INTERNATIONAL DESIGN CONFERENCE - DESIGN 2006
Dubrovnik - Croatia, May 15 - 18, 2006.

DESIGN 2006

EXPERIENCING ENGINEERING DESIGN

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Keywords: anthropology, ontology, methodology, experience

1. Introduction

At the *department of engineering design and materials* at NTNU, they realized (in 1999) that the training they were offering their students of product design was not adequate. Specifically, their students were not able to adjust well to the change of settings from that of a study situation to that of the "real world". They wanted to change this. They wanted instead to become the best. In order to make this change they first had to find out what they were doing wrong and what they should be doing instead. An interdisciplinary research program was launched, that was hoping to discover this. The research project focused on a specific problem that design teams have, both in study situations and in real life; that they have to collaborate. Collaboration can be challenging enough, but to make things even more ambitious they decided to find out if and how collaboration can be done when teams and participants are separated by geographical distance.

In 2002 I started to work as an anthropologist in this research project at the *department of engineering design and materials* at NTNU. This was highly educational, and I ended up writing a masters thesis in anthropology from this project. In this paper I offer an anthropological view on what happened when very different research traditions met and created a new research praxis.

I was introduced to this multidisciplinary project at a conference at NTNU, when engineer Kjetil Kristensen and anthropologist Håkon Fyhn presented two aspects of Action Learning (the project's name at that time). Two things struck me as they where presenting: (1) the anthropologist represented familiar topics in an unfamiliar way, and (2) I could understand the engineer. Later I learned that this was a result of a learning environment that included both action and reflection, and a multidisciplinary research method that was not based on a common denominator, but rather founded on the differences of the disciplines. Difference has the seemingly paradox nature of implicating sameness, and the differences of perspectives was joined in a common goal of understanding collaboration over a distance.

One of the first things that struck me, or rather startled me when meeting and collaborating with engineers was their ability and willingness to act. As an anthropologist I am trained to describe and understand, but not to do anything about it. So when I experienced that my contributions not only got implemented but also had consequences, I was both shocked of and startled by the difference of doing research. To appreciate the importance of this difference, we will look at scientific forms of inference.

In this paper I argue is that the difference was a result of completely different ontological foundations, and that the project's ontology was based on experience. Furthermore we will see that this ontological foundation is not immanent in anthropology or engineering, but in the whole act of this specific research project's praxis.

2. Multidiscipline and reasoning

One of my contributions to the research project was that I interviewed both engineers and social scientists. A mutual feature were that everyone was surprised about the others' way of doing research.

Like me, the other social scientists emphasized their surprise about *having to do something*, while the engineer Hildre told that he was shocked when he found that anthropologists considered their research finished when engineers started theirs:

> It was a real shock to find that when the anthropologists clap their hands and say "ah – we're finished, we have done all there is to be done" then we – the engineers – have just started something […] if we are to communicate and talk reasonably to each other we need to understand this, because engineers don't look for problems, only solutions.
> Hans Petter Hildre 2002 (My translation)

The project's framework implies that knowledge must be used for something; changes based on evaluation. But the framework also implies abductive learning. To learn through participation is to learn from experience and involvement in what you want to know about. As stated, this is immanent in engineering praxis, but not in the engineering research, something that can lead to significant errors.
Some questions and hypothesis was formulated at the very beginning of the project. One was based on the information that creative groups use *more new nouns* than groups that are less creative. The engineers of the group got excited and found out that it was possible create a machine that automatically counted any time a new noun was used in a group. This way, the idea was that by using this creativity-counting-machine, the group could find an answer to the question: *How creative is the student group?*
This machine was never developed, not because it couldn't be created, but because *the question was wrong*.
This was a very important realization, and changed the research praxis of the project. The focus changed from verifying to understanding. This is not a change from hypothetical deduction to abductive inference, but a change to abductive learning in the hypothetical deduction. Or in other words: to learn from experience.
For the product designer the end result, or *answer*, is always the design, or the object. If the answer is an object, this may lead to presuppositions about the question. John Dewey (1980) speaks of experience as both *doing* and *undergoing*. In other words experience is both something you do and something that happens (to you). These two aspects are of course interdependent, thus in order to understand experience, such as creativity, one has to understand the question in terms of both these aspects. Accordingly it is not sufficient to ask the question "what do creative teams do?" (i.e. use new nouns) one has to ask a question such as "what happens in creative teams?" as well.

