

A REFERENCE MODEL FOR USING VISUALIZATION WITHIN PRODUCT REALIZATION PROJECTS

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ABSTRACT

There is a need to develop and implement new innovative methods and models that will support and strengthen SMEs (Small and Medium sized Enterprises) to generate new ideas and realize these into successful products and improved processes. The use of visualization (in the early stages) in the innovation process is the focus in this research. The current understanding of the situation within visualization for innovation is that it is important to use visualization but few have a developed approach in how. However there are some examples in how visualization is an active part within the innovation process. IDEO and Decathlon are examples of companies that use visualization in a strategic and structured way. This paper presents a reference model on how visualization can be used within an innovation process. The model will look in to the existing situation, and highlight the problem that is relevant in this research topic. The model will also point out the factors that are most suitable to take in to consideration when improving the situation.

Keywords: Visualization, Product development, Innovation, Design, Product realization

1 INTRODUCTION

In a world where global competition is a fact and the successful release of new products and services is dependent on time-to-market and timing. The focus is to develop products in shorter time then the competitors and with the same quality, performance, and functionality. To do so it needs research within specific activities as Eckert and Clarkson [1] explain, “over the past 20 years design research has focused on methods for delivering more efficient processes and support tools for design.” And goes on, “the current challenge to the design research community is to provide designers with a wider range of methods and tools to support specific activities within the design process and to improve its overall co-ordination.” These activities needs support systems and communication systems to be easy to handle and work with.

To fully understand the importance for companies to conduct an innovative approach towards NPD (new product development) one need to explore the use of different methods used in the process. According to Utterback et.al [2] “Swedish design firms claim that they follow processes that are mostly standard and linear: some firms use specific tools and metrics. (In reality processes are not always linear, but there is a feeling that clients wish to see understandable logic.)”.

In this research there is a focus on SMEs with in-house design engineers, design firms, inventors and innovation advisors. The reason for choosing SMEs are mainly the fact that they stand for over 90% of the companies in the world and they need to be more competitive. The other is chosen because they are likely to cooperate with these SMEs and it would be interesting to know about their references in the use of visualization.

The design process is a model for the application of design in product development. It is part of the company's entire development process and is used to achieve successful, creative results through the medium of design skills and know-how. The design process can be applied to many different areas and projects that concern processes, messages, goods, services, or environments. One problem in communicating this model is the complexity of the iterative process that characterizes the design process. However, that is partly solved by design firms by communicating the linear stage-gate-model to their customers, but applying an iterative process when designing the solution.

This approach is used by design firms but much of a company's NPD is carried out by in house design engineers. These designers are fully aware of the processes needed and the methods used but they are in a completely different context then consultants within design. A design consult often gets there

verbal brief and then goes “home” to do some work often they come back with a visual brief and this back and forth continues through the project, while in house design engineers tend to work with the design brief along with the development of the solution. And the brief are often not taken in to serious in the work.

By clarifying and exemplify the problems that exist in the current situation and identify those factors that are most suitable to improve the situation a reference model for the use of visualization in the NPD was created. By clarifying the relationship between different parts of the design process and the implementation of it in development projects the importance of the research area was demonstrated both practical in industry as well as theoretically.

A clear description of the factors that are important in the visualization of the NPD and the gaps identified in the SME leads to the development of new methodology for visualization of the NPD.

2 METHODS USED

This paper is based on semi structured interviews, action research, and literature studies, along with observations in projects that have been conducted using the idPeo model. The purpose of this has been to try existing theories and to explore the use of visualization within innovation projects.

Yin presents six data sources for case studies: documents, archival records, interviews, direct observation, participating observation and physical artifacts [3]. The empirical data collected in the case studies and presented in this thesis has been collected through documents, interviews, observations and participatory observations.

According to Yin, interviews are one of the most important data sources in case studies [3]. When looking into a system that depends on people's opinions and decisions interviews with key individuals within the model are considered as valuable data. The aim of the qualitative interview is to explore and discover what happens according to Starrin and Renck [4].

