Flow in interplay with the textural quality of the ceramic material gained by firing.

Thus the mixed material which came into existence during another experiment turned out to be a solution to this latter issue based on an unpredictable relationship.

## 5. Conclusion and the role of the artefact as a tool in related fields

In the paper I have shown that the creation of an artefact and the artefact itself in the context of design research can have the sole purpose to be a tool to develop theory in the context of practice-based design research and by that be characterised as an epistemic artefact. Furthermore I have discussed the advantages afforded the design researcher by such “epistemic artefacts” advantages to do with practice, method and communication of the outcome of design research.

The notion of artefacts that serve as a medium to achieve overall objectives is not unique. Parallels can be found in fields such as Participatory Design Approaches whose use of the concept of “Make Tools” (Sanders, 1999) is comparable to the use of “epistemic artefacts” suggested above. Make Tools cover a range of artefacts which serve as a common ground for connecting the thoughts and ideas of people from different disciplines and perspectives, e.g. between designer and consumer. The purpose of Make Tools is to discover as-yet unknown, undefined, and/or unanticipated user or consumer needs. Make Tools can be prefabricated or developed by the participators.

*Quote:Because they are projective, the Make Tools are particularly good in the generative phase of the design development process. Generative research occurs very early in the design development process. Its purpose is to discover as-yet unknown, undefined, and/or unanticipated user or consumer needs. It is in the generative phase that we are looking for ideas and opportunities to fill unmet user needs. Ideas and opportunities generated by users are usually quite relevant and powerful when acted upon and brought to market. (Sanders, 1999)*

Another example is Critical Design named by Dunne and Raby. Critical Design emerges from the field of interaction design, which investigates the way mobile phones, computers and other electronic devices influence people's experience of their environment. Critical Design uses design as a medium to stimulate discussion and debate amongst designers, industry and the public about the social, cultural and ethical implications of emerging technologies.

*Quote: Critical Design is provocative and challenging and asks about what we really need by pushing the cultural and aesthetic potential and role of electronic products to its limit. Its purpose is to stimulate discussion and debate. (Dunne 2001).*

## Acknowledgements

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# Paper 3 //
# A Search for Unpredictable Relationships

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EKSIG, London, Metropolitan University, Great Britain, 19. June 2009 - 19. June 2009.

# A Search for Unpredictable Relationships

**Flemming Tvede Hansen**, The Danish Design School, Copenhagen, Denmark.

## Abstract

This paper explores how design research that includes experimental design practice, can utilize the researcher's background as a practitioner, and make the practice central to the research. The aim of this paper is to make a case that practical experiment in a research context is a fruitful way to produce knowledge that supports the interplay between designer, material and technique in design practice. The research reported in the paper experimentally explores how a ceramist can utilize his approach to designing in the use of 3d digital media as a design tool, and what that use of digital media can add in a qualitative sense in interplay with the ceramic material. The investigation explores themes such as movements and metamorphosis. The paper suggests a method of research that the author has named *Method of Branching Experiments.* Subsequently, the method is exemplified by the author's experiments. The method is characterized by an explorative approach based on own design practice in interplay with techniques and materials, and by relying on a cluster of parallel and interdependent experiments within a defined frame rather than single experiments. The method has shown how new questions derived from an introductory experiment have influenced the process of exploration, by suggesting new parallel experiments. The new questions do not change the direction of the original experiment, but rather clarify and specify it, allowing the process to branch off in a variety of directions, and to be fuelled by spontaneous curiosity. Furthermore the method has shown how the parallel experiments have contributed unpredictable solutions to other experiments. Thus the notion of parallel interdependent experiments can be seen as a dynamic system in which a number of unpredictable and surprising relationships can emerge and be exemplary for what can be done and how, within the context of the original research question.

### Keywords

Research method; design practice; experiments; ceramics; 3d digital media.

## 1. Introduction

As a PhD. student with a background in design practice I have been exploring how design research that includes my own experimental design practice, can utilize the researcher's background as a practitioner and make the practice central to the research. This paper is about how my approach to designing can contribute to my method of research and under what circumstances design practice can be seen as an integral part of design research; a whole rather than two parallel tracks.

The paper reflects an ongoing Ph.D. project about experimental use of 3d digital graphics in the field of ceramics.

### *1.1. Research question and Design Practice as a Tool for Design Research*

My research question is about how as a ceramicist I can utilize my approach to designing in the use of 3d digital media as a design tool; and what, more generally, such a use of digital media can add in a qualitative sense in interplay with the ceramic material. The research question is investigated through practical design experiments with digital media and ceramic material that are

part of the design research and contribute empirical data. The experiments explore how the designer can use themes such as movements and metamorphosis in his work.
Arguably, for this purpose the design process can be divided into three sections: problem identification, design practice and production (see figure 1). Problem identification is about identifying what to design e.g. by a participatory design process (Sanders 2000); design practice is about how to design an artefact or prototype in interplay with techniques and materials; and finally production is about how to distribute the design to the user. Thus my research question is neither about the design process as a whole nor about identification of a user problem or the context of an artefact, but is focussing on the explorative and experimental part of design practice. In this context the design practice is the shaping process; that is, the process by which the artefact emerges as physical form in interplay between designer, techniques and material. Thus I disengage design practice from the design process as a whole (see figure 2), focussing solely on the interplay between designer, material and technique (see figure 3).

