SETTING UP A RESEARCH EXPERIMENT — HOW DOES PERSONAL MOTIVATION AFFECTS PROBLEM SETTING?

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Collaborative user oriented design activities are difficult experiences that need to be practiced. Doing so in a professional setting, but without prior experience, can and probably will jeopardize the whole project. So, it is important for design education to offer students the possibility to collaborate in student projects and to assign them to solve open-ended problems. However, it is of interest to find out how differing motivations for individuals affect their team's ability to successfully meet user needs. This has been investigated in an experiment where students were categorised into two distinct models of design motivation. It was found that one of these models was more apt to manage user orientation in the design team. In this paper, the design of the experiment per se is outlined in order to invite more research within the area.

Keywords: User oriented design, team work, design experiment, motivation, communication.

1. INTRODUCTION

Companies today are using more interdisciplinary approaches in product development. The success of such collaborative efforts builds on the team's capability to create a shared design vision. Hence, a key to success is sound communication within the team.

The information that the team can use to build a shared design vision comes mainly from understanding what users or customers wish to achieve when they make use of the "to-be" designed product. The team embarks from a point where they do not exactly know what to do or what the users wish to do. This kind of problem is commonly referred to as a wicked problem [1], that is, much of the necessary information is embedded in experiences and has to be interpreted into a new context. Dealing with this kind of "soft" information is not straightforward, yet the team has to agree on what to design, what user needs that the design should fulfil and in what way.

Rough, quick prototypes, for example, simple representations made of cardboard or everyday things, can be used to support idea generation in early development phases. This is a feasible way to communicate when managing radical innovation, but can also used in an incremental approach. One warning against diving too deep into prototypes is that the team might just be focusing on "What?" and "How?" rather than the important question "Who?" [2], that is mainly focusing on problem solving instead of first understanding potential users and problem setting. By beginning the innovation process by asking "Who?" and not "How?" the potential for an efficient and repeatable processes is better, and

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above all creates possibilities for radical solutions rather than incremental improvement of existing products. Interaction between players with different skills, background, and so on, contributes strongly to the creative phases and the creation of new concepts, but such cross-functional work is not entirely smooth and may jeopardize the entire project if not done thoughtfully. A contributing factor to the difficulties of interacting and understanding each other's perspective is that the team no longer manages product requirements as first and foremost, but rather must find, interpret and build on customer needs.

When a team is assembled it is primarily based on what there is at hand or on the competences considered necessary in the future project. Besides skills and competencies, the success of the project is much depending on each team member's individual focus, regardless if it depends upon internal or external factors or change over time. Hence, awareness of individual's focus makes it possible to set up a "dreamteam" that fits different purposes.

From experiences in teaching customer determined design approaches in both architecture and mechanical engineering, we have noticed that students, when exposed to a wicked design situation, tackle it with a variety of motivations. Some get frustrated and ask for more theoretical lectures, and turn to us as teachers to provide them with answers. Others gladly take on the task and more or less find their own ways of dealing with the situation. Naturally, people are different and learn differently, but these experiences have triggered an interest to discover how the student's individual focus affects the team's problem setting activities. So, we set up an experiment to find out how the students individual focus affected the team's ability to design. The experiment was based on the assumption that a design team consists of different skills and personalities at various levels.

One key challenge was to separate the students based on their different personal motivation. We separated the students' individual focuses into two categories, to describe how this was done is the purpose of this paper. Thus, in this paper we present the rationale for the categorization and outline how the experiment has been designed and performed. We do this in order to invite other researchers to set up similar experiments.

One result of the experiment indicates that the students performed differently depending on how they managed the "Who?" whether to a high degree or not. Results also indicate that the team communications were performed in different ways and to different extents when one team was compared to the other. The results from the experiment will be accounted for in another publication. However, in this paper we would like to share how the experiment was setup to invite similar research efforts in industry.