They conducted interviews have mainly been directed to open, but semi-structured questions arise. For the most part, the respondents were industrial designers, product developers, innovators, innovation consultants and project managers.

The selection of the companies was done according to the criteria of SMEs with 20-200 employees and with in-house design engineers within a 50 km radius of the campus. The final selection was done through availability of the company. The number of the interviews conducted was 26 and the interviews were performed during a time of six months.

3 THORETICAL FRAMEWORK

To get an understanding of the initial reference the theoretical framework based upon two different areas will be presented and these are:

- The Design Process
- The Creative behaviors

These areas are what need attention during the development of new products or services. A presentation of these areas one by one will be performed and a suggestion of a common focus within these areas will end up this section.

3.1 The Design Process

To start up this section a presentation of what literature says about a generic design process. This specific process is from Aseplund [5] and consists of these six steps, Figure 1.

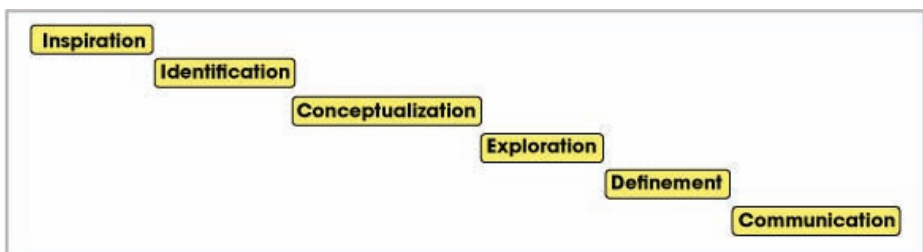


Figure 1.

This specific generic process is one of many but they all look quite the same even though they have different names and numbers of the activities they have the same meaning. This generic process supports designing and design thinking. Aspelund [5] explains designing like:

“Designing is about ideas: needing and finding ideas, examining and identifying their nature, and, most important, illustrating and explaining them so they can be realized. “

Pahl and Bates [6] design process consists of only four phases and are more abstract than others, the four phases are: clarification, conceptual design, embodiment design, and the detail design phase. In these four phases there are special tasks in different stages to solve and the interaction between previous and following stages are important activities.

In designing there are different aspects of creating success. The design process rests upon three parallel sub processes:

- The creating of a satisfied customer
- The knowledge about team processes and multidisciplinary work
- The continuing development of processes and ensuring of an efficient and well carried out process [7]

So to be able to succeed in designing you need to be successful in all three sub processes, yet the success in this doesn't guarantee a success on the market. In idPeo a Multidisciplinary Approach to Innovative Product Realization [8] a methodology for innovative product development is proposed, Figure 2. The model focuses on a collaborative approach of needed expertise knowledge, key activities, and decisions within NPD and the need of a process leader who could support the project and the team in the process in developing new products.

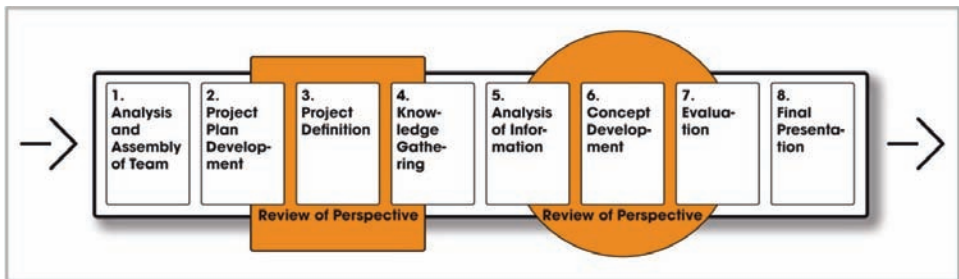


Figure 2 idPeo, a methodology for innovative product development.