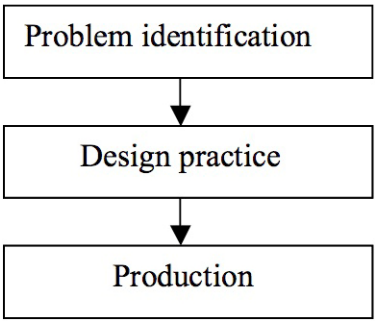


Figure 1

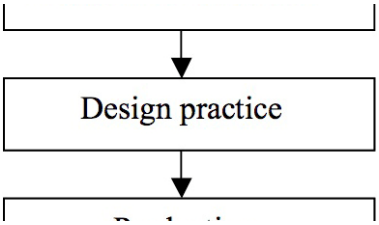


Figure 2

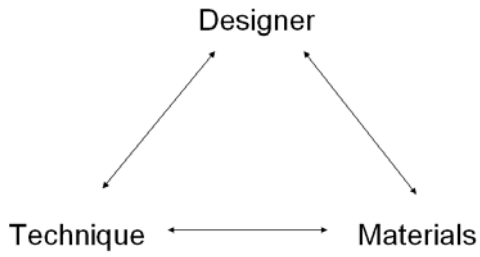


Figure 3

Michael Biggs (2004) has advocated a combined linguistic and non-linguistic research approach, in contrast to an entirely non-linguistic thesis, in so-called practice based design research. Following

his combined approach, the experiments and artefacts to be described do not stand alone in the context of design research, but will always be accompanied with a verbal reflection and discussion. This supports the notion of design practice disengaged from the design process as a whole. The linguistic element will explain the background and provide a basis for communicating the experiment and artefact, as well as the findings about what is possible and how, regarding the research question. This is how, in the present project, design practice is turned into a tool for design research.

## *1.2. Contextualisation in relation to Design Research*

Design research involving the researcher's own experimental design practice can be labelled in many ways; e.g. as practice-based research, design-based research, practice-led research etc. Niedderer and Roworth-Stokes (2007) provide a critical discussion of the existing terminology concerning different roles of practice. They find a way to classify these terms in three categories but state: "Within these categories, terms are often synonymous or denote overlapping phenomena, and some terms span two categories which highlights the difficulty of interpretation and utilisation of such terms in a consistent and rigorous manner." (Niedderer and Roworth-Stokes 2007) However their category "research involving practice" is relevant regarding the research presented in the present paper.

| **Category** (with reference to terms identified) | **Context** | **Purpose** |
|---|---|---|
| **Research involving practice** (practice-based research, studio-based research, practice-centred research, practice-led research, arts-based research, design-based research) | Research process based on or rooted in practice, or where practice plays a lead role in the investigative process<br><br>Interventions/experiments are 'framed' investigate how practice can be enhanced or improved | Research outcomes make a direct contribution to, or are of direct relevance for, the advancement of practice<br><br>Practice informs theory building within research to gain new insights,<br>knowledge or understanding |

Table 1, Excerpt from a model presented by Niedderer and Roworth (2007).

Marchand and Walker (2009) draw on the contribution by Niedderer and Roworth's category "Research involving practice", which they further develop and subdivide into two main approaches. One being more oriented towards the tradition of "applied research" while the other is a counterpart of "fundamental research".

| **Research Components** | **Practice in research oriented towards applied research** | **Practice in research oriented towards fundamental research** |
|---|---|---|
| **Role of artefact** | Regarded as, and represents, an "end" | Regarded as a "means" and a design approach to fundamental knowledge development. |

Table 2, Excerpt from a model presented by Marchand and Walker (2009).

Of particular relevance for the present project is their research component “role of the artefact” (see table 2) “regarded as a ‘means’ and a design approach to fundamental knowledge development”. My field of interest is what I will call an *exploration oriented design process* included in design research; a process focussing on the interplay between designer, techniques and materials. The role of the artefact is to act as a reflecting and responding means for pushing the research process forward to clarify what is possible and how, regarding the research question. A related example of such an approach to research is found at the research cluster *Autonomatic* http://www.autonomatic.org.uk/ at Falmouth College University, which do research that explores the use of digital manufacturing technologies in the creative process of designing and making three dimensional objects. This approach is based on the PhD work of Katie Bunnell (1998) who proposed an open and emergent practice-based methodology for exploring the integration of digital technologies into her practice as a ceramic designer-maker.

As a contrast, consider a *problem oriented design process* included in design research. That is, designing which, although research embedded, nevertheless aims at developing working prototypes or appearance models, just as ordinary professional design. An example is the Ph.D. project by Jonathan Allen discussed by Pedgley and Wormald (2007). The aim of the Jonathan Allen’s research was to advance the design of, and champion new approaches to designing, products for people with severe communication disabilities and physical impairment. During his project, he developed a fully working prototype communication device.

However, in the present paper I shall demonstrate that *exploration oriented design* can be fruitful as a design research method, because it is relieved from the usual obligation to fulfil a purpose of everyday use, solve problems or fulfil certain needs. As we shall see, the exploration oriented design process does not proceed as a series of isolated experiments, but rather as a cluster of parallel and interdependent experiments, which as a whole reflect the potential of the research question. I will argue that this approach turns design practice in which the design researcher is trained into an effective tool for design research.

In the following sections I will explain more thoroughly my method of research *The Method of Branching Experiments* and exemplify the method by a series of parallel and interdependent experiments. Finally I will discuss the method.

# 2. Method of Research: Branching Experiments

As briefly mentioned in the introduction, my approach to design research is explorative, using experiments based on my own design practice in interplay with relevant techniques and materials. The role of the experiments is to contribute empirical data. This overall approach can be seen as “reflection-in-action” (Schön 1983), and is inspired by *action research* which Bruce Archer (1995) has described as:

> Systematic investigation through practical action calculated to devise or test new information, ideas, forms or procedures and to produce communicable knowledge. … the investigator is explicitly taking action in and on the real world in order to devise or test or shed light upon something. … Action Research is pursued through action in and on the real world, in all its complexity, its findings only reliably apply to the place, time, persons and circumstances in which that action took place (Archer 1995).