2. COMMUNICATION IN DESIGN TEAMS

It is hard to analyse and capture the reasoning and the actual understanding in design. But how a team communicates gives a base for what is going on in the process. Design process has been summarized into four basic elements by Stempfle and Badke-Schaub [3]:

- Generation
- Exploration
- Comparison
- Selection

The first two elements are divergent operations and aim to widen the problem space. Comparison and selection are convergent elements of the design process that narrow the problem space. This is a simplified model and describes the design process, but operations in such a process can just as easily be divided into content focused *task-work* and process intensive *team-work* [4].

One picture of process and content related communication has been identified. By analyzing the frequencies in team communication it was found that two thirds of the communication within teams dealt with content [3]. It should be noted that these teams were likely heterogeneous with respect to individual members' motivation as dealt with in this paper.

The two first basic elements (generation, exploration) in the design process tend to increase the complexity of the problem space. A group of design learners that constantly tries to reduce the complexity and evaluation of ideas will have a more ‘quick and dirty’ approach to the task.

Teams working in this kind of process will not put as much time and cognitive effort into the task compared with the other process described by Stempfle and Badke-Schaub [3]. A second version of the process is more suitable for complex problems. Ideas are analysed before any evaluations are made; a rationale behind decision is elaborated as a. This process minimizes the risk of making wrong decisions because it allows for continual bricolage throughout the elaboration.

There are some conditions that have been mentioned [3] that will change a team’s use of the first process to develop into the second kind of process, which is described to fit more complex problems. *Lack of common understanding* will provoke questions as well as *disagreement and challenging of ideas*, and conflict resolution will lead to analyses of solutions. *Failure* of the first process will lead to analysing the already discarded ideas and solutions and that reflection and iteration indicate a change into the second process. *Adoption of a methodology* in terms of using creative methods will change the team’s process. The last condition proposed was individual *self-reflection*, which also contributes to a more analytic approach close, related to the second process [3].

2.1. A model for prototyping communication

Early phases of design work describe a divergent mode, though treated differently depending on what the team has to achieve. In a traditional problem solving mode (e.g., incremental improvement of an existing product), converging all information in order to focus on that product is important to do as early as possible. In radical innovation work, however, preserving ambiguity throughout the early design activities is vital. The team looking for radical innovation has to define the problem before they can solve it, thus they are widening the solution space rather than narrowing it in the planning phase.

The approach of preserving ambiguity is commonly not applied in product development, so team members are not used to, and do not feel comfortable in, this way of working. The use of early rough communicative prototypes (different from the usual late prototypes used in field tests) support communication in the team. The communication process based on such prototypes has been addressed in a model [5], see Figure 1. The model is based on the idea that a common ground (i.e. when a team has a mutual understanding of the design vision [6]) could also mean that the team is aware of its members’ different perspectives. Hence, radical innovation is often the product of mutual understanding of different perspectives.

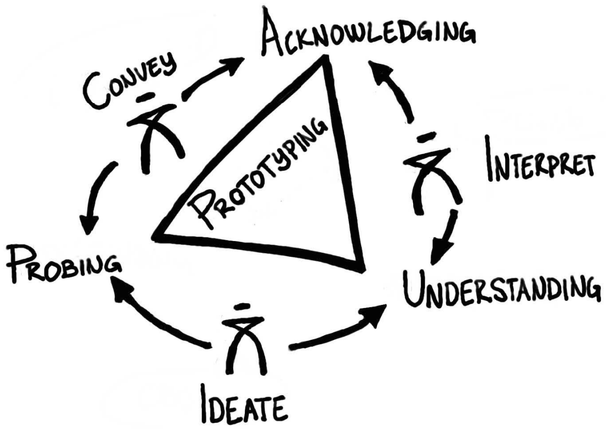

Figure 1. A model for prototyping communication [5].