Takeuchi and Nonaka [9] describes three changes that companies have to consider when moving towards speed and flexibility in NPD. First, the management need to recognize that the development of new products are an iterative and dynamic process. Second, a different kind of learning has to be adopted from depth towards a broader base of knowledge to challenge the status quo. Third, a different mission on NPD needs to be assigned by the management that see NPD as a catalyst for change in the organization.

Ulrich and Eppinger's [10] approach towards NPD is well used in developing new products among SMEs. This model is based on a sequence of steps that follows after each others. However, there are different thoughts about this process of sequence and its step-by-step activities. Lawson [11] is referring to this when he suggests his model that is based on negotiation between problem and solution where the activities analysis, synthesis and evaluation building up the process but without any start or ending. With this type of process it is hard to communicate the exact position of a project and its current status.

There is not one design process similar to another and one could argue that there is no meaning in trying to explain this process. But there is a belief in this process and in an abstract level one could explain all processes. Ideo have there "IDEO Deep Dive" process and Decathlon their imaginew [12]. Most of the companies working with product development have their own unique process. These processes start with gathering background information so that all in the team have the same information about the current challenge, and ends up in a prepared concept to take to the next level in the innovation process. Many companies work with the "Stage-gate-model" as a way of controlling the process and keeping projects into the pre-defined goals.

“The use of stage-gate-models is actually built upon the assumption that one actually learns gradually as the project develops, however gate decisions are often applied as locking mechanisms for the end result from the very beginning. During high uncertainty projects the gate model should be used to set up hypotheses that are tested and evaluated in the next coming phases” [13] translated by author.

In Design Process Improvement Eckert et.al [1] are discussing communication in design. “Communication strategies should be clear, simple, engaging and sustainable. A carefully thought-through communication strategy does not guarantee, but rather increases, the likelihood of successful communication.” If the strategies are to be clear the process needs to be clear, this can only happen if we create a common mental image of what is to be done and by creating visions for the project. This common mental image of what is to be done is something that Engwall [13] describes as an critical information problem. Communicating this mental image between different parts in a development process is hard and demands a dialogue that does not flinch for analogies and metaphors, and that the receiver interpret from his or hers experiences. The challenge is to, among the co-workers; create this common mental image of the project, not only of the result, but the way to the result.

Best suggest in Design management [14] a model that is linear because of the communication with the client. She also warns about the “adhering to standard processes too rigidly however, can result in an uninspiring ‘assembly-line’ solution, where tasks are passed linearly from one team to another with little dialogue or debate. Standardized processes can ensure a project is finished on time and within budget, but the result may be uninteresting if the process of design and the creativity of the design team has been stifled by standardization.”

3.2 The Creative Behaviors

Sticky wisdom by Dave et.al [15] is describing behaviors that are important to create a creative climate at any company. They are discussing and proposing six behaviors that one should take into consideration when making creative environments. These habits of highly creative people can be adopted by anyone and are not something you have but actually can learn. Among these six behaviors there is one that catches my attention more than the others regarding this research. That is realness, realness is about making things happen, trying ideas out. If this idea were real what would it look like? These questions are triggers for creating prototypes of any kind. It could be a simple user experience prototype as Buxton [16] suggests or it could be a collaborative sketch something like Shah [17] describes.

These behaviors are not the key to effective processes but it gives guidance to the most important source, the people. As Ekman and Jacksson [18] explains “The most important source toward innovation is people with their free opportunities to use their skills, express their ideas, develop inventions and create intra- and entrepreneurship for innovations and companies”.

However, today it is often too complex to handle innovation unless one is using larger groups of people. This stresses the importance of a multidisciplinary team, where people differ in their roles, have the freedom to think big in a creative and innovative environment.

Richard Florida describes how technology, talents and tolerance for diversity are closely connected. Today, more often than not, multidisciplinary teams are responsible for successful innovations – in the research and in the company world [19].

Gardner describes in his book “five minds for the future”, a way of looking for the right people or creating the right people [20]. His “five minds” give us something to start up from when we assemble a development team for a new project. It also gives us a forecast of the knowledge of minds that the future is demanding for people to be able to take part of the future, not only as passengers but also as drivers. It is time to educate individuals to be disciplined, synthesized, creative, respectful, and ethical.