An experiment executed in the context of design research is rarely seen as a stand alone, but is communicated visually and accompanied verbally by a discussion and reflection. According to Bruce Archer, research is ‘systematic enquiry whose goal is communicable knowledge: Communicable because the findings must be intelligible to, and located within some framework of understanding for, an appropriate audience’ (Archer 1995). Recently, Per Galle defined research as ‘disciplined acquisition of new non-trivial knowledge and documentation of it by means of theory (Galle 2009). Arguably the purpose of an experiment in the context of design research is to

produce knowledge expressed in terms of theory, which is communicable. Thus it is the researcher's responsibility to target and make the theory intelligible to an appropriate audience. Since my research question is about design practice, so as to support it in the best possible way, the primary audience will be colleagues in design research or design practice. Thus it is not the artefact produced in the experiment that is of interest, but rather how it appeared in interplay between designer, material and technique. This relieves the artefact from its usual obligation to fulfil a purpose of everyday use. Hence it is possible to focus solely on the explorative and experimental part of the design practice to explore what is possible, and how. This encourages a mode of research, which offers unpredictable and surprising results. I have explored this by a cluster of parallel and interdependent experiments, as I shall now try to demonstrate.

The method is defined by a frame for carrying out experiments inspired by *Exemplary design research* in the sense of Binder and Redström:

> With the notion of "exemplary design research driven by programs, experiments and interventions", we refer to research based on the explicit formulation of design programs that act as a frame and foundation for carrying out series of design experiments and interventions. It is 'exemplary' in the sense that it enables critical dissemination primarily by creating examples of what could be done and how, i.e. examples that both express the possibilities of the design program as well as more general suggestions about a (change to) design practice (Binder and Redström 2006).

The frame is defined by my research question (section 1.1). One experiment has formed the starting point in the research, which has given rise to new questions and experiments. Subsequently the research has comprised parallel experiments, which influence one another through verbal discussion and reflection. The frame and cluster of parallel and interdependent experiments can be illustrated as in figure 2.

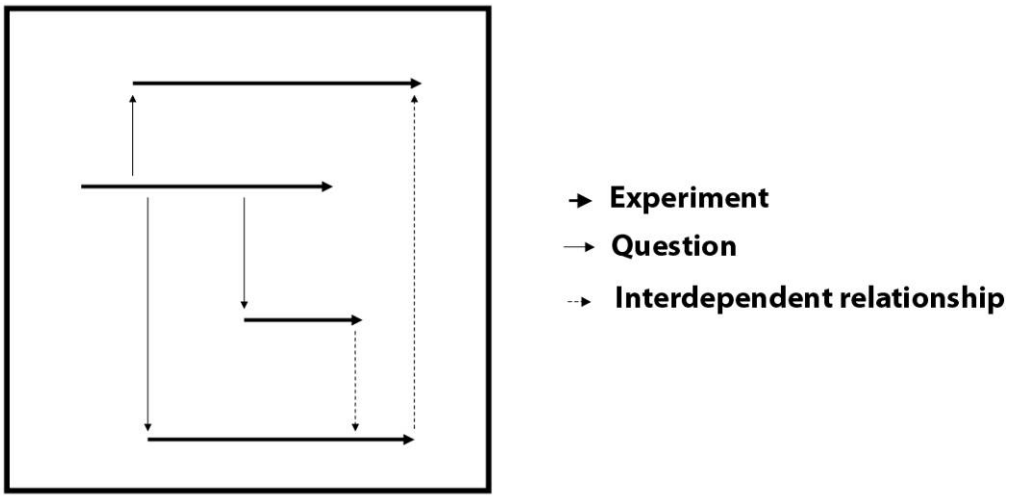


Figure 2, Cluster of parallel and interdependent experiments

It is by this approach, which I have named *The Method of Branching Experiments*, that I have investigated my research question. In the following section I will exemplify the method by describing the particular parallel and interdependent experiments that were undertaken.

# 3. Exemplification

Recall that the research question was about how as a ceramist I can utilize my approach to designing in the use of 3d digital media as a design tool and what such use of digital media can add in a qualitative sense in interplay with the ceramic material. The research question is investigated by experimenting with digital media and ceramic material. The pivotal point for these experiments is as the theme of *movement* and *metamorphosis*. To be able to explain the research method, I shall first consider the traditional approach of a ceramist and then briefly review state-of-the-art use of 3d digital media within the field of ceramics and related fields. After that I shall go into more details about my experiments, to exemplify *Method of Branching Experiments.*

## *3.1. The ceramicist's approach to form*

In the field of ceramics, many approaches are taken to form-finding. The one of interest in this research is to rely on the material as a major source of design ideas. This means the material itself generates form in interplay with the designer. An example of such an approach is the design by the Danish ceramist Anne Tophøj (figure 3).

The pattern of the edges of the plates appeared by centrifuging fluid porcelain from the base. This pattern could never have been realized without the potential of the material to flow and be captured in this way. The material determined the spread of the pattern, and Anne Tophøj exerted her influence by controlling speed and acceleration of the centrifuging process. The pattern of the edges was determined by the interplay between the liquid porcelain, the idea of centrifuging and the intervention by Anne Tophøj (2009). This intervention relies on an explorative and playful approach to design practice regarding material. I have named this approach *material-driven form-finding.*
As a contrast, I can refer to an example of my own, which can be seen in Figure 4.

Figure 3

Figure 4

These plates were realized by three profiles that were initially drawn, then modelled in plaster, and finally executed in ceramic material. The ceramic material did not contribute anything to the form itself, as opposed to the example by Anne Tophøj. The design was simply determined before being executed in ceramic material. I call such an approach *constructional form-finding.* However, it is by an approach such as *material-driven form-finding* that I have chosen to explore the digital media.