Probing is an explorative phase and the start point of the communication model in Figure 1. It could start with an utterance, a team member expresses an idea and maybe explains it with making gestures or a sketch. The probe is then conveyed to the team. The model proposes that the team then *acknowledges* the probe, most likely with a gesture or a confirmative utterance. In this moment the probe can either be positively encouraged or challenged. By acknowledging an idea in a negative way it is likely that the team will drop the idea at this stage instead of further building on it. Thus, they risk the potential of that "for the moment poor" idea to become a great one.

Another team member will interpret a probe, in order to build up an *understanding*. This could be shared or contrasted understanding. Shared understanding is when an idea has evolved and the team agrees and has nothing more to explore from the probe, and they start over with a new probe. Contrasted understanding is explained as a waypoint towards either conflicting understanding or common understanding [7]. Which will result in the team's making new probes or iterating and building on existing ones.

3. BASIC RESEARCH/APPLIED RESEARCH VERSUS MASTERY LEARNING/PERFORMANCE LEARNING

An analogy can easily be made between the range of intent for researchers and that for learners: first consider the differences between basic research and applied research and then compare those to the differences between mastery learning and performance learning.

The following is taken from the United States Office of Budget Management (OMB), with regard to basic and applied research [8, p. 8]:

> "Basic research is defined as systematic study directed toward fuller knowledge or understanding of the fundamental aspects of phenomena and of observable facts without specific applications towards processes or products in mind... Applied research is defined as systematic study to gain knowledge or understanding necessary to determine the means by which a recognized and specific need may be met."

Meanwhile, Pintrich, Marx, and Boyle [9, p. 176] have this to say about mastery and performance learners:

> "Students who adopt a mastery orientation are assumed to focus on learning, understanding, and mastering the task while those who adopt a performance orientation are assumed to focus on obtaining a good grade or besting others."

The resulting analogy is that basic research, like mastery learning, is pursued for its own sake while applied research, like performance learning, is conducted toward a particular end, whether it is addressing the weakness of a product or attaining a desired grade.

However, the analogy requires a closer examination with regard to beneficiaries from performance learning versus those from applied research. In the former case, goal accomplishment is centred on the learner's advantage, while in the latter, depending on the circumstances; goal accomplishment might have nothing to do with the learner at all. Therefore, it will be more inclusive (and perhaps less confusing to the reader) to refer to students who are expected to pursue specific goals as being "goal-oriented," both implying their performance orientation with respect to learning and allowing that the research they perform during their designing will tend to be "applied" to accomplishing goals, but without further explication of any of those specific goals, themselves.

Mastery learners, on the other hand, are more likely to recognize design processes as being generalizable beyond the situations used to present them, that is, as having educational worth in their own right, independent of course work. This coincides with a "basic" approach to design and research as a practice to be cultivated, not necessarily for what it produces, but for what it represents as expertise to the individual and as a resource for historical creativity indicating novelty on a social scale as opposed to mere individual psychological creativity, and discussed further in Boden [10].

Table 1. Categorizations of the student's individual motivation.

Goal-oriented, based on:	Insight-oriented, based on:
Performance learning	Mastery learning
Applied research	Basic research

3.1. Institutionalized Cognitive Dissonance

Thus, there are two incidents of cognitive dissonance that might be expected in a design course at the university level:

- Performance learning with a goal orientation is depicted in educational psychology literature as inferior to mastery learning, yet maps very well onto aspects of applied research that is often a desirable pursuit in one's professional career.
- Basic research and mastery learning, when those are aligned with radical innovation (a desirable educational pursuit at university), could tend to circumvent need finding of users, which is a fundamental activity for design in practice and, supposedly, design education.

This leads directly to a research question related to observation of insight oriented (mastery) and goal-oriented (performance) students, working in homogeneous groups, in order to gain some comprehension into what a particular course for engineering design students actually affords them. In order to understand how personal motivation affected the result it was decided to divide the students into these two categories in the experiment, as shown in Table 3.1..