4 SUMMARY OF THEORETICAL FRAMEWORK

This summary will explain why these two areas, the Design Process and the Creative Behaviors, leads to communication and visualization. Ferguson [23] talks about the mind’s eye and the use of our unconscious. This use of visual thinking is one of the skills that designers have and use both conscious and unconscious.

In the creative process one often refers to a five step model that consists of preparation, incubation, insight, evaluation and elaboration. According to Csikszentmihalyi [21] ”this classical analytic framework leading from preparation to elaboration gives a severely distorted picture of the creative process if it is taken too literally. A person who makes a creative contribution never just slogs through

the long last stage of elaboration. This part of the process is constantly interrupted by periods of incubation and is punctuated by small epiphanies.” However, if we don’t take the framework to literally as Csikszentmihalyi suggests this description of a creative process could be useful in communicating what actually happens within this process. Figure 3 shows how this process could be linked to the “conversation” that designers have with their sketch.

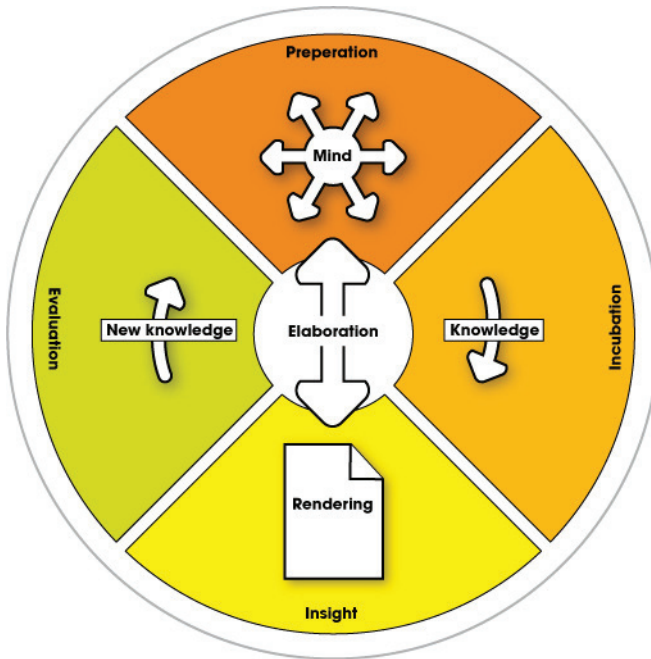


Figure 3 the creative process linked to the “conversation” that designers have with their sketch.

A central part in all processes is communication. In design processes this is no exception but according to Eckert [22] designers often fail to recognize that the resulting problems are communication problems.

Henderson [24] describes the use of sketches and drawings like this “engineering sketches and drawings are the building blocks of technological design and production. Moreover, because they are developed and used interactively, these visual representations act as the means for organizing the design to production process and serve as social glue between individuals and between groups.”

All kinds of communication have to be effective and efficient. First of all, an external rendering type can carry understanding in multiple interpretations, in terms of creating a common mental image in the project. The lack of information and the need to communicate this “mental image” of the project to the next group of people, who continue the work process, is considered a difficult step. This handover situation is described by Eckert et.al. in Design Process Improvement [1].

When we discuss different strategic decisions, it is important to have tools designed for understanding. This paper takes a step forward in developing a sustaining model, including interpretation. From an information designers perspective we will make an effort in understanding the receivers of information, to provide them with the right information at the right time in an adequate way. Here is deep knowledge in perception, cognition, and esthetic important. This speaks for a cross-functional development team.

These communicative processes are not strictly in the explicit product development process but in phases impeding the process such as scenario planning, observing the user, understanding the user, explaining the gathered information and communicating this to the members of the team. This understanding that comes with the visual communication of all this information improves the overall

performance of the design process and conveys information to the entire group. To make this happen the team members must understand each other's information needs. [1]

4.1 Visualization

To be able to facilitate memory successful external cognitive tools must be developed to compensate for limitations in human memory and information processing at the same time that they take advantage of them [25].