## *3.2. State-of-the-art use of 3d digital media*

There are several of examples of explorative and experimental use of digital media operating with themes such as movement and metamorphosis within the field of ceramics. An example is the work by Tavs Jørgensen, who is part of the research cluster at Falmouth College University "Autonomatic" (http://www.autonomatic.org.uk/ ). Tavs Jørgensen has been experimenting with a Microscribe® G2L – a digitizing arm to record a 3d gesture movement by the hand in a 3d virtual space. These data constitute the basis for a 3d digital form, which can be transformed into a

physical model by Rapid Prototyping (RP). RP is a range of techniques for transforming 3d digital form into 3d physical form. Figure 5 shows the recorded gesture movement and the 3d digital form, respectively.

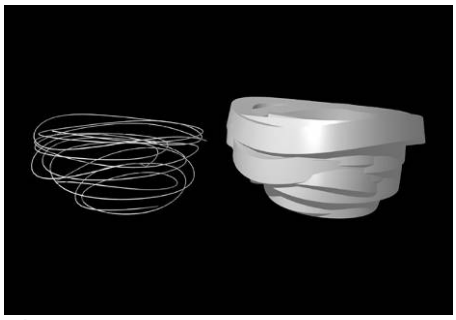
Figure 5

Another example is provided by Geoffey Mann (http://www.mrmann.co.uk ), who has been experimenting with the use of 3d digital software to generate and simulate naturalistic phenomena such as waves on water surfaces. This was then utilized in the design of a coffee cup. The coffee cup was initially designed as a 3d digital form and was subsequently transformed into a physical model by RP and finally executed in ceramic material (figure 6).


Figure 6

In the course of my project, a survey of experimental use and research in the field of 3d digital media was made. It has continuously influenced the exploration of the research question. Examples of such media range from the use of Generative Components by Bentley and primarily used in field of architecture, Interaction design by the use of the programming language Processing to animation based software developed for the film and game industry; e.g. Real Flow. The significance of these influences will be explained while presenting the experiments in the following section.

## *3.3. Experiments*

I will now give a brief chronological presentation of the series of experiments that I have undertaken. Firstly I will present an introductory experiment, which raised new questions, and thus gave rise to new experiments. It had the important role to keep my exploration of the research question on the track. After that, further experiments will be presented and the interdependence among the multiplying experiments will be explained.

The system of experiments, questions and interdependency relationships are visualized in figure 7. The meanings of the labels are given in Table 3.

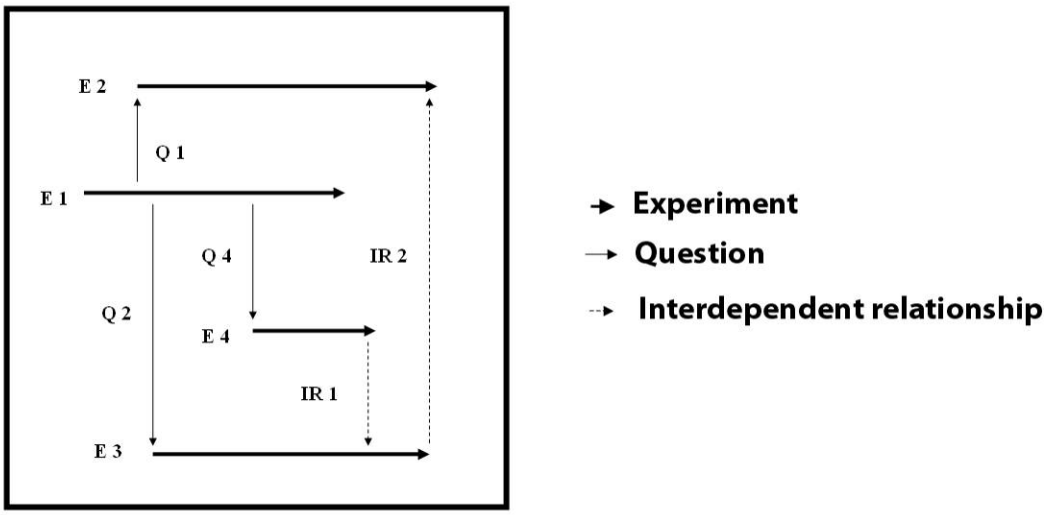


Figure 7

**Table 3. Key to figure 7.**

| | |
|---|---|
| E1 | Dynamics |
| E2 | Interactive Dynamic Design Tool |
| E3 | Silicone moulds and clay plaster mixture |
| E4 | Capturing flowing form |
| Q1 | Is it possible to achieve a higher degree of interaction regarding generative software? This question initiated the experiment: Interactive Dynamic Design Tool. E2. See section 3.3.2 |
| Q2 | Is it possible to improve the degree of complexity in the Rapid Prototyped produced model, when used within traditional techniques? This question initiated the experiment: Silicone moulds and clay plaster mixture. E4. See section 3.3.4 |
| Q3 | How can the digitally produced model contribute in interplay with the ceramic material? This question rather targets the present experiment than initiates a new one. E1. See section 3.3.1 |
| Q4 | Is it possible to capture transient phenomena and achieve similar effects as in reality by the use of e.g. plaster and what is gained by the use of digital media? This question initiated the experiment: Capturing flowing form. E3. See section 3.3.3 |
| IR1 | The mixture of plaster and liquid porcelain used in E4 was found suitable for improving the degree of complexity, when transforming the digitally produced form to the ceramic material, used in traditional techniques with moulds of silicone E3, Q2. |
| IR2 | Complex digitally produced forms carried out by the Interactive Dynamic Design Tool in E2, can be transformed into the ceramic material by moulds of silicone and the mixture of plaster and liquid porcelain (developed in E3, Q2). The mixed material shows potentials as a material for solid models and strong textural qualities gained by firing. |

### 3.3.1. Dynamics (E1)

At a very early stage I developed an interest in using digital media as generative software, as in the work of Geoffrey Mann (figure 6). It seemed quite obvious to investigate such software regarding a material-driven form-finding approach of the kind taken by Anne Tophøj (figure 3). The first experiment, which formed the starting point, is about the use of “Dynamics” in the 3d animations based software program Real Flow. Dynamics cover a range of tools in 3d digital graphic software to simulate effects related to reality such as wind, gravity, liquids etc. Dynamics allows you to simulate these transient phenomena, making it possible to work with physical representations of these. Through the use of Real Flow, I am not bound by the laws of physics and can even freeze a moment in the film sequence at any time. The generative software is very useful as a means to explore the interaction between forces and the physical representation. For example, it is possible to set up an event such as a collided water surface, which delivers a water splash (figure 8).