2.1 Action research

When I started working at the department, I had just come home from a somewhat troublesome fieldwork on Bali, with *what war is good for* as my project working title. My project was defined by my complete lack of understanding violence. I could not understand why and how people could kill, and I wanted to find out why. I ended up experiencing some very violent and significant episodes. And I could rationally understand some of the killings. But when I came home I found it difficult to write about the episodes, about my informants and why they killed. I had a very unpleasant feeling of reducing my informants into variables in some model when I should understand and explain their actions. I felt that I didn't lie, but still I didn't tell the truth. I understood it was the classic anthropological question: *how can I say anything about what happens the other?*
My job can also be seen as a fieldwork, I ended up writing my master thesis based on experiences from my work. In this project, anthropology was an important element in *action research*. And after some time I understood that in this project and within this way of *being an anthropologist* the question *how can I say anything about the other?* was an impossibility. At the same time I experienced that my anthropological praxis was given significance by being an important element of a greater whole. After some time I realized that the praxis of my first fieldwork was done in object based ontology, while the praxis in the multidisciplinary project was based on ontology of experience.
I had to learn the research praxis, to act and reflect in a way that was meaningful for the rest of the project participants. At this time, in autumn of 2002, there were three engineers, two anthropologists and one media scientist working as researchers. I anticipated that I would speak the same language as the anthropologist and media scientist, and that I would have a hard time understanding and

collaborating with the engineers. But this was not the case; starting in the project I did not have to adjust to some parts of it, but rather learn how to be a part of the whole.
When I started interacting and working it was clear that it was a lot to adjust to if I was to collaborate in the project. Personally I had to struggle to learn to *use* my anthropological knowledge. The project had, and still has an action oriented superior goal: to learn how to collaborate over a distance. This implies that all perspectives and knowledge where meaningful only if they could correct or initiate changes. As an anthropologist this was difficult to understand, accept and to do.

2.2 Research frames

The project has changed in many and important ways through the years. But there has been a very concrete and permanent framework for the research. *Action learning* is the project's method, *how* the research is done. The classroom laboratory is *where*, and to find out how to collaborate over a distance is *why* the research is done.
Action learning is how the research is organized and carried out, strongly influenced by action research. Traditionally action research is carried out by a researcher that gets involved with a company where she develops hypotheses for changes that can reform the company. Furthermore the researcher is responsible for initiating and evaluating these reforms (Finset 1973). Jean McNiff points out that action research is a learning process:

> Action research involves learning in and through action and reflection, and it is conducted in a variety of contexts, including the social and caring sciences, education, organization and administration studies, and management. Because action research is always to do with learning, and learning is to do with education and growth, many people regard it as a form of educational research.
> (McNiff 2002, s15)

The reason why the project's method was action learning was to further emphasize the educational and learning aspects of the process. Industrial challenges are taken into the classroom. This way, students and researchers learn about these challenges in the *classroom laboratory*.
The reasons for the classroom laboratory are:

- Heavy instrumentation is easier in a laboratory, and it allows a systematic evaluation.
- Each semester, a new study with relatively identical starting point can be conducted.
- Radical changes can be introduced without great consequences if there are failures (low risk).
- It allows for an insulation of effects in detailed tests.
- A great number of studies can be conducted throughout the world and be compared.
- A base of knowledge for learning in product designing can systematically be developed.
- It is cheaper than using employees from the industry (Hildre et. al 2001: 6, my translation)

To learn *how to collaborate over a distance* is the objective of the research. The externally addressed reasoning behind this objective is the global development toward more and larger multinational organizations, the possibilities of new technology and the lack of methodological research. But another important goal was to teach relevant engineering in a rapidly changing world by linking the industry and teaching challenges.
Within this framework the multidisciplinary project worked within a context that made the project as a whole larger than the sum of parts. The challenges were formulated with experiences from the industry, the answers formulated after experiencing trials and errors in the classroom laboratory together with the students and implementation in a learning process with industry, business and the public sector.

2.3 Abduktive inference

The method used in the classroom laboratory is described as combining hermeneutic and hypothetical deduction (Hildre et. al 2001). Clifford Geertz explains hermeneutics as an interpretive method where a part of a system is understood by the whole of its system and vice versa. This is also known as the hermeneutic circle, where ones knowledge spirals to higher and higher levels of understanding by changing perspectives between part and whole (Geertz 1972).