To use different rendering types according to where in the process you are is something that Buxton [16] describes. He identifies five different types of renderings that are sketches, memory drawing, presentation drawing, technical drawing and description drawing.

The creativity is enhanced by allowing designers to interpret sketches. The designer views this as interacting with the sketches as in a conversation: the designers see more in their sketches than they put in when they drew them, and these insights drive further designing [26].

Designing is about ideas: needing and finding ideas, examining and identifying their nature, and, most important, illustrating and explaining them so they can be realized. [5].

Henderson [24] talks about that "sketches are the real heart of visual communication. A senior drafter who had been promoted to engineer fought with management for the return of her drawing board, stating, "I can't think without my drawing board." It is where she solves problems. Sketches facilitate both individual thinking and interactive communication. Because they allow these processes to occur simultaneously, they become group thinking tools. Thorough designers continually use sketches, from early drafts talked over with designers and fabricators to rough drawings in margins to clarify an idea."

Three kinds of sketches can be identified. The first is the thinking sketch the next is the prescriptive sketch. The third kind of sketch, produced constantly in exchanges between technical people, is the talking sketch [23].

The goal is to eliminate traditional barriers and to foster good communication and cooperation. The process should be made explicit to facilitate development and the possibility to become increasingly flexible and creative, as well as robust to changes in the market, organization, task, and team.

5 CURRENT PRACTICE

According to the interviews that have been conducted there is a lack of competence regarding the effectiveness of using visualization within innovation processes. There are differences among the knowledge of the use of visualization for performance among the interviewed, where the designers and the innovation advisors had good knowledge about the use and effectiveness in using visualization, but the in house design engineers where aware of the effectiveness but did not practice visualization in an effective way. The inventors have knowledge about the importance but only used visualization with models. This might rest upon the lack of skills in visualization with paper and pen.

5.1 Designers

The designers have good knowledge about using visualization in their work, it's one of their key skills using sketches to visualize ideas and communicating thoughts about solutions and propositions. This sketching is referred to as a way of thinking and creating brainstorm within you. Through these sketches new knowledge about the solution arises and come to be interpreted in the next proposition. They are using visualization strategically but not as effective as they could.

5.2 Innovation Advisor

The innovation advisors are not using visualization themselves but are frequent buyers of visualization skills from designers and illustrators. They have good knowledge about the use of visualization and tend to buy these skills in a structured way according to their road map.

5.3 Inventors

The private inventors struggling for their new ideas to reach the market there are little knowledge why and how one could use visualization in the development, although they tend to use visualization in their own way. If they have the skills for sketching they use it and even if they don't have that skill they are using sketches for the same reason that designers are, testing and communicating with themselves. Inventors tend to use models more than all other groups and earlier in the process.

5.4 SMEs

The use of visualization in a structured way is something that SMEs are quite good at in the later stages of the development process. This is partly because of the use of stage-gate-models but they also have CAD systems that supports this way of structuring the process. However, the use of sketches in the beginning of the process isn't conducted as a tool. This part of the process is almost something that the design engineers are excusing themselves for doing. The use of models and drawings are rather high but also in the later stages, they don't use visualization as a tool in creating visions for the project team or the company.

6 EIGHT CATEGORIES

These are a presentation of eight different categories of visualization that are of interest in this research. These categories are a result of the analysis of the interviews. Yin points out the need to use an analytical approach for the analysis of research data [3]. Merriam describes analysis as a complex process that moves back and forth between concrete data and abstract concepts, but also between inductive and deductive reasoning, and between description and interpretation [27]. How to which researchers are doing to create meaningful and result is not some logical process, but more on intuition and the researcher's sensitivity for the information. In this analyze three different approaches have been used; pattern matching, clustering and probable.