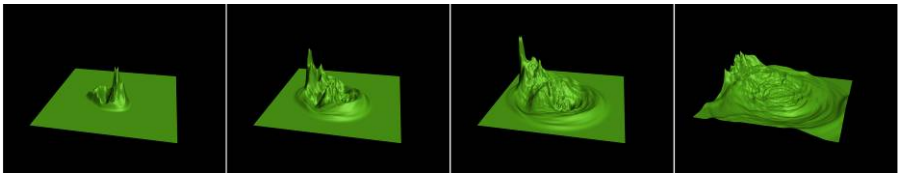

Figure 8

The event simulation in Real Flow is defined in advance with the possibility to change parameters and orientation. However, there is no possibility for the user to interfere while the simulation is executed. This differed from the material-driven form-finding approach and raised my first question (Q1): Is it possible to achieve a higher degree of interaction regarding generative software? This question initiated the experiment: Interactive Dynamic Design Tool; see section 3.3.2. Thus at this stage a new experiment was initiated about a higher degree of interaction regarding generative software, and at the same time a consciousness about a lack of interactivity became evident.

An attractive point using Real Flow is the possibility to have these naturalistic effects – in this case collided water – produced as a 3D physical model by the use of RP (figure 9).

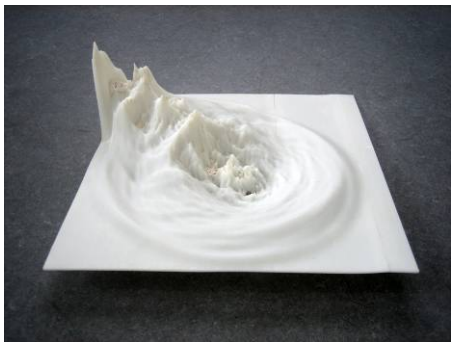

Figure 9

The digitally produced form in Real Flow can become very complex. The technique of RP is not developed to a satisfactory degree to transform the digitally produced form into the ceramic material. Thus this project focuses on the RP-produced models used in combination with traditional techniques. This sets some limitations regarding the degree of complexity allowed in the 3d model. However, this is not a problem in our example in figure 9, but necessitates some considerations and concerns regarding the overall research question. Thus a second question (Q2) was raised: Is it possible to improve the degree of complexity in the RP-produced model, when used within traditional techniques? This question initiated the experiment: Silicone moulds and clay plaster mixture; see section 3.3.4.

Meanwhile, the RP model raises a third question (Q3): How can the digitally produced model contribute in interplay with the ceramic material? This question targets the present experiment, rather than initiating a new one.


Figure 10

An artefact was produced by pouring liquid porcelain onto a plaster mould, which had been made on the basis of the RP model (figure 10). As the liquid material flows across the plaster, the water is drained out of the porcelain, whereby it slowly stiffens in its action and dries. The dry porcelain can subsequently be dismantled from the plaster mould, which now has made an imprint in the porcelain. At this stage of mould making by plaster a fourth question (Q4) emerged: Is it possible to capture transient phenomena and achieve similar effects as in reality by the use of e.g. plaster, and what is gained by the use of digital media? This question initiated the experiment: Capturing flowing form. See chapter 3.3.3.

The resulting artefact can be seen in figure 11. It has an organically growing and detailed formation in the middle (stemming from the 3d print), and a soft curved edge determined by the liquid material, in which it is produced.


Figure 11

The following observation relates to the third question (Q3). (How can the digitally produced model contribute in interplay with the ceramic material by a material-driven form-finding approach?) The formation describes and pictures a phenomenon about liquid. It is naturalistic but fictitious. It has never been a floating liquid itself and refers to a phenomenon that differs from its own creation, similar to the notion of a figure, model etc. On the other hand, the contour of the artefact rather refers to itself and its creation. It simply looks like what it is. It has never been the intention for it to be anything but the flowing porcelain, which has stiffened. Thus the two expressions differ and integrate at the same time. The two expression and thus the two media are interdependent to fulfil such an expression. When contemplating the artefact, we will alternate between fiction and reality and a fluid boundary emerges presented in one and the same thing.

The next three sections follow up on the questions that emerged above.

### 3.3.2. Interactive Dynamic Design Tool (E2)

First question (Q1): Is it possible to achieve a higher degree of interaction regarding generative software?

The experiment with Real Flow showed that I needed interactive software. This led me to other artists and designers experimenting with motion and interactive systems. Such an example is *Untitled 5* by the American-based artist Camille Utterback (http://www.camilleutterback.com). She designed *Untitled 5* as an interactive system, which can be explored by the audience (figure 12).

Figure 12

What is interesting in Camilla Utterback's work is the dynamic, generative and interactive system, which responds fluidly and intriguingly to physical movement. Camille Utterback has, by her aesthetic system, created a framework for various possibilities to occur through the physical relationships between the audience and the projection. The idea of Camille Utterback's work is to be an eternal living system projected onto a two-dimensional surface; it is not a design tool.

Another example is the Swedish based design group *Front* (http://www.frontdesign.se) using Motion Capture (figure 13). *Front* tracks 3d motion by an infrared pen, whose movements are recorded by two cameras and thus generate 3d digital files. The idea is similar to the experiment by Tavs Jorgensen. *Front*'s technique captures movements in 3 dimensions as a tool to define shape, but does not use a dynamic interactive system as in Camille Utterback's work.