4. DESIGN OF THE EXPERIMENT

Focusing on engineers and designers, or in this particular case, engineering design students and how they communicate and prototype, the experiment was designed to follow early phases of a general product development process [11]:

- Planning
- User analysis
- Product specifications
- Concept generations
- Concept selection

The main focus was delimited to two stages, namely user analysis and concept generation, because in these stages the designer must encounter: what the problem is; who is involved; and how it can be solved. The study was planned in a workshop format and the problem to be presented to the students was selected to be of the open-ended type. The purpose for that is because when an open-ended problem is encountered much is up to the respondents with regard to interpreting the breadth and depth of the problem. In this case a group of students would have the choice to freely interpret the question and take actions according to that, that is, they could assume the role of designer, solving a problem for a cause.

In general, design is defined as a change of an undesired situation into a desired one [12]. Successful design activities are depend on a multitude of factors. Some factors might be, for example, the social aspects of a design process, the degree of innovativeness desired, or the extent of satisfying the user need. To be able to understand how design teams perform with these factors and communicate as out model predicts, we decided to set up an experiment, blocking it by levels of individual motivation: whether the students were goal-oriented or insight-oriented. A student's individual motivation was determined by using parts of the Motivated Strategies for Learning Questionnaire (MSLQ) [13], which we used in the forming of two teams.

By doing so, we ensured that either team would consist of designers from the extremity of an orientation, and the analysis could then focus on the differences. The basic idea behind this setup is the assumption that both types of the extremities exist in design activities but could have different importance depending on where in the process they are utilized.

The experiment was staged in two different classrooms, isolating the teams from one another. In both rooms students were given the resources to perform a creative session: whiteboards to write on; other material such as paper, pens, scissors, and so on to prototype with; and enough space to freely arrange the session. In each room, the researchers also had the possibility to position camcorders to be able to record each session.

4.1. Selection of teams

How design learners adapt to one process or another might not be stable, in that it will most likely change when the engineering design students have elaborated their competences. The first time they are faced with a new approach of how to work, new materials or methods, the anxiety could be too large a challenge to overcome, and therefore not a preferred situation. Independent of which learning style or process that is used there are other parameters that have been found as more significant for how engineering design students perform, those are; knowledge, intelligence and motivation [14]. As previously mentioned, the Motivated Strategies for Learning Questionnaire (MSLQ) [13] can be used to understand what types of students a group consists of. That is, to distinguish between students who most likely would take a course with the goal to just pass tests and get a grade, and another type of student who is motivated to learn and puts more effort into a subject and develops interest in a course.

The MSLQ consists of two sections, one about learning strategies, and the other about motivation strategies. In the learning strategy section, three-fifths of the items deal with students' cognitive strategies, and the remainder with management of various learning resources. The motivation strategy section of the MSLQ that we have used in this study to distinguish between the main focuses of student motivation (i.e. goal-oriented or insight-oriented), consists of 31 items. This part deals with students' motivation for taking a course in terms of anxiety to pass a test, student goals, and beliefs about their skills to perform in a course.

The motivation section of the MSLQ consists of six sub-areas;

- *Value Component: Intrinsic Goal Orientation* — Why a student is engaging in a task (e.g., challenge or curiosity).
- *Value Component: Extrinsic Goal Orientation* — Is there any extrinsic reason to take a course, such as for grade, rewards or to be seen in competition.
- *Value Component: Task Value* — Refers to the perceptions of the value to the student of the course material (e.g. interest, importance and utility).
- *Expectancy Component: Control of Learning Beliefs* — How the student's engagement will result in a positive outcome.
- *Expectancy Component: Self-Efficacy for Learning and Performance* — Self-efficacy is about skills to perform and ability to accomplish a task; additionally, the expectancy refers to the task performance.
- *Affective Component: Test Anxiety* — It refers to anxiety when taking a test; negative for academic performance and could be reduced with help of training.

Two out of these 31 items were excluded due to difficulties to define whether they were more related to goal- or insight-oriented focus;

I expect to do well in this class.