The categories are divided in two groups where four are behaviors and four are rendering types for visualization. The different categories are shown in Figure 4 below.

- Importance, the attitude about importance and meaning of using visualizations in innovations processes.
- Use of, what are their own attitudes about how they use visualizations as a method.
- Vision, strategically use of visualizations the use of visualization as a tool for creating visions.
- Systematic, is this work with visualizations done with systematic or is it done ad hock.
- Sketches, why and how sketches are being used.
- Drawing, is the use of drawings in the process something that is seen as an important tool.
- 3D-cad, what does 3D-cad ad as a tool and is it being used reflectively.
- Models, the physical model as a powerful tool and how to they use them as a source of knowledge.

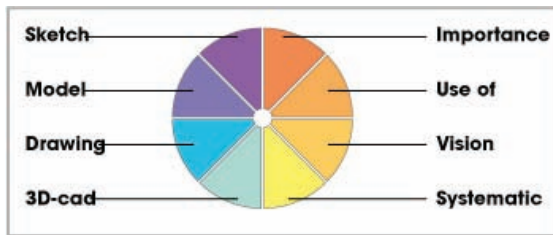


Figure 4, the eight categories of interest are divided in two groups where four are behaviors and four are rendering types for visualization..

The behaviors are of course important for using visualizations in an effective and efficient way, and as we can see in figure 5 there is a difference between the four focus groups. One could see that all groups are fully aware of that it could be of great importance to use visualization and are from their own perspective a good user of visualization. However, they lack in the systematic use and in the early stages in creating vision or common mental images.

The reasons for using visualization are effectiveness in communication and a need for the next step in the process. However, the next step in the process might be something that you do yourself and not a communication problem with a handover situation this could lead to that one doesn't investigate the step in the way that one should and the solution isn't the best one to solve the problem. The outcomes of the use of visualization is what the interview refer to as common understanding of the problem at hand, a sort of mental image in a project group, and this is also one of the reasons in using visualization for visionary thinking in projects.

The companies in this research have problems in the use of visualizations with resources and knowledge. The method of using visualization is well known and they think of themselves as good in using visualization, however only in what they are common with within visualization. So the use and knowledge is good in their own sphere and as far as they are concerned they are doing the things that can be done.

This leads up to the next part which are systematic in the process of using visualizations. The Figure 5 shows that this is where it differs between the groups, the innovation advisors are usually more strategically then the inventors but all of them are fully aware of that they could be better in the use. The design engineers use CAD tools with some kind of systematic approach and have a model or method that they use in creating new products. The designers are using their design process as a tool for keeping projects systematically. The reason for having systems and processes for the development are mainly the status and communication within project teams and the administration about the project regarding resources and budget. From a designers perspective the management of these projects are the main reason.

The tools/methods for visualization have one common goal and that is communication, the communication to define the solution for you and the team. This communication takes different rendering types in the process and the focus according to the interviewed has been on the use of sketches, models drawings and 3D-cad. The main reason is, as mentioned before, the effectiveness of communication within the process, however, the use of rendering type depends on where in the process the project are.

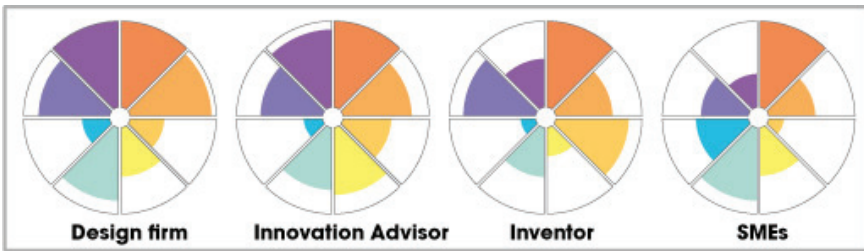


Figure 5, the differences between the eight categories of interest.