In modern science, deduction is often understood as one out of two scientific forms of science, the second one then being induction. But Charles Peirce shows as early as 1877 that abductive reasoning is a primary inference, preceding both induction and deduction (Peirce 1877). Abductive inference seems to be the most evident reasoning in engineering praxis, but rather neglected in research.
Peirce uses a famous syllogism to explain the differences between deductive, inductive and abduktive inference. The setting is that someone coming in to a room, and they see some sacks of beans standing by the walls. On a table, they find some white beans outside of their sack. After a short examination they find that one sack only contains white beans. In this situation we can give these syllogisms:

Deductive:	Premise:	All the beans in the sack are white	True
	Premise:	The beans on the table are from this sack	Possible
	Conclusion:	The beans on the table are white	True
Inductive:	Premise:	The beans on the table are from the sack	Possible
	Premise:	The beans on the table are white	True
	Conclusion:	All the beans in this sack is white	”true”
Abduktive:	Premise:	All the beans in the sack are white	True
	Premise:	The beans on the table are white	True
	Conclusion:	The beans on the table are from the sack	Possible

Comparing these syllogisms we see that the abductive reasoning is the one that formulates the hypothesis that are more or less verified by deductive and inductive reasoning. This is the logic behind the researchers' questions, a subliminal constant cognition. Bonfantini & Proni (1988) separate between (1) the automatic or semi automatic abductive reasoning, (2) those that are based in references and (3) the created ones. The latter an active and creative process, while the first two are kind of passive and psychological (Ibid). Here abductive reasoning refers to the inference from one case to that which best explains the case. Generalized and simplified we can say that anthropology is a process that leads to a hypothesis (abductive reasoning), which is the starting point of engineering, a process from the hypothesis and in to action (hypothetical deduction).
So, in my *experience*, what we *did* in "Action learning" was what each of us did best depending on our backgrounds, and what *happened* was that we came to realize that our knowledge was a part of the greater knowledge process, which is basically and ultimately rooted in experience. In the hermeneutical spiral of knowledge we each had our strengths at different parts of the spiral, so when the anthropologists clapped their hands and claimed that all had been done, the engineers took over and swung the group's knowledge another round, and so on. And as a whole, knowledge had to be seen as a process of experience.
Ultimately this implies an ontological change in the research praxis, from an object oriented to experience oriented ontology.

3. Conclusion

What is the difference between object oriented and experience oriented ontology? The question is interlinked with the question of what is primary real, objects or experience. Descartes had to start with the thought to have trustworthy knowledge, he could doubt everything but his thought (cogito ergo sum), which was the point of departure for his philosophy. Thought was the primary side of the duality between mind and matter, matter the secondary. Later this has changed, and the common way of looking at reality, is that the matter (the objects) are primary and effect the mind so the mind only have representations of the matter (Fyhn 2005).
The ontological can not be separated from epistemology. In other words: what we know (ontology) can not be separated from how we know (epistemology), and if our experience is a representation of

the object we cannot know if our experience is trustworthy. This is a classic scientific problem, because how can we say something about reality if we only experience a mediated representation?
The dualism between mind and matter in object oriented ontology has lead to great self reflexive theorization in anthropology. Specifically, through the post-modern era of the eighties, the great questions about knowledge of the world were in focus. How can we trust our experiences when they are only representations of reality? Eriksen and Nilsen (2002) show that this question has been important since the origin of the anthropological discipline, how can a western anthropologist say something about how non-westerns think?
As mentioned I was surprised to notice that there was no relevance in asking if I could know anything when I started in the research project. I understood that the reason was the nature of the research question, which was to understand something together with the students, not to understand the students themselves. The objective then was to learn through my experiences together with the students, abductive inference.
The experience oriented ontology was not immanent in either the engineering or anthropological way of doing research prior to the multi disciplined project. That is to say it was not inherent in what they *do*. But this way of doing and thinking research grew out of the meetings of disciplines and persons. It grew out of what *happened*. The engineers of the project learned to include the abductive inference, while the anthropologists learned to act according to their experiences, and that a whole is something greater than the sum of parts.

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