Figure 13

I saw a combination of these two examples as a good basis for a 3d digital design approach, which led me to a cooperation with the programmer and designer *Marcin Ignac* (http://www.vorg.pl/ ). Together we have developed what I have called an *Interactive Dynamic Design Tool.* We made use of Marcin Ignac's skills for programming in the programming language *Processing* and the use of a *wii* remote as a device to capture the 3d motions. By the *wii* remote the movement of the hand is tracked in a 3d virtual space (figure 14).


Figure 14

A dynamic and generative system is defined by emerging 3d geometries, which respond to speed. The size of geometry and the distance between the geometries reflects the speed of the movement of the hand with the *wii* remote (figure 15).

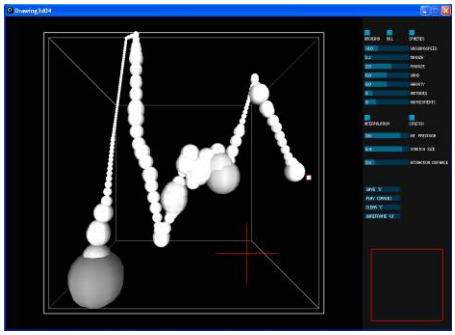
Figure 15

Furthermore the emerging geometries can either increase or decrease and be affected by the following movements of the hand by being repelled or attracted. The geometries provide a trace of the movement in the interactive dynamic system, which may be captured at any time. The captured movement forms the basis for a 3D physical model produced by the use of RP (figure 16), which express the captured movement in physical form.


Figure 16

The constellation of a programmer and designer has been constructive. The programmer is the specialist in the "material" of computer software, and I as the designer have had the notion of a digital design tool based on the idea of material-driven form-finding. It is obvious in this cooperation that creative thinking relies on the dynamic system, rather than the particular artefact.

The next step is to test the Interactive Dynamic Design Tool in cooperation with an artist from the field of ceramics and related fields for further development.

### 3.3.3. Capturing flowing form (E4)

Fourth question (Q4): Is it possible to capture transient phenomena and achieve similar effects as in reality by the use of e.g. plaster and what is gained by the use of digital media?

Plaster has the quality of a crystallizing process, which enables us to capture a movement of the material in a process from fluid to stable. This was explored in several ways; e.g. using gravity and blasts of compressed air, as shown in figures 17 and 18 respectively.

Figure 17

Figure 18

The transformation of a ceramic material, which can subsequently be fired, is of paramount importance to this research. Plaster is not such a material. But by accident I was introduced to Karen Harsbo, associate professor at the School of Architecture in Copenhagen, Fine Art department and head of the Ceramic Lab, and her collaboration with Neil Brownsword, PhD from United Kingdom. As it turned out, they experiment with a mixture of plaster and liquid porcelain. This particular mixture constitutes a material with the quality of plaster as well the quality of a textural ceramic material meant for firing. This mixture was utilized in the experiment.

The mixture of plaster and liquid porcelain showed great potentials for capturing form in motion, which could be further developed, but most importantly regarding this research, the experiment put the use of dynamics into perspective. On one hand dynamics showed a potential to capture transient phenomena in a way which could be exactly controlled and even beyond the laws of physics, and furthermore a potential in an interplay with traditional techniques and materials. On the other hand, the experiment drew my attention to the lack of playfulness caused by the lack of interactivity found in the use of dynamics.

Another important and unpredictable outcome from this experiment was the idea of this mixture of plaster and liquid porcelain used in relation to the second question (Q2) in section 3.3.1, which the following section is about.

### 3.3.4. Silicone moulds and clay plaster mixture (E3)

Second question (Q2): Is it possible to improve the degree of complexity in the RP-produced model, when used within traditional techniques?

The mixture based on plaster and liquid porcelain mentioned in the previous section has shown a potential for improving the degree of complexity when transforming the RP-produced model into the ceramic material. An imprint of the RP-produced model by silicone can make the basis for the transformation. The mould of silicone is much more flexible than the traditional mould made from plaster. The mixture can be poured into the mould of silicone and can be fired after being disengaged from the mould. Complex digitally produced forms carried out by the Interactive Dynamic Design Tool, are now being explored for the potential to be transformed into the ceramic

material. The mixed material has potential as a material for solid models and strong textural qualities gained by firing. Figure 14 shows such a test piece (left) and its silicone mould (right).

Figure 14

This experiment (E3) was based on the findings in the experiment: “Capturing flowing form” (E4) and thus an unpredictable interdependent relationship (IR1). The outcome from this experiment (E3) will subsequently support the experiment: Interactive Dynamic Design Tool (E2) transforming the RP produced model into ceramics and thus a second unpredictable interdependent relationship (IR2). These unpredictable relationships serve as examples for how interdependent parallel experiments are able to generate unpredictable and surprising results. Thus the *Method of Branching Experiments* is useful for the design researcher to generate new knowledge to support the designer in design practice.

# 4. Concluding Remarks

In this paper I have introduced my method of research, which I have named the *Method of Branching Experiments*. The method has shown a potential to produce knowledge that supports design practice regarding the interplay between designer, techniques and material. The method is characterized by an explorative and experimental approach based on the researcher’s own design practice in interplay with techniques and materials relevant for the research, and by parallel interdependent experiments. The experiments have shown how new questions derived from an introductory experiment influenced the process of exploration, by suggesting further experiments. The new questions did not change the direction of the original experiment, but rather clarified and specified it, allowing the process to branch off in a variety of directions, and to be fuelled by spontaneous curiosity. Furthermore I have shown how the parallel experiments have contributed unpredictable solutions to other experiments. Thus the notion of parallel interdependent experiments within a defined frame can be seen as a dynamic system in which a number of unpredictable and surprising relationships can emerge and be exemplary for what can be done and how, within the context of the original research question.