When deciding which rendering type to use one focuses on the resources and competence that are available, not on the rendering type that fits the purpose best. The purpose of sketches and models are quite the same and its main focus is in communication and exploring ideas, while drawings and 3D-cad are mainly for communicating and to define solutions. So it differs between the different rendering types which are used and for what reason. This is explained in Figure 6 with the dependencies of rendering type according to reason of use.

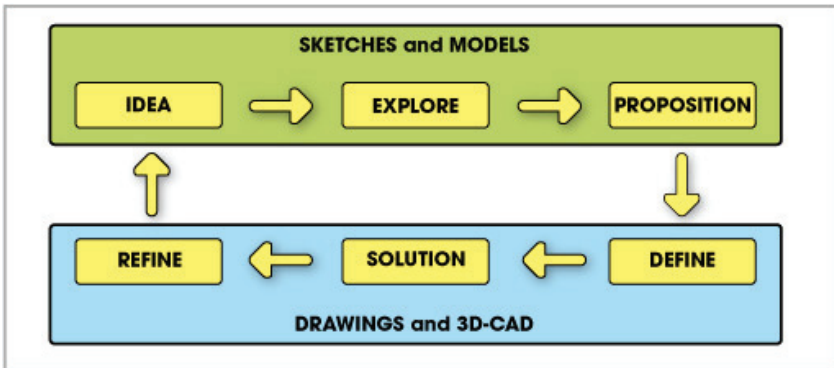


Figure 6, types of rendering according to reason of use.

If we use Buxton [16] description of five different types of rendering according to the Figure 6 it could be like this.

- Explore uses sketches and memory drawings.
- Define uses technical and descriptive drawing
- Refine uses descriptive drawing
- Communication between the different steps are using presentation drawing

7 BEST PRACTICE

To create an overview of the best practice is both difficult in finding this practice and evaluating it according to the categories that are of most interest for the SMEs. These studies have been strictly based upon literature in this part and the impression is that there are not much written within this area and the conclusion that have been taken is that visualization in an structured and strategic way is key factors for successful product realization.

According to Takala et.al. [12] “there are a few design companies that have developed their businesses from a well-defined concept and product creation process. Typically these companies excel in designing clear processes for creative tasks.”

IDEO, a design firm who are seen as one of the world’s most famous design firm has developed a process that focuses on the user experience and the user situation. This “Deep Dive” that IDEO does is based upon observations, rapid 3D visualization and modeling of ideas. They are highly creative and use visualization as a method in communicating between all the phases in the process. This is most legible in the iterative cycle of visualizing, modeling, evaluating and refining. However, the use of visualization is a systematically support all through the process. Takala [12] continues “the IDEO process shows that it is possible to provide a service based on the ideation process. There are some modifications to the generic process that adapt the ideo process to make it easier to use a customer’s seed idea and to emphasize the design activities in the process in order to allow for continuous reporting to the customer.” So one could make a service out of a process that is almost a generic process, this leads to my believes of making a supportive model for SMEs in using visualization as a tool in NPD.

Decathlon is a company that develops concepts for their own use primarily. Takala et.al [12] describes there process like this. The work is carried out in seven phases: information gathering, brainstorming, scenario creation, concepts, formalization, evaluation and finally integration with project planning. . “The Imaginew programme primarily aims to anticipate the desires and needs of future users and to create corresponding product proposals based on those wants and needs.” And continues, “the programme enables the iterative evaluation of new product innovations and thus minimizes the risk of innovation.” There process shows that one could make this in house and even though Decathlon is a rather big company there are ways of scaling there programme down to fit smaller companies. These two examples are fully aware of how and why they use visualization, there use is strategically with focus on idea based use as well as solution based use as seen in the Figure 7 below.

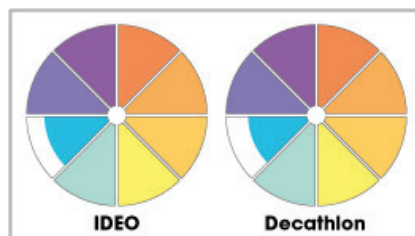


Figure 7 the differences between the two examples of best practice depending on the eight categories of interest.