Considering the difficulty of this course, the teacher, and my skills, I think I will do well in this class.

The reason for exclusion is that to do well in class could be to pass the exam for one student and to learn and benefit from the class for others. The items in the questionnaire are basically statements, and the answering alternatives were a terms of a Likert scale from 1 to 7, with 1 representing "not at all true of me," and 7 as "very true of me."

The engineering design students had to take the questionnaire in the first class meeting. They were later divided into two groups depending on their main focus (i.e. one insight-oriented team and one goal-oriented team) before the workshop in the third class meeting. To make this distinction for each individual we took the mean value of the items that were defined as insight-oriented motivation and subtracted the mean value of those items that were related to goal-oriented motivation. The students with the highest values from that equation were designated as insight-oriented students.

Insight-oriented motivation means that the student wants to understand and learn the content of a course. The goal-oriented motivated student has a focus on passing the course and might not be as interested in understanding why he or she does anything in the course or how it could be used to increase his or her learning.

4.2. Implementation/execution

The empirical study was performed on under-graduate engineering design students in one of their project courses during one afternoon, in a workshop format. The students can be described as evenly distributed female and male and in the same stage of degree program completion.

First the students were given a short introduction to the problem, to the model of the process and to their task, followed by a video describing the problem context. They were also given a short document providing the problem context. The problem was described as a "real life" problem, and stated as an open-ended problem (i.e. there were no exact or quantifiable answers to the problem). Introduction of the problem gave the students information that they were free to interpret themselves, but the context gave them an environment that the problem could be related to.

To guide the students and to improve the process, two methods for ideation were presented. The first method was a normal brainstorming method, where the students were told to try to be positive, go for quantity, build on each other's ides, be open minded and contribute to the process. The second method was presented as a simple need finding method, where the students were told to come up with, and describe a typical stakeholder and his or her, age, occupation, needs, and so on. When the first session started the students were told to use the brainstorming method as an approach for how to determine a range of stakeholders and their needs. The need finding method was then used to analyze differing stakeholders and their needs.

After the first session, the students had the opportunity to search for more information on the Internet that they had possibly realized was lacking during the session. In the second session the students were told to use the same brainstorming method but to focus at trying to find solutions to the needs.

After the first two sessions, which could be described as more divergent, the students went in to a more convergent phase where they first played a computer game simulating a similar problem context. Then they made physical prototype of their solutions (e.g., drawings, charades, physical artefacts, stories). As a final step each team presented its concepts to the other team.

Each session was attended by the researchers, who also acted as facilitators for the process, clarifying the assignment or answering questions related to the assignment. The data collection was done by researcher observation of the students and written notes. Each session was also recorded on video for later analysis, by camcorders located on both team sites.

5. CONCLUDING REMARKS

In this paper our efforts have been to outline the design of an experiment aiming to find out how personal motivation affects team problem setting, as well as to present the rational for the categorisation of the students into distinct orientations toward design. A key for a good experiment was the categorisation of a student's personal motivation. Our approach to block students by level of individual focus was a feasible way, but performing such a test one should also be aware that motivation could be something that depends on a lot of factors and can change over time and environment.

Further, this kind of experiment generates rich data, both in terms of video and of observations. We have used a so-called Design Observatory as the location for the experiment, meaning that video recordings were readily made and design prototyping materials were at hand. This kind of rich qualitative data offers several ways of analysis, so the experiment had to be designed with the analysis in mind.

We applied three types of analyses on the data (observational, conversational analysis [15] and horizontal [16]). From the analysis we found that the insight-oriented team did build their solutions on their understanding of "Who?" i.e. they applied a customer determined design process and made a solution that solved the problem on several levels of abstraction. The goal-oriented team did come up with a solution that satisfied the course assignment, but did not meet real needs of users. For education this is particular interesting for assessment and grading. Since this study is limited to a student course such results is not extensive enough to be applicable in industry, therefore we hope that this paper would encourage such studies.

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