As we have seen, the method utilizes design practice and the artefact as a means especially for design research. This is in a way that differs from the usual obligation of design to fulfil a purpose of everyday use, solve problems or fulfil certain needs. The strength of the method was found to lie in its capacity for producing unpredictable and explorative situations that stimulate the researcher’s search for new knowledge. The main weakness and danger of the method is that it may render the experiment, artefact and discussion too abstract and thus incomprehensible, inaccessible or irrelevant for the intended audience, thereby making the knowledge it generates useless.

As a measure against this potential problem this research included collaboration with other designers. Selected designers are introduced to the research and invited to explore the obtained results in collaboration. Thus the relevance and usefulness of the results are evaluated currently, through the interaction with designers, traditional design practice and production of artefacts such

as jewellery and tableware. Yet the process of research itself is secluded from such collaboration, and remains a practice in its own right, subject to its own criteria of quality.

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# Paper 4 //
# Capturing movements in a 3d interactive dynamic system

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Conference: Engaging artefacts, Nordes, Oslo, Norway, 30. August 2009 - 1. September 2009.

# CAPTURING MOVEMENTS IN A 3D INTERACTIVE DYNAMIC SYSTEM

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This paper discuss 3d digital dynamic systems as an interactive design tool for 3d physical form as an approach to the design process useful for the ceramic artist and related fields. The paper is about an experiment based on the cooperation between the programmer and designer Marcin Ignac, and the author of this paper, a ceramic artist. The experiment explores interactive 3d digital drawing, which responds visually to the movement of the hand in a virtual 3d space using a wii remote as a device. The captured movement forms the basis for a 3D physical model produced by the use of Rapid Protyping, which express the captured movement in physical form.

## INTRODUCTION

This paper reflects an ongoing Ph.D. project titled "Experimental use of digital media within the field of ceramics", which comprises own experimental design practice by the author. The paper is presenting one of these experiments.
The overall research question is about how 3d designing by digital media can take advantage of the approach a ceramic artist has to designing. The approach to designing is in this case based on the interaction between designer and material as a generative component. In the field of ceramics this generative potential is found in materials such as clay and plaster etc. and laws of physics. Such an approach is not defined by a field such as ceramics, but is rather an approach to the design process as such, which is found in related fields such as textile design, furniture design etc. The aim of the research is to explore 3d digital media as a tool, which makes it possible to invent and design such generative potentials. This can enable such a designer to focus on a phenomenon as such without being bound to a material and the laws of physics. This paper will focus on how the designer is supported to work experimentally, exploring themes such as movement, transience and metamorphosis by the use of digital media.
The paper is about an experiment based on the cooperation between the programmer and designer Marcin Ignac (http://www.vorg.pl/ ), and the author of this paper, a ceramic artist. The experiment explores interactive 3d digital drawing software, which responds visually to the movement of the hand in a virtual 3d space using a wii remote as a device.
The project focuses on 3d design, more specifically 3d digital graphics and Rapid Prototyping (RP).
Furthermore the study is focussing in the experimental stage of sketching - more precisely the stage, when form appears as physical form. In that sense the project does not operate with practical functional solutions and user centred problem identification.

## METHOD

In this research it is relevant to use the term ”research through design” (Frayling 1993), which for our purpose can be defined as an experimental design practice that is part of the design research and contributes empirical data. The method is explorative and experimental, which in this study means that the research questions and empirical series of experiments are produced and developed in the process of research. This approach can be seen as a “reflection in practice” similar to Schön ideas (Schön 1983). The method begins with a definition of a frame for carrying out experiments, which is defined by the overall research question. This approach is inspired by Binder and Redström’s notion of ‘exemplary design research’:

*With the notion of “exemplary design research driven by programs, experiments and interventions”, we refer to research based on the explicit formulation of design programs that act as a frame and foundation for carrying out series of design experiments and interventions. It is ‘exemplary’ in the sense that it enables critical dissemination primarily by creating examples of what could be done and how, i.e. examples that both express the possibilities of the design program as well as more general suggestions about a (change to) design practice. (Binder and Redström 2006)*

The intention with this paper is to give an insight into one of these experiments in this frame and the potential it may exhibit.

## ON THE PROPERTIES OF CLAY

The role of the material and the approach to the design process can be very different in the field of ceramics. In this experiment the material is the pivotal point for the design process, which means the material itself generates form in interplay with the designer. An example of such an approach is the design by the Danish ceramist Anne Tophøj (figure 3).

The pattern of the edges at the plates has appeared by centrifuging fluid porcelain. It has been possible to intervene and control the way the dynamic pattern emerged based on parameters such as changing speed over time. Thus the design has appeared in interplay between the property of clay and the idea using centrifuged porcelain to design a pattern by Anne Tophøj (2009). This interplay in the design process can for this purpose be named *material driven form finding*.

The pattern of the edge is based on the basic structure of liquid clay, which can appear in a vast number of unpredictable and surprising versions depending on the values assigned to the parameters.

Figure 3

Sanford Kvinter (2002) describes a dynamic and uncertain process that links a virtual component to an actual one. The actual component expresses a variation of the virtual component. To exemplify such a relationship Sanford Kvinter refers to the Kymatic images by Hans Jenny. These images are generated by sinus tones emitted across steel plates covered by a mixture of sand and superfine lycopodium powder. The mixture is transported by the sinus tones into a pattern. The sinus tones and the steel plates make up the virtual component and the mixture makes up the actual component.