The impression that the work at both IDEO and Decathlon is that they use visualization as a strategic tool in the process. How they keep this focus and continue to develop their process with visualization could be the use of process leaders in their projects. These processes that IDEO and Decathlon uses are not strictly using visualization in the explicit product development process but in phases impeding the process such as scenario planning, observing the user, understanding the user ,

explaining the gathered information and communicating this to the members of the team. This understanding that comes with the visual communication of all this information improves the overall performance of the design process and conveys information to the entire group. To make this happen the team members must understand each other's information needs.

8 A GENERIC MODEL OF VISUALIZATION

The idea of two different kinds of approaches, idea and solution based is the main focus in this model. The use of different rendering types according to these approaches is the way it is suggested in this reference model. If we look at the Figure 6 regarding dependencies of rendering type according to reason of use and adopt the knowledge from literature regarding visualization we could look at a generic model like Figure 8.

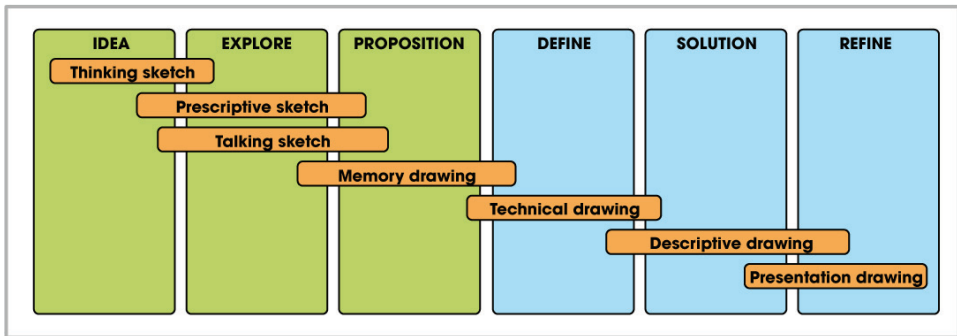


Figure 8, a generic model of visualization according to rendering type.

This suggested model gives direction of when to use what type of rendering and map this to one generic design process. This gives us directions on supporting systems for using visualization in NPD projects. By improving the knowledge about the positive effects of using different rendering types according to the process and learning when to use these different types of rendering one could look at a development of the entire process. However, this model focuses on the exploration of ideas towards defining a solution, and there are steps to be taken both before and after this exploration and define phases. These steps need more attention and will be subject to future research.

9 DISCUSSION AND CONCLUSION

This paper provides a classification and characterization of SMEs need for resources in visualization for communication in their ambition in creating innovations. The big difference between best practice and the current practice within SMEs needs attention.

According to the model of eight categories the suggestion is that the categories are classified as four groups namely awareness, strategies, solution- and idea based rendering type. This leads to the conclusion that SMEs are aware of their use of visualization; however they think that they use visualization better than they do. They tend to prefer solution based rendering types and are through that week in their idea phase. This could easily be taken care of, and are partly being solved by the use of design firms in these cases that they prioritize that kind of competence. This puts the management in a difficult situation where they have to take these kinds of situations without sufficient information. Design firms are good in the idea phase but could be more structured during the whole process. This leads to problems when communicating ideas and solutions to the customer. However, this is not a purely communication problem but also a knowledge problem where customers tend to believe that they know what the process consists of and what to expect from it.

This implicates the need for methods and tools for applying visualization in SMEs innovation processes as well as for design firms, the use of a roadmap like the one IDEO uses could lead to better understanding and more effective projects. However this is applicable in larger companies or not this study doesn't go in to.

The research in this area will continue and will in the next step focus on the use of visualization as a tool for effective and efficient processes and projects. The next step will be in developing guidelines

for how visualization can be used and to suggest tools and methods for efficient support by visualization through the innovation process based upon the developed idPeo methodology. The understanding of what information needed and how this information could be communicated to the receiver is one important issue that needs attention.

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