In a similar way the originality of the design by Anne Tophøj can be described as a process in two levels, forming a whole. Firstly to discover and identity a potential of a material, in this example the dynamic potential of the liquid porcelain to create patterns when centrifuged – this can be named *first level of material driven form finding*, and secondly to transform and actualize this potential within the framework established in a number of versions –this can be named *second level of material driven form finding.*

A potential of *material driven form finding* as described above is not based on predictability, but rather on unpredictable results generated by interventions in a dynamic potential in a material. This is not an approach which is specified for a particular material, but is rather a design methodology and approach that can be transferred to other fields. It is by this approach to the design process - material as a generative and responding component - that this research explores the digital media in relation to phenomena such as movement and metamorphosis.

## A 3D DIGITAL INTERACTIVE DESIGN TOOL

The example by Anne Tophøj showed a need for interactive software. This led the research to other artists and designers experimenting with motion and interactive systems. Such an example is Untitled 5 by the American-based artist Camilla Utterback, who has designed an interactive system, which can be explored by the audience, *Figure 7.*

*Untitled 5 is the fifth interactive installation in the External Measures Series, which Utterback has been developing since 2001. The goal of these works is to create an aesthetic system which responds fluidly and intriguingly to physical movement in the exhibit space. The installations respond to their environment via input from an overhead video camera. Custom video tracking and drawing software outputs a changing wall projection in response to the activities in the space. The existence, positions, and behaviours of various parts of the projected image depend entirely on people's presence and movement in the exhibit area. (Camille Utterback 2004)*

Another example is the Swedish based design group Front using Motion Capture, Figure 8.

*Motion Capture is a technique that translates motions into 3D-files. Motion capture is mostly used for animations in movies and computer games. Front have used the technique to simply record the tip of a pen when they draw pieces of furniture in the air. (Front 2006)*

Figure 7

The combination of operating in three dimensions, while being able to interact with a dynamic and efficient generating system formed the basis for an experiment and the notion of a 3d digital interactive design tool.

This was executed in cooperation with the programmer and designer Marcin Ignac. The experiment made use of the programming language *Processing* and a *wii* remote as a device to capture the 3d motions. By the wii remote the movement of the hand is tracked in a 3d virtual space, Figure 9.

Figure 8

Figure 9

The dynamic and generative system is defined by emerging 3d geometries which respond to speed. The size of geometry and the distance between the geometries reflects the speed of the movement of the hand with the *wii* remote, see figure 10. Furthermore the emerged geometries can either increase or decrease and be affected by the following movements of the hand by being repelled or attracted. The emerged geometries provide a trace of the movement in the interactive dynamic system, which may be captured at any time. The captured movement forms the basis for a 3D physical model produced by the use of Rapid Protyping, figure 11, which express the captured movement in physical form.

The cooperation about the 3d digital interactive design tool was a constructive and continuous dialogue between the programmer and the designer developing the dynamic system. This development occurred in an interaction with actualized 3d artefacts to reflect on and improve the potential of the dynamic system.

The experiment constitutes *material driven form*

*finding*, and a parallel to Anne Tophøj's approach can be drawn. The development of the designed dynamic system and Anne Tophøj's "discovery" of the potential of the liquid material are both examples of what was termed *first level material driven form finding* and the captured movements in the dynamic system expressed in physical form and Anne Tophøj's patterns of the edges at the plates are both examples of what was termed *second level material driven form finding*.

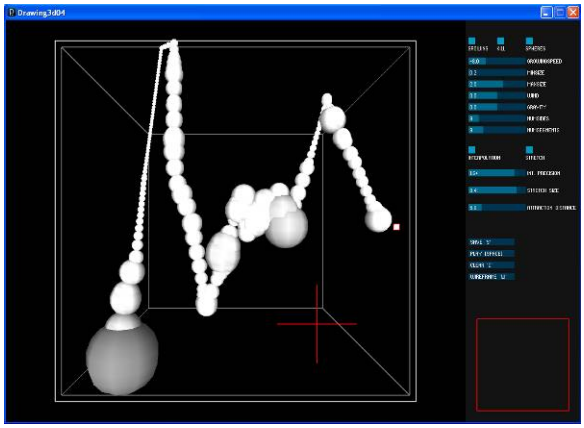

figure 10

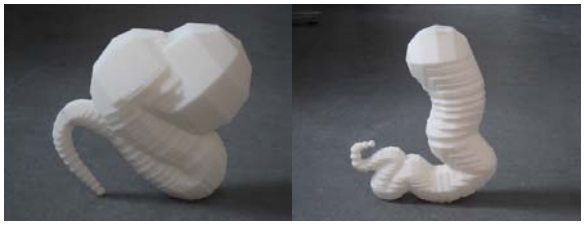

figure 11

## CONCLUSION

This paper has described an approach to the design process named *material driven form finding* practised in the field of ceramics and related fields. This approach is characterized by two levels; a *first level* which is to identify a dynamic and generative potential in a material, and a *second level* which is to transform and actualize this potential in a representative number of artefacts by interacting with the generative potential in the material.

This approach was explored in an experiment using 3d digital media in collaboration with the programmer and designer Marcin Ignac. The experiment was argued to be similar in nature to *material driven form finding*.

It is obvious in an approach such as *material driven form finding* that creative thinking relies on the condition of the form finding, that is *first level material driven form findings*, rather than the particular artefact.

In the field of ceramics, the ceramicist is used to identify such generative potentials to explore specifically in the ceramic material. It requires a thorough knowledge and critical awareness of the material to identify such a generative system and subsequently to transform and realize it in a particular context.

In the experiment using digital media the constellation of a programmer and designer was found constructive. The programmer is the specialist in the "material" that is programming and the designer is the specialist within the context of which the digital material should be transformed and developed. The experiment showed a great potential not only to identify, but rather invent and design generative and responding systems to explore in the *first level material driven form finding.* This enabled an exploration which was not bound to a material and by laws of physics, but rather explored a phenomena as such.

The experiment was successful, but limited to a visual responding system and asks for further exploration. Generative and responding systems for 3d form embedding tactility as well could be a topic relevant to explore in an interdisciplinary collaboration with designers and programmers.

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